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EFFECTS OF NITROGEN AND POTASSIUM ON YIELD AND QUALITY OF POTATO (*SOLANUM TUBEROSUM* L.) CULTIVARS

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Abstract

Effects of nitrogen (N) and potassium (K) fertilization rates on the yield and quality of two potato cultivars, Asterix and Courage were conducted. The treatment combination of N_2K_2 (N_2: 140 kg ha^{-1} and K_2: 152 kg ha^{-1}) had the highest total yield (31.38 and 22.51 t ha^{-1}), marketable tuber yield (29.08 and 20.49 t ha^{-1}) and chips potato yield (36.63 and 36.96%) of the 18 treatment combinations for Asterix and Courage cultivar, respectively. The treatment combination of N_2K_2 had also the highest specific gravity (1.07 and 1.17 gcm^{-3}), dry matter (22.65 and 22.77%), firmness (45.13 and 42.92 N), and lowest total soluble solid (4.30 and 4.23 ^{o}Brix) in both the cultivars, whereas the colour of the chips revealed the least crispness (0.15 and 0.17 N). In order to enhance potato processing quality without reducing production, a lower N and higher K treatment combination may be employed.

Introduction

Potato (*Solanum tuberosum* L.) is regarded as a high-potential food-security crop and can be used as a low-cost energy source with excellent nutritional values (Ali *et al*. 2021). In addition, it has value in the fresh market and other food processing sectors, such as frozen form, chips, dehydrated products, and potato starch (Torabian *et al*. 2021). Bangladesh is the 7th largest potato producer in the world and ranks 2nd after rice in production (FAOSTAT 2020). But there is a surplus production (2 million metric tonnes over its total production of 9.65 million metric tonnes after meeting the annual demand of 6.5-7 million metric tonnes) for potatoes in Bangladesh (BBS 2019). Besides, only 2% of the surplus potatoes are processed since most of the potatoes do not meet the requirements for processing or export quality (Khandker and Basak 2018). Thus, to meet customer demand, processing potato yields and quality must be increased. Potato tuber yield and quality are influenced by many distinct factors, such as cultivar, soil fertility, climate, plant nutrition, and good agricultural practices (Torabian *et al*. 2021). To optimize tuber output and achieve desired processing quality, it is thought to be crucial to control nitrogen (N) and potassium (K) fertilization rates properly (Gondwe *et al*. 2020). For instance, N fertilization has a significant effect on potato processing quality as well as potato size for the fresh market. When N is present in the soil at planting time, yield can be increased, but when N is present in excess, tuber bulking can be delayed, reducing the formation of large tubers (Zotarelli *et al*. 2015). Excessive N fertilization can increase the protein concentration in the tubers, resulting in a darker fry colour

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(Assuncao *et al.* 2021). Additionally, it has been proposed that too much N can lower the quality of tubers by decreasing their dry matter content and increasing their asparagine concentration, which increases the propensity for acrylamide to develop during chips processing (Rosen *et al.* 2018). There is a health safety concern regarding the need to minimize acrylamide in human food because it is linked to human neurotoxins and is a carcinogen (González-Mulero *et al.* 2022). Potassium (K) is the second-most important macronutrient for potatoes. The function of K in photosynthesis is well known, which improve photosynthetic translocation, enzyme activities, and the synthesis of proteins, carbohydrates, and fats, and is responsible for higher crop productivity (Mello *et al*. 2018). Bista *et al.* (2019) reported that K increased the specific gravity and improved the chips' colour and quality of potatoes. Thus, K supplementation is very important for improving the yield and quality of potatoes. Therefore, the present study was aimed to investigate the effects of supplementing K fertilizers with reduced N levels on two potato cultivars regarding yield and quality.

Materials and Methods

The study was carried out during the Rabi season of 2020–21 at the research field of Sher-e-Bangla Agricultural University, Dhaka (23°77 N latitude, 90°37 E longitude, and 8.6 m above sea level). The mean air temperature (°C) in the months of November, December, January, February, and March was 24.7, 20.3, 19.4, 22.8, 28.4, and 30.4. The mean rainfall (mm) was 40 and 3 in the months of November and March, and from December to February, it was about to zero (Meteorological Centre, Climate Division, Agargaon, Dhaka). Prior to planting, a representative soil sample from the experimental plot was analyzed by the Soil Resource Development Institute (SRDI), Dhaka. Organic matter (%), total N (%), exchangeable P (meq/100g), pH, and electrical conductivity (dS/m) in the soil were 1.19, 0.07, 0.12, 6.2, and 0.17, respectively.

The study was done with a split-split plot design, which had 18 treatments and 3 replications. N in the main plot comprised of 3 levels (N_1: 160 kg ha^{-1} (recommended), N_2: 140 kg ha$^{-1,}$ and N_3: 120 kg ha^{-1}), K in the sub-plot comprised of 3 levels (K_1: 132 kg ha^{-1} (recommended), K_2: 152 kg ha^{-1} and K_3: 172 kg ha^{-1}) and potato cultivars in the sub-sub plots comprised of 2 cultivars, *viz.* V_1: BARI Alu-25 (Asterix) and V_2: BARI Alu-29 (Courage). The distances between rows, plants, and plots were 50, 25, and 75 cm, respectively. The size of the unit plot was 2 m × 2.5 m. From the Tuber Crops Research Centre (TCRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, seed tubers (certified seed) of all cultivars (> 40 g) were obtained and kept at room temperature to facilitate good sprouting. The field was thoroughly ploughed and fertilized with the recommended amounts of farmyard manure (FYM), triple superphosphate (TSP), gypsum, and boric acid, where muriate of potash (MOP), and half of the urea were applied by split application as per treatment (Mondal *et al*. 2011). The remaining 50% urea was side dressed in two equal splits at 30 and 45 days after planting (DAP) during the first and second earthing up. Other intercultural operations were carried out as needed. Haulm cutting was done at 85 days after planting (DAP), when 40–50% of plants exhibited senescence. For skin hardening, the tubers were kept under the soil for 10 days. Potatoes were picked separately from each plot, bagged, and marked before being delivered to the lab for testing.

After harvesting, all tubers obtained from sub-plots of each treatment were weighed. Potato tubers below 20 g were separated for marketable tuber yield. This yield was counted by the weight of tubers from a plot, which was recorded in kilogram and converted to t ha^{-1}. Tubers harvested from each treatment were classified for different purposive uses based on diameter, i.e., canned 20-35, flakes >30, chips 45-80 mm, and French fries > 75 mm and expressed in percentage. Total soluble solids, specific gravity, and dry matter were determined as described by Zelelew and

Ghebreslassie (2015). The firmness of potatoes and the crispness of potato chips were measured as described by Van *et al*. (2007). Using the CIE Lab L*, a*, and b* colour scales, the colour was measured with a colour spectrophotometer.

Using the Statistix 10 software package, the analysis of variance (ANOVA) techniques were used to look at the data for the different parameters. A least significant difference (LSD) at a 5% level of probability was used to compare the significant differences between the treatment means.

Results and Discussion

Statistically significant variation was recorded in terms of the yield of tubers (Table 1) due to different levels of N and K application concerning cultivars. The maximum yield of tubers (25.85, 25.33, and 27.99 t ha^{-1}) was recorded from N_2, K_2, and V_1. The tuber yield increased with the increasing amounts of N and K. Li *et al*. (2015) suggested that increasing the K level has increased tuber yields. According to Anning *et al.* (2021), the increase in yield brought out by N fertilizer was beneficial up to a point after that yield reduction was noticed. Hence, a balanced supply of nutrients results in the highest yield without compromising quality. The highest tuber yields were observed at 31.38 and 22.51 t ha^{-1} from N_2K_2 for both Asterix and Courage, respectively. The highest yield (23.69 t ha^{-1}) of marketable tuber was recorded from N_2 which was statistically at per with (22.65 t ha^{-1}) N_1, while the lowest yield (20.65 t ha^{-1}) was found from N_3. The yield of marketable tubers increased with the increasing level of K. The highest yield (23.16 t ha^{-1}) was found from K_2. The highest yield of marketable tuber (29.08 and 20.49 t ha^{-1}) was found from $N_2K_2V_1$ and $N_2K_2V_2$, respectively whereas, the lowest yield (22.60 and 16.29 t ha^{-1}) was observed from $N_3K_3V_1$ and $N_3K_1V_2$. Furthermore, K plays a great role in the translocation of carbohydrates from the place of photosynthesis and results in the increase of the tuber size of the crop. Thus, the marketable yield of tubers increased with the application of potash.

The grading of tubers due to different levels of N was not significant (Table 1). For canned and flaked foods, the highest results (41.80 and 33.22%) were observed from K_1 and K_2, respectively. But for tubers used for chips, the highest result was recorded from K_2 and V_2 (31. 27 and 30.03%), while the lowest (27.36 and 29.24%) were from K_1 and V_1, respectively. In the case of French fries, different levels of N and K were found statistically non-significant. For Courage, the yield for French fries was not found, while it was only 3.03% for Asterix. The combined effect of different factors showed statistically significant differences in terms of the grading of potato tubers except for French fries. For canned, the highest (48.06%) result was found in $N_3K_1V_2$, and the lowest (25.22%) was observed in $N_2K_2V_1$. For flakes, the highest result was found in $N_2K_2V_2$ (38.46%), and the lowest was found in $N_3K_1V_2$ (26.71%). For chips, the maximum value (36.96%) was found from $N_2K_2V_2$ whereas, the lowest (25.21%) was recorded from $N_3K_1V_2$. It was widely reported that adding K and N to the soil increased the proportion of medium- and large-sized tubers (Ou *et al*. 2020). Pervez *et al*. (2013) reported that the highest yield of 23.43 t ha^{-1} was obtained from the application of 150 kg K_2O ha^{-1}.

Total Soluble Solid (TSS ºBrix) is an important quality characteristic that is influenced by N. Significant variation was observed between Asterix (4.93 ºBrix) and Courage (4.79 ºBrix) to TSS of the tuber (Table 2). The highest (5.55 ºBrix) TSS was found in N_1 and the lowest (4.50 ºBrix) in N_3, which was statistically significant compared to N_2 (4.52 ºBrix). Profound variation was found among different K levels. The highest (5.10 ºBrix) TSS was found in K_1 and the lowest (4.70 ºBrix) in K_3, which was statistically significant to K_2 (4.78 ºBrix). On the TSS of the tuber, significant variation was found among different N and K levels concerning cultivars. Maximum TSS was exhibited by N_1K_3 (5.7467 ºBrix), which was statistically similar to N_1K_2 (5.6933 ºBrix) and N_1K_1 (5.6367 ºBrix). The minimum TSS was exhibited by N_2K_2 (4.303 ºBrix), which was

Table 1. Effects of different levels of N, K fertilizers on yield attributes of two cultivars of potato.

Treatments	Total yield (tha^{-1})	Marketable yield (tha^{-1})	Grading of potato tubers (%) according to processing category			
			Canned (20-35mm)	Flakes (35-45mm)	Chips (45-75mm)	French Fry (>75mm)
Nitrogen						
N_1	24.942a	22.656a	40.481a	29.674a	28.173a	1.673a
N_2	25.851a	23.691a	32.994a	34.252a	32.752a	NF
N_3	22.697b	20.653b	39.643a	29.490a	27.990a	2.877 a
CV(%)	4.55	5.38	34.63	18.59	19.53	260.70
$LSD_{(0.05)}$	1.032	1.112	12.086	5.356	5.356	3.660
Significance level	**	**	NS	NS	NS	NS
Potassium						
K_1	23.784b	21.577b	41.808a	28.859b	27.359b	1.9757
K_2	25.333a	23.160a	34.154b	33.227a	31.727a	0.8919
K_3	24.373ab	22.263ab	37.157ab	31.330a	29.830a	1.6833
CV(%)	6.34	6.51	18.47	8.85	9.30	297.64
$LSD_{(0.05)}$	1.128	1.056	5.056	2.000	2.000	3.279
Significance level	*	*	*	**	**	NS
Cultivar						
V_1	27.996a	25.631a	36.984a	30.741b	29.241	3.0340a
V_2	20.997b	19.035b	38.428a	31.537a	30.037	NF
CV(%)	4.43	3.86	12.33	3.87	4.07	278.46
$LSD_{(0.05)}$	0.620	0.492	5.056	0.689	0.689	2.415
Significance level	***	***	NS	*	*	*
Combinations						
$N_1K_1V_1$	28.013cd	25.352cd	44.290	28.090	26.590	1.034
$N_1K_1V_2$	21.620fg	19.570gh	43.871	28.815	27.315	NF
$N_1K_2V_1$	29.117abc	26.596bc	39.450	29.793	28.293	2.466
$N_1K_2V_2$	21.593fg	19.565gh	39.841	30.831	29.331	NF
$N_1K_3V_1$	28.050bcd	25.702cd	33.554	30.702	29.202	6.542
$N_1K_3V_2$	21.260fg	19.150gh	41.882	29.810	28.310	NF
$N_2K_1V_1$	27.257cd	24.760cd	43.201	29.150	27.650	NF
$N_2K_1V_2$	21.770fg	19.821gh	38.706	31.397	29.897	NF
$N_2K_2V_1$	31.383a	29.083a	25.223	38.137	36.637	NF
$N_2K_2V_2$	22.510f	20.492fg	24.571	38.465	36.965	NF
$N_2K_3V_1$	30.337ab	28.107ab	34.582	33.457	31.957	NF
$N_2K_3V_2$	21.847fg	19.882gh	31.683	34.908	33.408	NF
$N_3K_1V_1$	25.840de	23.667de	32.714	28.984	27.484	10.820
$N_3K_1V_2$	18.207h	16.293i	48.067	26.716	25.216	NF
$N_3K_2V_1$	27.150cde	24.811cd	39.189	29.711	28.211	2.885
$N_3K_2V_2$	20.243fgh	18.413gh	36.651	32.426	30.926	NF
$N_3K_3V_1$	24.820e	22.603ef	40.657	28.642	27.142	3.558
$N_3K_3V_2$	19.923gh	18.130hi	40.582	30.460	28.960	NF
CV(%)	4.43	3.86	12.33	3.87	4.07	278.46
$LSD_{(0.05)}$	2.3014	2.1233	15.013	6.1904	6.1904	7.780
Significance level	*	**	*	*	*	NS

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at P 0.05 according to LSD test. NS=Non-significant; * = Significant at 5% level; ** = Significant at 1% level; *** = Highly significant. N_1: 160 t ha^{-1} (recommended), N_2: 140 t ha^{-1}, N_3: 120 t ha^{-1}; K_1: 132 t ha^{-1} (recommended), K_2: 152 t ha^{-1}, K_3: 172 t ha^{-1}; V_1: BARI Alu-25 (Asterix) and V_2: BARI Alu-29 (Courage); NF = Not found.

Table 2. Effects of different levels of N, K on quality attributes of two cultivars of potato.

Treatment	Specific gravity (gcm^{-3})	Tuber flesh dry matter content (%)	TSS(ºBrix)	Firmness (N)
Nitrogen				
N_1	1.060 b	19.366 b	5.5567a	41.869a
N_2	1.077 ab	21.816 a	4.5253b	40.899a
N_3	1.084a	21.848 a	4.5076b	36.827b
CV(%)	1.82	2.45	8.87	4.33
$LSD_{(0.05)}$	0.0181	0.4760	0.3992	1.5977
Significance level	*	***	**	**
Potassium				
K_1	1.071 ab	19.937b	5.1008a	39.493b
K_2	1.089 a	21.590a	4.7806b	40.514a
K_3	1.061 b	21.503a	4.7082b	39.588b
CV(%)	3.01	3.06	6.53	2.86
$LSD_{(0.05)}$	0.0235	0.4662	0.2305	0.8290
Significance level	NS	***	**	*
Cultivar				
V_1	1.061 b	20.634b	4.9300a	39.536a
V_2	1.086 a	21.385a	4.7964b	40.194a
CV(%)	2.94	1.87	2.73	2.89
$LSD_{(0.05)}$	0.0181	0.2252	0.0759	0.6584
Significance level	**	***	**	*
Combinations				
$N_1K_1V_1$	1.0707bc	17.727	5.6367a	40.940bcde
$N_1K_1V_2$	1.0651bc	18.930	5.5000ab	42.673bc
$N_1K_2V_1$	1.0623bc	18.776	5.6933a	41.700bc
$N_1K_2V_2$	1.0045d	21.065	5.6767a	41.493bcd
$N_1K_3V_1$	1.0720bc	19.501	5.7467a	41.783bc
$N_1K_3V_2$	1.0866b	20.196	5.0867bc	42.623bc
$N_2K_1V_1$	1.0703bc	19.732	5.0767bc	36.163f
$N_2K_1V_2$	1.0683bc	20.418	4.8680cd	38.987e
$N_2K_2V_1$	1.0770bc	22.654	4.3033ef	45.133a
$N_2K_2V_2$	1.1770a	22.778	4.2337f	42.920b
$N_2K_3V_1$	1.0310cd	22.540	4.3667ef	40.533cde
$N_2K_3V_2$	1.0391bcd	22.773	4.3033ef	41.660bc
$N_3K_1V_1$	1.0777 bc	21.441	4.7800cde	39.007e
$N_3K_1V_2$	1.0782bc	21.374	4.7433cdef	39.190de
$N_3K_2V_1$	1.0403bcd	21.815	4.3967def	35.280f
$N_3K_2V_2$	1.1737a	22.450	4.3800def	36.557f
$N_3K_3V_1$	1.0503bcd	21.523	4.3700def	35.287f
$N_3K_3V_2$	1.0893b	22.486	4.3757def	35.643f
CV(%)	2.94	1.87	2.73	2.89
$LSD_{(0.05)}$	0.0537	0.9380	0.5358	2.4045
Significance level	**	*	*	*

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at P 0.05 according to LSD test. NS=Non-significant; * = Significant at 5% level; ** = Significant at 1% level; *** = Highly significant. N_1: 160 t ha^{-1} (recommended), N_2: 140 t ha^{-1}, N_3: 120 t ha^{-1}; K_1: 132 t ha^{-1} (recommended), K_2: 152 t ha^{-1}, K_3: 172 t ha^{-1}; V_1: BARI Alu-25 (Asterix) and V_2: BARI Alu-29 (Courage).

statistically similar to N_2K_3 (4.303 ºBrix) for Asterix and for Courage, maximum TSS was exhibited by N_1K_2 (5.676 ºBrix) and minimum TSS was exhibited by N_2K_2 (4.233 ºBrix). Pervez *et al.* (2013) found that TSS was significantly affected by the application of K, and the highest value was obtained from the application of 150 kg of sulphate of potash (SOP). According to Zelelew and Ghebreslassie (2015), potato types differ noticeably in terms of some plant characteristics, including TSS content. For the production of high-quality potato chip products, SG ranging between 1.080 and 1.089 gcm^{-3} are preferred for potato processing (Sun *et al.* 2017). Cultivar had a substantial (P 0.01) impact on SG in the current study (Table 2). The highest SG (1.086 gcm^{-3}) was found in the cultivar 'Courage' and the lowest (1.061 gcm^{-3}) in the cultivar 'Asterix'. The results showed that treatment N_3 significantly possessed a higher value (1.084 gcm^{-3}) compared to the fertilization of potato plants at treatments N_1 and N_2, respectively. Decreasing N fertilizer levels from N_1 to N_3 significantly increased the SG of tubers. The results also showed variation with the addition of P on the SG. The treatment K_2 significantly gave the highest results (1.089 gcm^{-3}) compared to K_1 (1.071gcm^{-3}) and K_3 (1.061 gcm^{-3}).

The combination of N and K levels concerning cultivars showed significant variations (Table 2). The fertilization treatments $N_2K_2V_2$ and $N_3K_2V_2$ significantly achieved the highest mean values (1.177 and 1.173 gcm^{-3}) without significant differences between them compared to the other tested fertilization treatments. Gondwe *et al.* (2020) discovered a negative relationship between SG and tuber N and K concentrations. However, the use of K had no appreciable impact on SG. This means that for increased SG, the application of 150 kg ha^{-1} of potassium oxide (K_2O) was ideal.

Dry matter (DM) content is an important quality trait of potatoes, determining the solid content such as protein, starch, and sugars. Generally, 18–20% DM is accepted for the processing industry (Dingenen *et al*. 2019). Data presented in Table 2 indicated that the applied N fertilization treatments had a significant effect on tuber flesh DM content. The highest DM content (21.84%) was found at N_3, with no significant differences between N_3 and treatments N_1 and N_2. Dingenen *et al*. (2019) found that limited N does not affect the DM content of the potato. Besides, adding K to the soil significantly increased the DM content of tubers. Zelelew and Ghebreslassie (2015) found that tuber dry matter content had increased significantly with increased K application. The highest dry matter content (17.95%) was obtained with the application of 150 kg K_2O ha^{-1}, while the lowest dry matter content (16.17%) was obtained with the application of 300 kg K_2O ha^{-1}. In the present study, tuber DM content increased significantly with increased K application. The DM content was found to be statistically at per (21.59 and 21.50%) in treatments K_2 and K_3, but 19.93% in K_1. In the present study, the cultivar had a significant (P 0.001) effect on the DM content of potato tubers. The highest result (21.38%) was found in the cultivar 'Courage' and the lowest (20.63%) in the cultivar 'Asterix'. The highest DM content (22.77 and 22.65%) was found in N_2K_2 for Courage and Asterix, respectively. Significant variation was found among different levels of N on the firmness of tuber flesh. The maximum firmness of tuber flesh was found in N_1 (41.86 N), which is statistically similar to N_2 (40.89 N) and minimum firmness was found in N_3 (36.82 N). Significant variation was observed among different P levels on the firmness of tuber flesh (Table 2). Maximum firmness (40.51 N) was observed in K_2 while a statistically similar result was observed in K_1 (39.49 N) and K_3 (39.58 N). In the present study, the cultivar had a significant ($P < 0.05$) effect on the firmness of the tuber. The highest value (40.19 N) was found in the cultivar 'Courage' and the lowest (39.53 N) in the cultivar 'Asterix'. Profound variation was found among different interactions of N and K levels concerning cultivars in the firmness of tuber flesh. Maximum firmness (45.13 N) of tuber flesh was recorded by $N_2K_2V_1$ and minimum (35.28 N) was recorded by $N_3K_2V_1$ which was statistically at per with $N_2K_1V_1$ (36.16 N), $N_3K_2V_2$ (36.55 N), $N_3K_3V_1$ (35.28 N) and $N_3K_3V_2$ (35.64 N). Higher-firmed tuber does not lose too much water; as a result, potato tuber loses less water during storage time (Riahi *et al.* 2009).

Table 3. Effects of different levels of N, K on quality attributes of two cultivars of potato chips.

Nitrogen	Color of Chips L^*	a^*	b^*	Crispness (N)
N_1	83.56 a	3.953 b	33.656 a	0.205 a
N_2	84.98 a	3.086 c	33.945 a	0.173 b
N_3	82.33 a	5.311 a	33.415 a	0.204 a
CV(%)	3.67	7.70	5.49	5.62
$LSD_{(0.05)}$	2.841	0.293	1.711	0.010
Significance level	NS	***	NS	***
Potassium				
K_1	84.569 a	3.700 b	34.577 a	0.199 a
K_2	82.082 b	4.623 a	32.744 b	0.187 a
K_3	84.232 a	4.027 ab	33.694 ab	0.196 a
CV(%)	2.51	29.12	5.14	9.00
$LSD_{(0.05)}$	1.522	0.870	1.255	0.012
Significance level	**	NS	*	NS
Cultivar				
V_1	82.888 a	4.2874 a	31.95 b	0.195 a
V_2	84.368 a	3.9467 a	35.38 a	0.193 a
CV(%)	3.17	32.28	9.13	3.77
$LSD_{(0.05)}$	1.518	0.759	1.758	4.190E-03
Significance level	*	NS	***	NS
Combinations				
$N_1K_1V_1$	85.663	2.527 fgh	32.517	0.190
$N_1K_1V_2$	84.177	3.330 defg	34.310	0.190
$N_1K_2V_1$	81.500	5.017 cde	31.743	0.206
$N_1K_2V_2$	81.763	3.503 defg	36.437	0.206
$N_1K_3V_1$	86.377	2.573 fgh	30.693	0.233
$N_1K_3V_2$	81.903	6.773 bc	36.233	0.206
$N_2K_1V_1$	82.333	2.050 fgh	34.303	0.200
$N_2K_1V_2$	84.583	6.923 bc	34.037	0.200
$N_2K_2V_1$	81.197	3.197 efg	28.933	0.150
$N_2K_2V_2$	88.487	0.613 h	35.477	0.170
$N_2K_3V_1$	87.723	1.690 gh	31.940	0.150
$N_2K_3V_2$	85.573	4.043 def	38.980	0.170
$N_3K_1V_1$	84.513	2.080 fgh	33.250	0.220
$N_3K_1V_2$	86.147	5.290 bcd	39.047	0.196
$N_3K_2V_1$	76.627	12.137 a	31.563	0.200
$N_3K_2V_2$	82.920	3.277 defg	32.313	0.190
$N_3K_3V_1$	80.060	7.317 b	32.660	0.210
$N_3K_3V_2$	83.757	1.767 gh	31.657	0.210
CV(%)	3.17	32.28	9.13	3.77
$LSD_{(0.05)}$	4.768	2.048	4.454	0.022
Significance level	NS	***	NS	**

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at P 0.05 according to LSD test. NS=Non-significant; * = Significant at 5% level; ** = Significant at 1% level; *** = Highly significant. N_1: 160 t ha^{-1} (recommended), N_2: 140 t ha^{-1}, N_3: 120 t ha^{-1}; K_1: 132 t ha^{-1} (recommended), K_2: 152 t ha^{-1}, K_3: 172 t ha^{-1}; V_1: BARI Alu-25 (Asterix) and V_2: BARI Alu-29 (Courage).

In the present study, the lightness (L*), green-red chromaticity (a*), and blue-yellow chromaticity (b*) of potato chips were analyzed among different levels of N and K concerning cultivars (Table 3). The highest L* value (84.98 and 84.56) was obtained by N_2 and K_1, the highest a* value (5.31 and 4.62) was taken by N_3 and K_2, the highest b* value (33.94 and 34.57) was found in N_2 and K_1. Significant variation was found for Asterix (82.88 and 4.28) and Courage (84.36 and 3.94) for lightness (L*) and blue-yellow chromaticity (b*). Significant variation was obtained among different interactions of N and K levels concerning cultivar for blue-yellow chromaticity (b*). The highest L* value (87.72 and 88.48) was found in N_2K_2 and N_2K_3 and the lowest (76.62 and 81.76) was taken by N_3K_2 and N_1K_2; the highest a* value (12.13 and 6.92) was obtained by N_3K_2 and N_2K_1 and the lowest (1.69 and 0.61) was taken by N_2K_2 and N_2K_3; highest b* value (34.30 and 39.04) was found in N_3K_1 and N_2K_1 and the lowest (28.93 and 31.65) was in N_2K_2 and N_3K_3 for Asterix and Courage. The Maillard process, which depends on the amount of reducing sugars and proteins or amino acids at the surface as well as the frying temperature and duration, is primarily responsible for the color of potato chips (Pedreschi *et al.* 2011).

The term "crispness" is most usually used to describe the texture of potato chips and is the key characteristic used to judge the item's quality (Kwak *et al*. 2019). This study was carried out to forecast the perceived sharpness of potato chips as measured by instrumental methods. The crispness of potato chips due to different levels of N was highly significant (Table 3). The lowest result (0.173 N) was observed from N_2 and the highest result was obtained from N_1 (0.205) which was statistically similar to N_3 (0.204 N). However, the effect of K level and cultivar on the crispness of potato chips was not found statistically significant. Significant variation was obtained among different interactions of N and K level concerning cultivar for the crispness of potato chips. The highest results (0.206 N and 0.206 N) were found in N_1K_2 and the lowest (0.150 N and 0.170 N) was in N_2K_2 for Asterix and Courage cultivars. Crispness as well as the textural properties significantly changed as the moisture content of the potato chips increased. Result indicates that structural changes in texture occurred because of the moisture in the chips. The lower the crispness of the potato chips, the higher the overall acceptability of the product will be achieved (Kwak *et al*. 2019).

This study revealed that Asterix and Courage cultivars of potato sown with the N_2K_2 treatment combination showed the highest total yield, table potato yield, and chips potato percentage. The highest specific gravity, dry matter, firmness, and lowest TSS were also found in Asterix and Courage for the treatment combination N_2K_2. Moreover, the potato chips color from the two cultivars remained in a range and showed the lowest crispness for N_2K_2. However, further research may be needed for potato production to achieve better quality for potato processing and export purpose.

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