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Research Article

Effects of Nitrogen and Potassium Fertilizers on Potato Growth and Quality under Multimodal Sensor Data Fusion

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As one of the staple foods recognized by everyone, the quality of the potato determines the popularity of the potato. In order to grow healthy potatoes and improve the quality of potatoes, this research is based on multimodal sensor data fusion technology to achieve data detection and unified management. And it can analyze the data to find out the relationship between the application of nitrogen and potassium fertilizers and potato growth and quality, so as to have a reasonable plan for potato cultivation. This paper firstly described the research results of multimodal sensors, data fusion, nitrogen and potassium fertilizers, and potato quality, and then briefly introduced the multi-sensor data fusion technology, mainly including application areas, methods, and structures. Finally, the effects of nitrogen and potassium fertilizers on the growth and quality of potato were explained through the analysis of experimental data. And the experimental results showed that under different potassium treatments, Dongnong 311 had the highest starch content under K3 treatment, which was 13.9%. This study provides a certain reference for the application of nitrogen and potassium fertilizers in potato cultivation.

1. Introduction

In recent years, due to the rapid population increase and the reduction of arable land, the demand for food is increasing day by day. How to increase food production is crucial. However, in cultivation conditions, the amount of fertilizer and planting density greatly affects the yield and quality of potato. At present, there are many reports on potato cultivation, but due to the diversity of varieties and cultivation patterns, the complexity of soil types and natural conditions, the growth and development of potato, and the requirements of the environment are not static. For specific varieties under specific ecological conditions, the specific cultivation measures still need to be carefully studied. This research happens to fill the gap in this area and plays an immeasurable role in potato-related research. At the same time, it also provides a reference scheme for potato cultivation.

The innovation of this paper is to make full use of multisensor data fusion technology to realize the detection of potato growth and quality, and to integrate the detection data together, which saves a lot of manpower and material resources. In addition, this study conducted an experimental comparative analysis on the actual potato quality, which fully demonstrated the validity of this study. In addition, this research adopts D-S evidence theory algorithm to realize data fusion, which greatly improves the efficiency of data fusion.

2. Related Work

Many scholars have provided a lot of references for research on multimodal sensors, data fusion, nitrogen and potassium fertilizers, and potato quality.

Zhao et al. [1] conducted a meta-analysis that combined 84 long-term trials and 385 pairwise comparisons to augment the response of soil carbon stocks to the addition of synthetic fertilizers [1].

Zhou et al. [2] assessed maize yield, net yield, and stress interactions using a mixture of controlled-release urea and soluble urea in the North China Plain. The results showed that balanced fertilization based on mixtures of controlled-release urea and soluble urea could improve maize yield and net yield [2].

Nazir et al. [3] evaluated the concomitant use of plant-promoting rhizobia (QS1) and various combinations of urea-N and slurry-N to improve the development, yield, and nutritional quality of field-grown okra [3].

Aziz et al. [4] studied the effect of ZnO nanoparticles (ZNPs: 1.4, 2.8, and 3.6 mg kg (−1) soil) and zeolites (141, 282, and 423 mg kg (−1) soil) and biogas slurry (AS) on soil nutrient availability and nitrogen (N) and zinc (Zn) uptake by herbaceous plant effects in standard pot experiments [4].

Aljuraiban et al. [5] examined potato consumption by quantity, processing type, overall dietary pattern, and dietary nutritional mass in relation to blood pressure and body mass index [5].

Teng et al. [6] have made great progress in developing nutrient-efficient crops by molecular engineering of root characteristics required for efficient nutrient acquisition from soil, transporters for uptake, redistribution and balance of nutrients, and enzymes for efficient assimilation [6].

Zhou et al. [7] discussed the influence of urease inhibitor [N-(n-butyl) phosphorothioate triamide, NBPT], nitro inhibitor [2-chloro-6-(trichloromethyl) pyridine, CP], and their combined application on the leaching characteristics of potassium in loess soils. He investigated clay soils applied with urea (U) and urea ammonium nitrate (UAN) in indoor soil column simulations. Zhou et al. [7] aimed to improve soil potassium uptake by judicious application of biochemical inhibitors [7].

Nascimento et al. [8] evaluated the effect of addition of livestock manure to watermelon (cv. Crimson Sweet) production in potassium-containing and potassium-free soils in Paraíba, Brazil [8].

Shoaib and Awan [9] investigated the role of plant nutrients, namely, nitrogen, phosphorus, potassium (NPK), zinc (Zn), magnesium (Mg), and boron (B), in the control of tomato early blight. Pathogen infection camouflages cellular machinery and disrupts the regulation of key enzymes (SOD, CAT, POX, PPO, and PAL) that impair plant immunity, so plants exhibit 100% morbidity [9].

Frana et al. [10] reported the role of cellulose and cellulose nanofibrils (CNFs) as materials to encapsulate nutrients for agriculture. Frana D reported the use of cellulose and cellulose nanofibers to encapsulate nitrogen- and potassium-based nutrients [10].

Mahdi Najafi-Ghiri et al. [11] selected 16 representative soils for orange cultivation (Citrus sinensis (L.) Osbeck) in the arid and semiarid regions of southern Iran to calculate the soil potassium fixation capacity [11].

Van Dingenen et al. [12] used five cultivars: wild Andigena and commercial cultivars Desiree, Milva, Saturna, and Alegria, to study the effect of reduced nitrogen supply on potato (Solanum tuberosum) tuber yield and quality characteristics [12].

Giri et al. [13] used a 3-stage Box–Behnken design with a response surface methodology to optimize the vacuum frying process of the sweet potato slices with orange flesh. He used a deep fryer to prepare sweet potato slices with orange flesh and investigated the effect of different processing conditions on nutritional and sensory quality [13].

Jia et al. [14] evaluated and compared the effect on changes in the quality of frozen and thawed heated surimi gels of native sweet potato starch (NS) and slow countercurrent native sweet potato starch (NSL) at low pasting temperatures. Starch-fish surimi subgels were flash frozen or slow frozen and stored at 20°C for 4 weeks. The results showed that the ice crystal size and spatial size of NS-raw fish fillet gels were larger than those of NSL-raw fish fillet gels after thawing, and the structural damage of NSL-raw fish fillet gels was less after thawing [14].

The data of these studies are not comprehensive, and the results of the studies are still open to question, so they cannot be recognized by the public and thus cannot be popularized and applied.

3. Multimodal Sensor Data Fusion

Data fusion is usually defined as the process of analyzing, processing, and synthesizing the observation data of multiple sensors obtained in time series or the processed data under certain criteria to complete the required estimation and decision-making. Applications of multi-sensor fusion technology are as follows(Figure 1).

Military applications: Data fusion technology has been widely used in the military. For example, military tactical and strategic detection, command, control, communication, and intelligence tasks all involve data fusion technology. This technology is also widely used in target tracking, remote sensing, automatic threat identification system, battlefield surveillance, etc. Data fusion technology has played a key role in modern warfare [15, 16].

Application in robotics: The application in industrial robots is mainly reflected in the recognition and reasoning of three-dimensional objects through the information of multi-sensor groups, the automatic operation of robots, and the avoidance of obstacles. A single sensor does not make the robot have a good perception and self-control ability to the outside world. In order to ensure that the robot can obtain more complete information about the dynamic changes of the external environment, the redundant and complementary characteristics of multiple sensors can be used to obtain a more consistent evaluation of the external environment, so that the robot can respond in real time [17].

Although the prior data are relatively easy to obtain, which fusion algorithm combined with prior knowledge can more effectively improve the performance of the system is also an issue that needs to be studied. In order to meet the requirements of large data volume and complex operations in multi-sensor fusion systems, it is also necessary to develop software and hardware systems that can process data in parallel.

The data fusion process is shown in Figure 2.

Data layer fusion is mainly aimed at homogenized sensors. This fusion method can directly merge the original sensor data without preprocessing, then extract the feature vector from the merged information, and discriminate the target according to the feature vector. Since heterogeneous

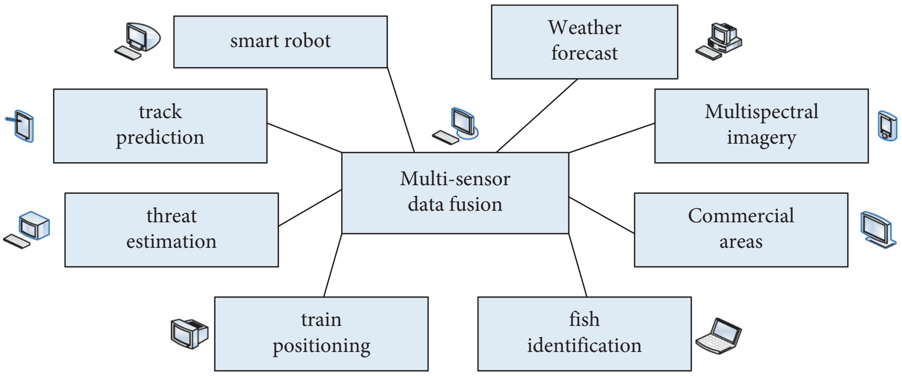


Figure 1: Application areas of data fusion.

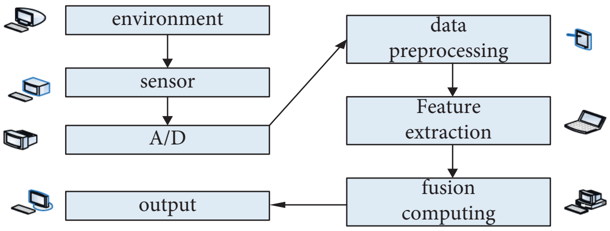


Figure 2: Schematic diagram of the data fusion process.

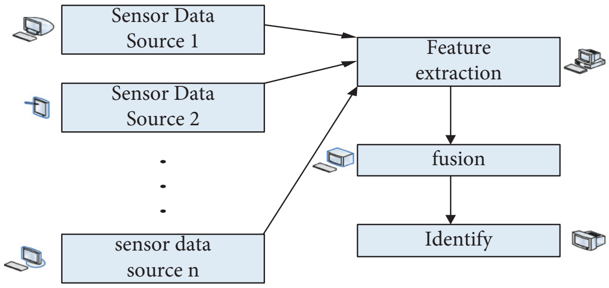


Figure 3: Data layer fusion.

sensor data are inconsistent, data from heterogeneous sensors can only be merged into one feature layer or decision layer. The data fusion process is shown in Figure 3.

The data fusion process is shown in Figure 4.

Feature layer fusion refers to an intermediate fusion layer, which firstly extracts the vector or scalar feature information representing the feature value from the sensor data source and then performs complex analysis and processing on the feature information. In general, the extracted feature information must be a sufficient representation or sufficient statistics of the measurement information. Then, it classifies, combines, and synthesizes the data collected from multiple sensors, and combines the reliability or probability representing each feature according to certain aggregation rules. It obtains a quantitative representation of the reliability or probability of an event, and finally makes a decision based on the pooled results. The data fusion realized at the feature level is mainly used in the field of target recognition. The data fusion process is shown in Figure 5.

Fusion methods are the basis for a system to fuse data from multiple sensors. Fusion methods are the most effective ways to improve a system's ability to process information and identify objects. Due to the complexity and diversity of multi-sensor data, fusion methods must be able to process information in parallel with reliability and high computational speed and accuracy, as shown in Figure 6.

On sample space Ω, the basic probability distribution function is a function δ of universe $2^{\Omega} \longrightarrow [0,1]$, which satisfies

$$\delta(\varnothing) = 0 \text{ and } \sum_{\Lambda \subseteq \Omega} \delta(\Lambda) = 1. \tag{1}$$

When $\delta(\Lambda) > 0$, Λ is called the focal element.

For all $\Lambda \subseteq \Omega$, $\mathrm{M} \subseteq \Lambda$, the belief function of the proposition is

$$\varepsilon(\Lambda) = \sum_{\mathrm{M} \subseteq \Lambda} \delta(\mathrm{M}). \tag{2}$$

Likelihood function:

$$\varphi(\Lambda) = \sum_{\mathrm{M} \cap \Lambda \neq \varnothing} \delta(\mathrm{M}). \tag{3}$$

D-S evidence theory:

$$\delta_1 \oplus \delta_2(\Lambda) = \frac{1}{\Gamma} \sum_{\mathrm{M} \cap \mathrm{N} = \Lambda} \delta_1(\mathrm{M}) \cdot \delta_2(\mathrm{N}), \tag{4}$$

where δ_1 and δ_2 are the body of evidence, and Γ is the normalization constant.

$$\Gamma = \sum_{\mathrm{M} \cap \mathrm{N} \neq \varnothing} \delta_1(\mathrm{M}) \cdot \delta_2(\mathrm{N}) = 1 - \sum_{\mathrm{M} \cap \mathrm{N} = \varnothing} \delta_1(\mathrm{M}) \cdot \delta_2(\mathrm{N}). \tag{5}$$

The role of Γ is to avoid assigning a nonzero probability to the empty set when synthesizing.

The conflicting evidence values for the two sets of data are

$$1 - \Gamma = \sum_{\mathrm{M} \cap \mathrm{N} = \varnothing} \delta_1(\mathrm{M}) \cdot \delta_2(\mathrm{N}). \tag{6}$$

So,

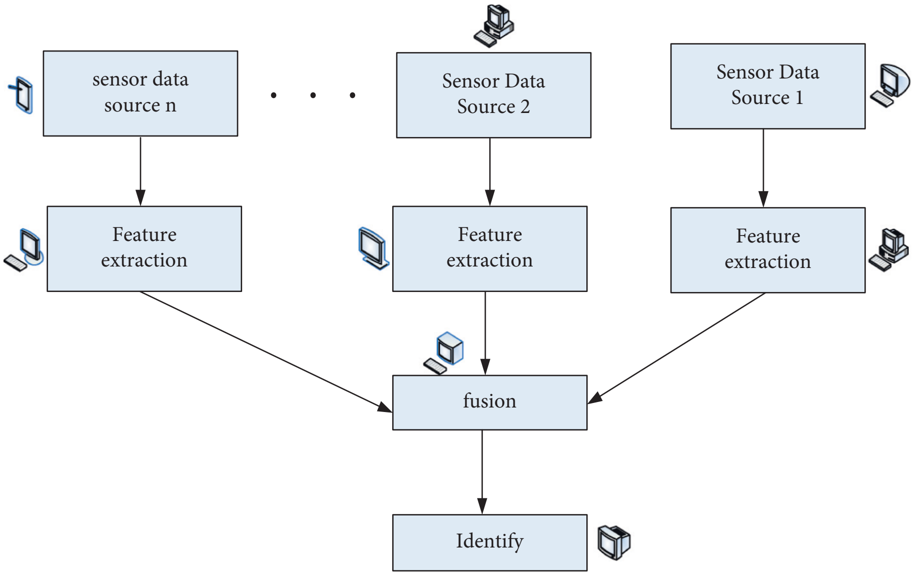


Figure 4: Feature layer fusion.

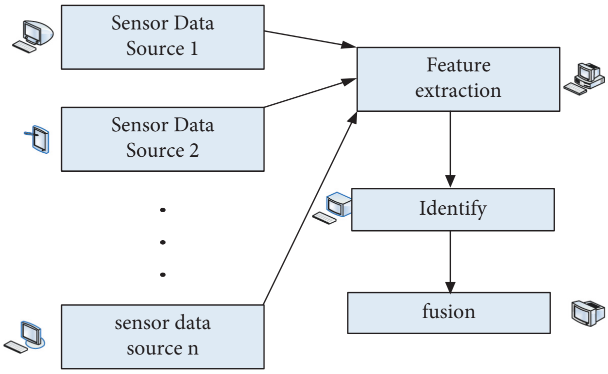


Figure 5: Decision layer fusion.

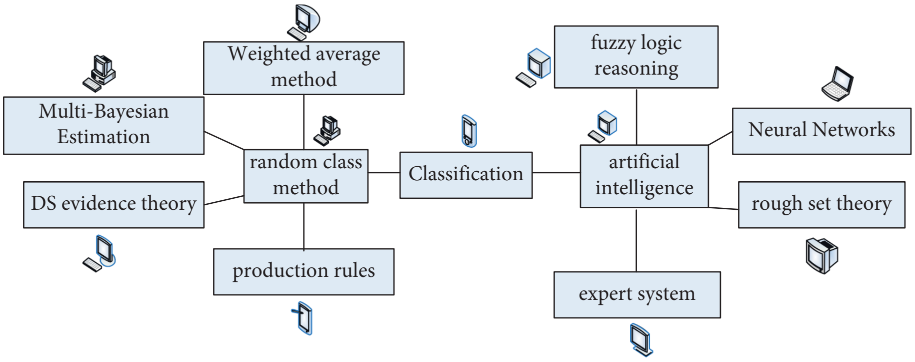


Figure 6: Classification of multi-sensor data fusion methods.

$$\begin{aligned}\left(\delta_1\oplus\delta_2\oplus\ldots\oplus\delta_\phi\right)(\Lambda) &= \frac{1}{\Gamma}\sum_{\Lambda_1\cap\Lambda_2\cap\ldots\cap\Lambda_\phi=\Lambda}\delta_1(\Lambda_1)\cdot\delta_2(\Lambda_2)\ldots\delta_\phi\left(\Lambda_\phi\right),\\ \Gamma &= \sum_{\Lambda_1\cap\Lambda_2\cap\cdots\cap\Lambda_\phi\neq\varnothing}\delta_1(\Lambda_1)\cdot\delta_2(\Lambda_2)\ldots\delta_\phi\left(\Lambda_\phi\right) = 1-\sum_{\Lambda_1\cap\Lambda_2\cap\ldots\cap\Lambda_\phi=\varnothing}\delta_1(\Lambda_1)\cdot\delta_2(\Lambda_2)\cdots\delta_\phi\left(\Lambda_\phi\right).\end{aligned} \tag{7}$$

For any set γ, let $\forall\Lambda_1,\Lambda_2\subset\gamma$, and we have

$$\begin{aligned}\delta(\Lambda_1) &= \max\left\{\delta\left(\Lambda_\mu\right),\Lambda_\mu\subset\gamma\right\},\\ \delta(\Lambda_2) &= \max\left\{\delta\left(\Lambda_\mu\right),\Lambda_\mu\subset\gamma\text{ and }\Lambda_\mu\neq\Lambda_1\right\}.\end{aligned} \tag{8}$$

If the following formula is satisfied,

$$\begin{aligned}\delta(\Lambda_1)-\delta(\Lambda_2) &> \eta_1,\\ \delta(\gamma) &< \eta_2,\\ \delta(\Lambda_1) &> \delta(\gamma).\end{aligned} \tag{9}$$

That is, Λ_1 is the judgment result of the event, and η_1 and η_2 represent the set threshold value.

Membership function:

$$\begin{gathered}\chi_\mu^\nu\left(\kappa_{\mu\phi}\right) = \exp\left(-\frac{\left(\kappa_{\mu\phi}-\lambda_{\mu\nu}\right)^2}{2\varpi_{\mu\nu}^2}\right),\\ \mu = 1,2,\ldots,\phi,\mu = 1,2,\ldots,\delta_\mu.\end{gathered} \tag{10}$$

Observe the fuzzy membership of the potato sample:

$$\chi_\mu^\nu\left(\bar{\kappa_\mu}\right) = \sum_{\mu=1}^{8}\theta_\mu * \chi_\mu^\nu\left(\kappa_{\mu\phi}\right), \tag{11}$$

where θ_μ is the weight of the ϕ th feature parameter.

$$\delta_\mu = \frac{\chi_\mu^\nu\left(\bar{\kappa_\mu}\right)}{\sum_{\nu=1}^{\delta_\mu}\chi_\mu^\nu\left(\bar{\kappa_\mu}\right)},\quad \mu = 1,2,\ldots,\phi,\nu = 1,2,\ldots,\delta_\mu. \tag{12}$$

The fusion of the two sets of data results in

$$\begin{aligned}\delta_{12}(\sigma) &= \frac{\delta_1(\sigma)\cdot\delta_2(\sigma)}{1-\Gamma_{12}},\\ \delta_{12}(\varsigma) &= \frac{\delta_1(\varsigma)\cdot\delta_2(\varsigma)}{1-\Gamma_{12}},\\ \delta_{12}(\tau) &= \frac{\delta_1(\tau)\cdot\delta_2(\tau)}{1-\Gamma_{12}},\\ \delta_{12}(\rho) &= \frac{\delta_1(\rho)\cdot\delta_2(\rho)}{1-\Gamma_{12}}.\end{aligned} \tag{13}$$

$\rho,\sigma,\varsigma,\tau$ is the quality category of the potato.

4. Effects of Nitrogen and Potassium Fertilizers on Potato Growth and Quality

Heilongjiang Province is one of the main provinces and cities for potato planting in China, and its potato planting history has a history of nearly a hundred years. Heilongjiang Province is the first province and city in the country to successfully research and promote the production technology of virus-free seed potatoes. The successful promotion of this research has greatly improved the yield per unit area and cultivation area of potatoes. The cultivation area of potato increased from 143,000 hm^2 in the early days of the People's Republic of China to 240,000 hm^2 in 2010, and the yield per unit area increased from 8 $\mathrm{t/hm}^2$ to 25.7 $\mathrm{t/hm}^2$. Heilongjiang Province is located in the alpine region of China, with a cool climate, fertile soil in most areas, abundant rainfall during the growth period, long sunshine hours, large temperature difference between day and night, and few transmission vectors of potato viruses. It has the natural advantage of planting potatoes. In 2010, the potato output in Heilongjiang Province reached 6.16 million tons, and the output per unit area and total output of potato increased by 78% and 36%, respectively, compared with 2005.

Potato is a crop with high yield and fertilizer-loving characteristics, and it is extremely sensitive to fertilizer. Throughout the entire growth and development process of potatoes, the amount of output has a great relationship with the soil and fertilizer conditions. Insufficient soil fertility will directly lead to lower yields. And fertilizing more than the standard amount or missing the best time will also result in lower yields.

On fertile soil, the proportion of plant absorbing nutrients is approximately equal to the plant's demand for nutrients. It can also be considered that the proportion of nutrient absorption can be used to calculate the proportion of fertilization. It is very important to explore the dry matter accumulation and nutrient characteristics of potatoes for guiding rational fertilization and increasing potato yield. In the process of potato growth and development, it is restricted by many factors, among which the influence of nutrients is the most important. The supply of nutrients and the absorption and utilization of nutrients by plants have obvious effects on tuber formation, expansion, and starch accumulation, and reasonable fertilization is beneficial to the improvement of potato yield and quality.

Potassium is involved in various metabolic processes in potato plants. In the potato seedling stage, if the supply of potassium fertilizer is sufficient, the stems of the plants will be strong, the leaves will be thicker, and the disease resistance will be strong. Potassium can increase the yield of potato. The content of potassium fertilizer is related to the potato commodity rate, and the commodity rate decreases with the decrease of potassium application rate. If the potassium supply is insufficient, it will not only cause short plants, slender stems, short internodes, underdeveloped root systems, small leaves, easy premature aging, poor photosynthetic efficiency, and low commercial potato rate, and most of the tubers are long or spindle-shaped, with low yield, poor quality, and poor disease resistance, and will also cause poor tuber quality indicators and increased hollowness. And it will also cause the tuber quality index to deteriorate and the hollow rate to increase. The composition of potato tuber yield is about 8% moisture and about 20% dry matter.

Materials to be tested: 2 materials have to be tested, including the mid-late-maturing fresh food species Dongnong 311 and the middle-early-ripening fresh food species Dongnong 312. Seed potatoes are cut into 40 g–50 g pieces for planting.

This experiment adopts a two-factor three-level orthogonal experimental design, and the two factors are N (nitrogen) and K (potassium). Three levels are set for each variety, $N1 = 5\,kg/667\,m^2$, $N2 = 10\,kg/667\,m^2$, $N3 = 15\,kg/667\,m^2$; and $K1 = 7.5\,kg/667\,m^2$, $K2 = 12.5\,kg/667\,m^2$, $K3 = 17.5\,kg/667\,m^2$, as shown in Table 1.

Table 1: Test treatment.

Process	Nitrogen rate	Potassium application amount	Column 4
1	N1	K1	1
2	N1	K2	2
3	N1	K3	3
4	N2	K1	3
5	N2	K2	1
6	N2	K3	2
7	N3	K1	2
8	N3	K2	3
9	N3	K3	1

The plant growth vigor of Dongnong 311 and Dongnong 312 was investigated during the flowering period of potato. Plant growth vigor is represented by three indicators: plant height, stem diameter, and leaf area index. Analysis of variance was performed on the data under nitrogen and potassium fertilizer treatments, as shown in Figure 7.

It can be seen from Figure 7 that under nitrogen treatment and potassium treatment, the plant height, stem diameter, and leaf area index of the tested varieties were not significantly different.

Under the nitrogen and potassium fertilizer treatments, multiple comparisons were made on the leaf area index of the tested varieties, as shown in Table 2.

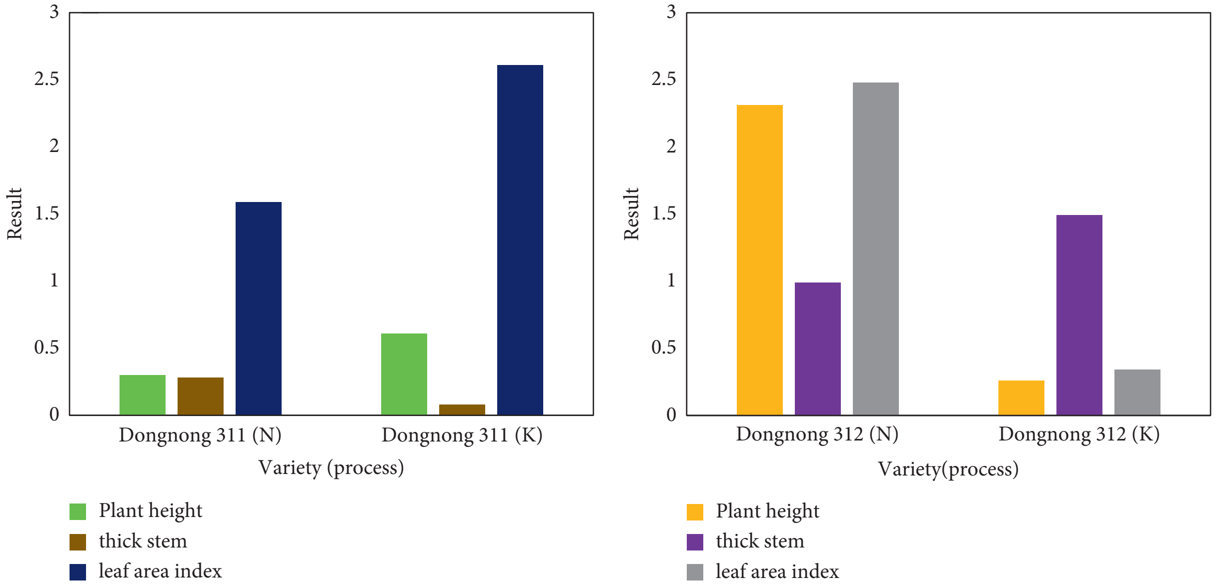
It can be seen from Table 2 that under the N2K2 and N3K1 treatments, the leaf area index of Dongnong 311 is higher, and the difference between it and other treatments is extremely significant. Under the treatments of N1K3, N3K1, and N2K2, the leaf area index of Dongnong 312 was higher, and the difference was extremely significant with other treatments.

Analysis of variance was performed on the data of the five indicators under the nitrogen and potassium fertilizer treatments, as shown in Figure 8.

The SPAD value in Figure 8(a) shows the relative chlorophyll content in the plant, and nitrogen is one of the components of chlorophyll, so nitrogen has a great influence on the SPAD value. Figure 8(b) shows that the difference in transpiration rate and intercellular carbon dioxide concentration was not obvious when treated with potassium, while stomatal conductance reached a significant level in Dongnong 311 but not in Dongnong 312.

The morphological indicators of the two tested varieties under each potassium fertilizer treatment were subjected to multiple comparison analysis: under potassium sulfate treatment, Dongnong 312 and Dongnong 311 had different degrees of increase in plant height, number of main stems, and stem diameter, and all showed that the K3 treatment had the best effect or the increase was not obvious after K3 treatment. At this time, the potassium dosage was $187.5\,kg/hm^2$. Potassium sulfate treatment of Dongnong 312 plant height, the number of main stems, and the increase of stem diameter ranged from 2.56% to 5.87%, 7.39% to 27.39%, and 11.11% to 23.93%, respectively; the increased range of Dongnong 311 was 4.35% ~ 14.28%, 4.58% ~ 32.68%, and 9.30% ~ 23.26%, respectively. The morphological indexes of Dongnong 312 and 311 increased gradually with the increase of potassium chloride application rate, but the increase rate was not as high as that of potassium sulfate treatment, indicating that potassium sulfate fertilizer had a stronger effect on improving plant morphological indexes. Dongnong 312 plant height, number of main stems, and stem diameter increased by 2.20%–3.43%, 7.39%–18.70%, and 11.97%–20.51%, respectively; the plant height, main stem number, and stem diameter of Dongnong 311 increased by 4.48%–10.12%, 13.07%–22.22%, and 15.50%–20.93%, respectively. It can be seen from the various increases that the morphological indicators of the fresh food variety Dongnong 311 are more affected by potassium fertilizer than that of the starch-processing variety Dongnong 312, and the plant height and stem diameter of Dongnong 311 are larger than those of Dongnong 312. But the difference in plant height was not significant. The number of main stems of Dongnong 312 was more than that of Dongnong 311. In the two varieties, the morphological indexes of K2 treatment were not significantly different from those of K3 treatment and were higher than other treatments, indicating that the potassium fertilizer application rate of $187.5\,kg/hm^2$ had the best effect on improving plant morphological indexes. Potassium fertilizer is applied as base fertilizer at one time and 1/2 as base fertilizer when sowing, and the other 1/2 can be top-dressed during the full blooming period.

The SPAD values of Dongnong 312 and Dongnong 311 were subjected to multiple comparison analysis, respectively. The SPAD values of Dongnong 312 and Dongnong 311 plants increased with the increase of potassium sulfate dosage and reached the maximum value in K1 treatment. But it was not significantly different from K3 treatment, indicating that the SPAD value of the tested varieties could reach a higher level at the K3 treatment level, that is, when the potassium sulfate dosage was $187.5\,kg/hm^2$. The effect of potassium chloride on the SPAD value of the tested varieties was similar to that of potassium sulfate, and the K2 treatment reached the maximum value. But it is not significantly different from K3; that is, when the potassium chloride dosage is $150\,kg/hm^2$, the SPAD value of the tested varieties



(a)

(b)

Figure 7: Measurement results.

Table 2: Leaf area index under N-K fertilizer treatments.

Process	Dongnong 311	Dongnong 312
N1K1	3.7	2.7
N1K2	5.2	3.6
N1K3	5.5	4.2
N2K1	4.3	3.3
N2K2	6.4	4.8
N2K3	3.6	2.9
N3K1	5.8	4.7
N3K2	3.4	2.8
N3K3	4.6	3.4

can reach a higher level. When the dosage is lower than 150 kg/hm^2, the SPAD value of the potassium chloride treatment is higher, and the SPAD value of the two potassium fertilizers is not significantly different when the dosage is higher than this. The SPAD value of K1 treatment was not significantly different from that of K3 treatment, indicating that topdressing potassium fertilizer during tuber formation had no significant effect on promoting the accumulation of chlorophyll content in leaves. In terms of varieties, the fresh food variety Dongnong 311 has larger SPAD.

The test results of the tested varieties under nitrogen treatment are shown in Table 3.

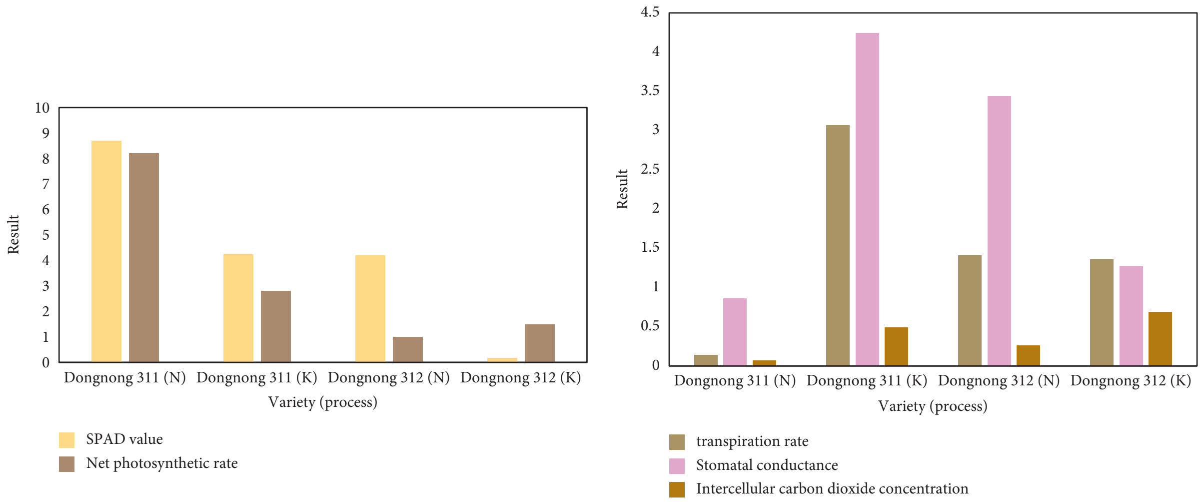
The detection results of Dongnong 311 under potassium treatment are shown in Table 4.

Under the nitrogen and potassium fertilizer treatment, the detection results of the tested varieties are shown in Figure 9.

It can be seen from Figure 9 that the SPND value of Dongnong 311 was significantly lower under N1K3 treatment than other treatments. The SPND value of Dongnong 312 reached a significant level under N1K1, N2K2, N2K3, N3K1, N3K2, and N3K3 treatments. The stomatal conductance of Dongnong 311 was significantly lower under N2K1 treatment than other treatments.

The photosynthetic indexes of leaves under each treatment of Dongnong 312 and Dongnong 311 were analyzed by multiple comparison, and the photosynthetic indexes were significantly different from the control after adding potassium sulfate and potassium chloride. In the K3 treatment, the four photosynthetic indicators of the two varieties gradually grew with increasing application rate when the potassium sulfate application rate was lower than 187.5 kg/hm^2, after which the indicator values decreased or increased insignificantly with increasing application rate. Except for stomatal conductance of Dongnong 312 under potassium chloride treatment, other photosynthetic indexes were not significantly different at application rates of 150 kg/hm^2 and 187.5 kg/hm^2, indicating that the enhancement of plant photosynthesis no longer continues to increase when the amount of potassium chloride is high. It may be because with the increase of potassium chloride application, the inhibitory effect of Cl on plant growth and development is gradually reflected, which limits the increase of various indicators, so potassium sulfate K3 treatment is more suitable for increasing the intensity of photosynthesis. In the two cultivars, the photosynthetic indexes of K1 treatment and K3 treatment were not significantly different, indicating that the effect of topdressing potassium fertilizer on the photosynthetic intensity of plants was not obvious in the full bloom period. In terms of varieties, the photosynthesis intensity of Dongnong 311 is greater than that of Dongnong 312.

With the increase of potassium sulfate dosage, the yield of Dongnong 312 increased first and then decreased. The yield reached its peak in the K3 treatment; that is, when the potassium sulfate dosage (the fertilization amount below is



(a)

(b)

Figure 8: Measurement results.

Table 3: SPAD value and net photosynthetic rate under nitrogen treatment.

Process	SPAD value (Dongnong 311)	SPAD value (Dongnong 312)	Net photosynthetic rate (umol/m^2/s) (Dongnong 311)
N1	40.26	34.43	12.68
N2	44.20	36.84	17.35
N3	43.66	37.36	15.16

Table 4: SPAD value and stomatal conductance of Dongnong 311 under potassium treatment.

Process	SPAD value	Process	Stomatal conductance (umol/m^2/s)
K1	44.32	K1	3.41
K2	46.58	K2	4.83
K3	42.83	K3	3.42

expressed as the effective dosage) was 187.5 kg/hm^2, the yield of Dongnong 312 was the best, which was 37155 kg/hm^2. Compared with the control, the yield increased by 4213 kg per hectare, with an increase rate of 12.8%. The yield decreased but not significantly under the K1 treatment. With the increase of potassium sulfate application, the yield of Dongnong 311 increased, reaching the maximum value of 39494 kg/hm^2 at K1, an increase of 5811 kg per hectare compared with the control, and the yield increase rate was 17.3%. That is to say, when the potassium sulfate dosage is 225 kg/hm^2, the yield of Dongnong 311 is the best, but there is no significant difference in yield between K1 and K3. By analyzing the experimental data of potassium chloride on the output of Dongnong 312 and Dongnong 311, it can be concluded that the yields of Dongnong 312 and Dongnong 311 both showed a trend of increasing first and then decreasing with the increase of potassium chloride dosage. The K2 treatment showed the highest yield when the potassium chloride dosage was 150 kg/hm^2, which were 36772 kg/hm^2 and 39308 kghm^2, respectively.

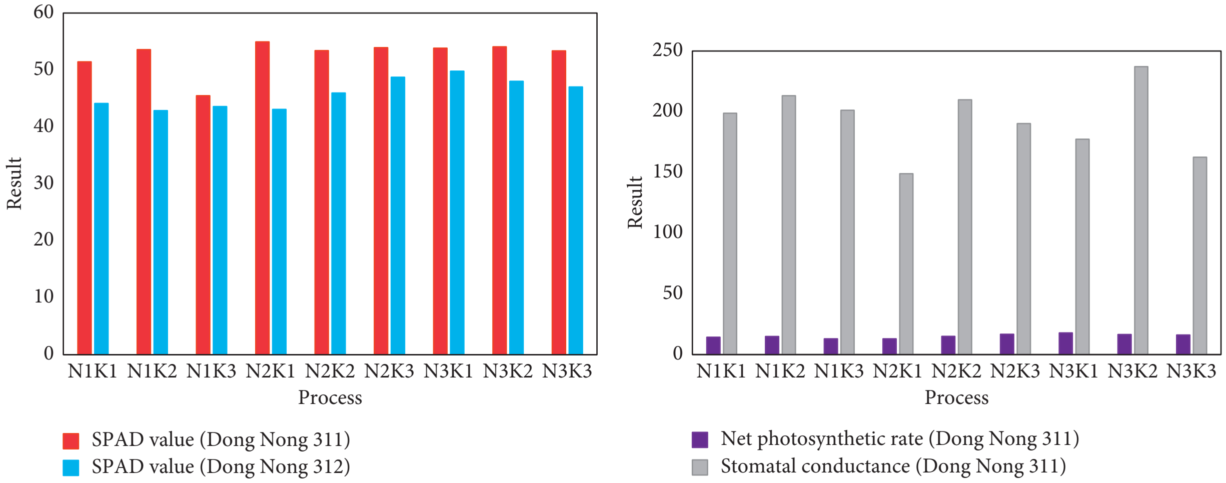
The multiple comparison analysis of the experimental results of potassium sulfate treatment and potassium chloride treatment shows that the yield of potassium chloride treatment is higher than that of potassium sulfate treatment at low potassium fertilizer dosage. The yield of potassium sulfate treatment was higher than that of potassium chloride treatment at high potassium fertilizer dosage, and the highest yield of potassium sulfate treatment was higher than that of potassium chloride treatment.

The yield of the two cultivars Dongnong 311 and K2 treatment was significantly higher than that of K3 treatment. This shows that applying 1/2 potassium fertilizer during the tuber formation period can effectively supplement the source of potassium for the growth and yield formation of fresh potato tubers after the tuber formation period, but had little effect on the yield of starch-processing varieties.

Comprehensive analysis: the application of potassium sulfate is better than potassium chloride in improving yield. K2 treatment can not only effectively improve the yield of fresh food varieties, but also avoid waste caused by excessive fertilization, which is suitable for fresh food varieties. K3 treatment is suitable for starch-processing varieties. In terms of varieties, Dongnong 311 is more productive than Dongnong 312 in this area.

After harvesting, an indoor test was conducted to measure the quality indicators under nitrogen and potassium fertilizer treatments, including the following 4 indicators: starch content, vitamin C content, protein content, and reducing sugar content, and the quality index data of Dongnong 311 and Dongnong 312 were subjected to variance analysis, as shown in Table 5.

It can be seen from Table 5 that under nitrogen treatment, the starch content, protein content, and reducing sugar content of the tested varieties all reached extremely significant differences. Under potassium treatment, except that the protein content of Dongnong 312 reached a



(a) (b)

Figure 9: SPAD value, net photosynthetic rate, and stomatal conductance under nitrogen and potassium fertilizer treatments.

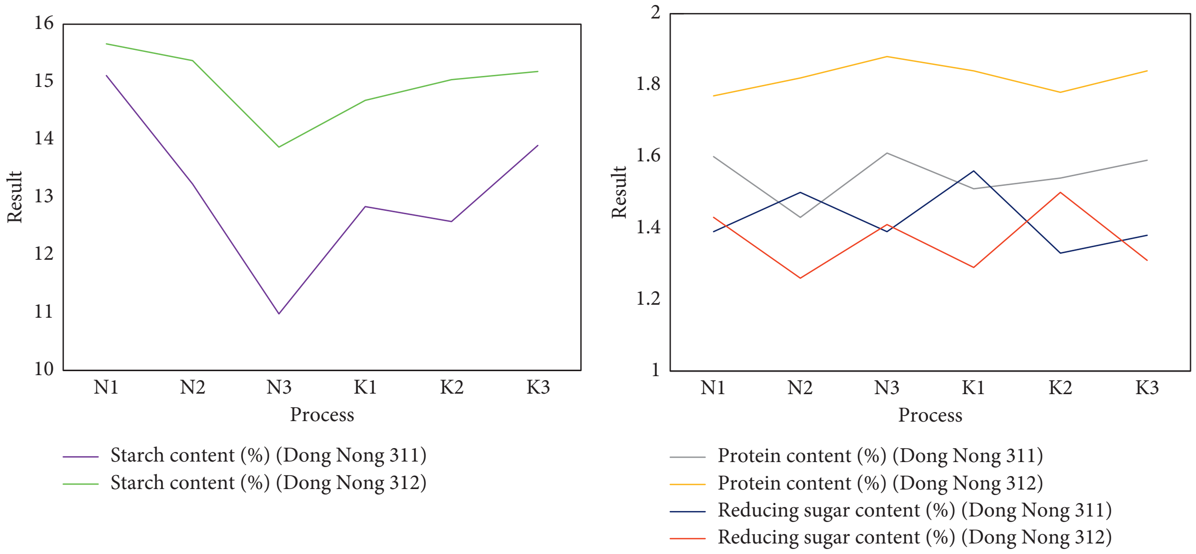
significant level and the starch content was not significantly different, the starch content, protein content, and reducing sugar of the tested varieties all reached extremely significant levels.

The content of mineral elements in tubers of three fresh food varieties treated with potassium sulfate was subjected to multiple comparison analysis. The potassium content in the tubers of Dongnong 311 showed a trend of first increasing and then decreasing with the application of potassium fertilizer, and the potassium content in the tubers reached the peak at the K2 level. Compared with no potassium fertilizer application, it increased by 25.77%, and the potassium content in tubers at K2 level decreased slightly, but not significantly. The iron content in tubers also changed significantly with the increase of potassium application, and the change was in the range of 1.24–1.61 mg/100gFW. It was extremely significantly increased at the K1 level and reached a peak value, and it was slightly decreased at the K1 to K3 levels, but not significant. With the increase of potassium fertilizer application, the range of zinc content in tubers was 0.12–0.16 mg/100 gFW, and the zinc content reached the highest at the K2 level, which was 24.86% higher than the control. The potassium content in the tubers of Dongnong 312 showed a continuous increase trend with the increase of potassium fertilizer application, and the potassium content in the tubers reached the peak at the K2 level. Compared with the control, it significantly increased by 38.61%, but the potassium content in the tuber at the K1 level was only 0.73% higher than that of the K2 level, and the difference was not significant. The iron content in tubers increased significantly with the increase of potassium fertilizer application. When the fertilization amount reached the K3 level, the iron content in the tubers tended to be stable and no longer increased. The iron content in the tubers at the K3 level was 23.39% higher than that of the control. The trend of zinc content in tubers was to increase with the increase of potassium fertilizer application, and the variation range was between 0.14 and 0.21 mg/100 gFW. The zinc content in tubers at K1 and K2 levels was significantly higher than other fertilizer levels. The potassium content in the tubers of Dongnong 311 showed a continuous increasing trend with the increase of potassium fertilizer application rate and reached the peak at the K2 level, which was significantly higher than that of the control by 20.59%. The iron content in tubers increased gradually with the application of potassium fertilizer and reached the peak at the K2 and K3 levels, with a significant increase of 26.16%, while the iron content in the K1, K2, and K3 levels did not increase significantly. The variation range of zinc content in tubers was 0.14–0.20 mg/100 gFW, the change trend was consistent with that of iron content, and both peaked at K2 level. Multiple comparisons of starch content, vitamin C content, protein content, and reducing sugar content of potatoes under nitrogen and potassium fertilizer treatments are shown in Figure 10.

Figure 10 shows that under different nitrogen treatments, the starch content of the tested varieties all reached a very significant level, and the trend was the same, showing that the starch content decreased with the increase of nitrogen application rate. The protein content of the tested varieties all reached a very significant level, and the protein content of the tested varieties reached the maximum under N3 treatment. The reducing sugar content of the tested varieties all reached a very significant level of difference. The reducing sugar content of Dongnong 311 reached the maximum under N2 treatment, and the reducing sugar content of Dongnong 312 reached the maximum under N1 treatment. Under different potassium treatments, Dongnong 311 had the highest starch content under K3 treatment. The protein content of Dongnong 311 reached the maximum under the K3 treatment, and the protein content of Dongnong 312 reached the maximum under the K1 treatment. The reducing sugar content of Dongnong 311 reached the maximum under K2 treatment, and the reducing sugar

Table 5: Analysis of variance for the effect of nitrogen and potassium fertilizers on potato quality indicators.

Variety	Process	Starch content	Vitamin C content	Protein content	Reducing sugar content
Dongnong 311	N	113.36	0.49	198.06	71.34
	K	13.25	0.58	29.12	238.24
Dongnong 312	N	8.94	0.21	5.13	187.23
	K	3.14	4.02	4.33	232.51



(a)

(b)

Figure 10: Quality indicators under nitrogen and potassium fertilizer treatments.

content of Dongnong 312 reached the maximum under K2 treatment.

In Dongnong 312, both the commercial potato rate and average single potato weight increased with the increase of potassium fertilizer dosage under potassium sulfate treatment and potassium chloride treatment, and reached the maximum value in K2 and K3 treatments, respectively. Continuing to increase the amount of potassium fertilizer subsequently, both the commercial potato rate and the average single potato weight decreased. In Dongnong 311, the commercial potato percentage and average single tuber weight increased gradually with the increase of potassium sulfate application rate, but the increase was not significant after K3 treatment. There was no significant difference in the commercial potato rate and average single potato weight of Xiangling 312 in the treatment of K1 with low potassium chloride dosage. Continuing to increase the potassium chloride dosage, the commercial potato rate and average single potato weight decreased significantly. The commercial tuber rate and average single tuber weight of K2 treatment were higher than all treatments in both varieties. It can be seen from the analysis results of the components of yield that appropriate application of potassium sulfate fertilizer can improve the value of the components of potato yield. However, the trend of increasing over-application slowed down and even led to a decrease in the value of yield components, which directly affected the final yield. Under the K2 fertilizer dosage (187.5 kg/hm^2), the topdressing of 1/2 potassium sulfate fertilizer in the tuber formation stage had the best effect on improving the components of potato yield. In terms of varieties, the commercial potato rate of Dongnong 312 was higher than that of Dongnong 311, and the difference in average potato weight and number of tubers per plant was not significant.

5. Discussion

The centralized fusion processing has high precision and easy algorithm modification. The disadvantage is that it has high requirements on the processor, low reliability, and a large amount of data to be processed, which is difficult to implement. Distributed fusion processing requires low communication bandwidth, fast computing speed, and good reliability, but the tracking accuracy is not as high as that of centralized ones. The hybrid fusion process strikes a balance among various constraints that affect each other, such as speed, bandwidth, tracking accuracy, and reliability, according to specific actual needs. Sometimes in order to improve the tracking ability of local nodes, the local nodes of distributed, hybrid, and multi-level systems also often receive feedback information from fusion nodes.

With the increase of nitrogen and potassium application, the yield of Dongnong 312 also increased. With the increase of potassium application rate, the yield of Dongnong 311 and the commercial potato rate of Dongnong 312 both increased first and then decreased. The plant height, stem diameter, and leaf area index of Dongnong 311 and Dongnong 312 did not reach a significant level of difference under the nitrogen and potassium treatments set in the experiment. Photosynthetic characteristics respond differently under the action of different factors. The SPAD values of Dongnong 311 and Dongnong 312 were significantly different under nitrogen treatment in this experiment, showing a trend of first increase and then decrease, and the SPAD value of the tested varieties reached the peak value under N2 treatment; the net photosynthetic rate of Dongnong 311 showed a trend of increasing first and then decreasing, and the net photosynthetic rate of Dongnong 311 reached the peak under N2 treatment.

6. Conclusions

Nitrogen had a very significant effect on the starch content of Dongnong 311 and Dongnong 312, it showed a downward trend with the increase of nitrogen application, and the starch content was the highest under N1 treatment. The protein content of Dongnong 311 and Dongnong 312 showed a trend of first increasing and then decreasing with the increase of nitrogen, and the protein content reached the peak under N2 treatment. With the increase of potassium application rate, the starch content of Dongnong 311 and Dongnong 312 showed an upward trend, and the starch content was the highest under the K3 treatment. The protein content and reducing sugar content increased first and then decreased, and the protein content and reducing sugar content reached the peak under K2 treatment. The disadvantage of this study is that the effect of nitrogen and potassium fertilizers on potato yield was not studied, and this aspect can be considered in the next research direction.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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