Influence of different levels of sulphur and potassium and their interactions on different quality and storage parameters of Potato

Abstract

Quality and storage attributes are major concern for potato cultivators as well as processors. Therefore an investigation was carried out to study influence of different levels of sulphur and potassium on different quality and storage parameters of potato. The experiment was laid out in Randomized Complete Block Design with three replications of two factors with four levels of each factor. The two factors were S (sulphur) and K (potassium) with four levels as, S_0 (control or no sulphur), S_1 (20 kg S ha^{-1}), S_2 (40 kg S ha^{-1}) and S_3 (60 kg S ha^{-1}) where as potassium levels were, K_0 (control or no potassium), K_1 (100 kg K ha^{-1}), K_2 (125 kg K ha^{-1}) and K_3 (150 kg K ha^{-1}). Maximum value (1.48 g cc^{-1}) for specific gravity, Soluble solid content (6.31 ^{0}Brix), vitamin C (16.58 mg 100 g^{-1}), crude protein content(1.93%) and Dry matter content (23.09%) in tubers were recorded with S_3 (60 kg $ha^{-1)}$, besides significantly lower values of physiological weight loss (17.50%), sprouting (16.93%) and rotting (15.04%) were also recorded with S_3 (60 kg ha^{-1}) level followed by S_2 (40 kg S ha^{-1}). Significantly maximum values of quality traits like specific gravity (1.79 g cc^{-1}), Soluble solid content (6.92 ^{0}Brix), vitamin C (21.62 mg 100 g^{-1}), crude protein content (2.35%), Dry matter content (25.49%) in tubers were recorded with K_3 (150 kg K $ha^{-1)}$, further significantly lower values of physiological weight loss (13.89%), sprouting (11.47 %) and rotting loss (9.92%) were recorded with S_3 (150 kg K ha^{-1}). Conjugation of 150 kg K ha^{-1} K+ 60 kg S ha^{-1} recorded maximum values of quality traits specific gravity (1.80), soluble solid content (7.63 ^{0}Brix), vitamin C (22.10 mg 100 g^{-1}), crude protein content (2.49%) and dry matter content (25.92%), however S content of 0.367% was recorded with K_3S_3(150 kg K + 60 kg S ha^{-1}), besides significantly lower values of physiological weight loss (13.47%), sprouting (10.44%) and rotting loss (5.43%) followed by S_3K_3 treatment.

Key words: Potato, sulphur, potassium, tubers, quality and physiological weight loss.

INTRODUCTION

Potato is a major world food crop ranging fourth only after rice, wheat and maize (Hussain, 2015). Potato crop produces more edible energy and protein per unit time and area compared to many other crops, fits well into multiple cropping systems prevalent in tropical and subtropical agro-climatic conditions, provides profitability and employment generation and is thus expanding rapidly in developing countries. Potato is a starchy tuberous crop from the perennial night shade family. The cultivated potato (*Solanum tuberosum* L.) is an autotetraploid with chromosome No. 2n=48. Potato has been recognized as wholesome food and having an energy value of 321 kilo joules, carbohydrates 17.47 g, starch 15.44 g, dietary fiber 2.2 g, protein 2 g, water 75 g per 100 g of potato besides other vitamins and nutrients (Drewnowski and Colin, 2013). Quality parameters of potatoes are major concern of potato growers in order to fetch more price. There are various methods to increase the quality of potato tubers one of the best way is the application of nutrients. There are several macro and micro nutrients which are essential for enhancing quality of a plant. Among primary nutrients potassium has a crucial role in the energy status of the plant, translocation and storage of assimilates and maintenance of tissue water relations (Singh and Lal, 2012). Potassium is not an incorporated component of plant molecules, in opposite to N and P which are constituents of proteins, nucleic acids, phospholipids, ATP etc. High mobility in the plant explains the major functional characteristics of K, as the main cation involved in the neutralization of charges and as the most important inorganic osmotic active substance (Singh *et al.*, 2010). Potassium is involved in many aspects of the plant physiology. It activates more than 60 enzyme systems, aids in photosynthesis, favours high energy status, maintains cell turgidity, promotes water uptake, regulates nutrient translocation in plant, favours carbohydrate transport and storage, enhances N uptake as well as protein synthesis and promotes starch synthesis. Potassium application has been reported to increase aerial stem number, plant height, leaf number as well as tuber yield (Zelelew *et al.*, 2016). Besides primary nutrients other nutrients are also important for quality production of vegetable crops. Among them Sulphur is an important macronutrient after NPK, required by plants. As it plays an essential role in chlorophyll synthesis which in turn is essential for the production of starch, sugars, fats, vitamins and other vital compounds through photosynthesis. It is also the basic constituent of the amino acids such as cysteine, cystine and methionine which are building blocks for essential proteins in plants. It acts as activity promoter for various enzymes and vitamins and influences various developmental processes. Many enzymes which are essential for biochemical reactions within the plant cell are activated by sulphur. Continuous removal of S from soils through plant uptake has led to widespread S deficiency and affects soil S budget (Aulakh, 2003) all over the world. Sulphur applications have been found to improve storage life and quality of vegetable crops (Mudasir *et al.,* 2017). It has been observed when sulphur is present in critical amount in soil (less than 10 ppm), the plant growth, quality and total production of crop is adversely effected (Jones *et al.,* 1972). Sulphur application in vegetable crops have been found to improve quality attributes, protein content, oils and vitamins. Keeping in view of the above facts the present investigation entitled "Influence of different levels of sulphur and potassium on different quality and storage parameters of Potato" was carried out.

MATERIALS AND METHODS

A field experiment entitled "Influence of different levels of sulphur and potassium on different quality and storage parameters of Potato" was conducted at experimental fields of Division of Vegetable Science, SKUAST–K, Shalimar during *Kharief* 2018-2019. **The planting material of potato variety, Shalimar potato-1, chemical fertilizers and FYM were used as an experimental material.** Shalimar Potato-1 was planted at a Spacing of 60 cm×20 cm and total no of treatments were 16 in 03 Replications. Experiment was laid in RCBD. 02 factors was used each with four levels The two factors were S (sulphur) and K (potassium) with four levels as, S_0 (control or no sulphur), S_1 (20 kg S ha^{-1}), S_2 (40 kg S ha^{-1}) and S_3 (60 kg S ha^{-1}) where as potassium levels were, K_0 (control or no potassium), K_1 (100 kg K ha^{-1}), K_2 (125 kg K ha^{-1}) and K_3 (150 kg K ha^{-1}). Recommended FYM (25 t ha^{-1}), N (160 kg ha^{-1}) and P (100 kg ha^{-1}) was applied as a uniform dose as per package of practices for all treatments. Moreover, sulphur and potassium were also applied to soil as per the treatments at the time of planting. Urea (46% N), Di-ammonium phosphate (18% N, 46% P_2O_5), Muriate of potash (60% K_2O) and Gypsum (12% S) were applied as sources of nitrogen, phosphorus, potassium and sulphur, respectively. **Different quality and storage parameters were recorded are mentioned below**

Specific gravity (g cc^{-1}) : Representative samples of harvested tubers from each net plot were weighed. The volume of tubers was determined by water displacement method and specific gravity was determined by using formula as under

$$\text{Specific gravity(g/cc)} = \frac{\text{Weight of tubers}}{\text{Volume of tubers}} \times 100$$

SSC (^{o}Brix): Three medium size potatoes from harvested lot of each treatment were washed, pealed, cut into pieces and crushed. Their juice was extracted by juicer with the help of a fine muslin cloth. A drop of this juice was placed on the hand refractometer and TSS was obtained and expressed in ^{o}Brix.

Vitamin C content (mg 100^{-1} g) :The freshly harvested tubers preferably of uniform size from representative plants were taken and cut into small pieces. Hundred gram of chopped tubers from each plot/treatment were then used for estimation of Vitamin C content in the laboratory following 2,6,dichlorophenol indophenol visual titration method (A.O.A.C. 1975) and expressed in milligrams 100 g^{-1} of tubers.

Crude protein content(%):The protein content was calculated by multiplying a factor 6.25 (protein factor) with total nitrogen content in tubers. Total nitrogen content in tubers was determined by Kjeldahls method as outlined by Tandon (1993) and expressed in (%).

Dry matter content (%): Dry matter content was determined by drying a known weight 100g of the sample in an oven at 60 ^{o}C. After complete drying final weight of the sample was taken and expressed as per cent dry matter content.

$$\text{Dry matter content (\%)} = \frac{\text{Fresh weight of sample}}{\text{Dry weight of sample}} \times 100$$

Storage quality over a period of four months (total weight loss%): Tubers were cured for a period of 10 days under shade. After curing, 3 kg of tubers from each treatment were kept in perforated plastic trays at ambient room conditions for 120 days (4 months). The physiological weight loss, sprouting per cent and rotting per cent during storage were recorded after each month in each treatment and total weight loss was then calculated after 4 months of storage of tubers by respective formulas given as:

$$PWL\ (\%) = \frac{\text{Initial weight} - \text{final weight}}{\text{Initial weight}} \times 100$$

$$Sprouting\ (\%) = \frac{\text{No. of sprouted tubers}}{\text{Total No. of tubers}} \times 100$$

$$Rotting\ (\%) = \frac{\text{No. of rotted tubers}}{\text{Total No. of tubers}} \times 100$$

Statistical analysis: In order to test the significance of results, the experimental data was subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984). Levels of significance used for 'F' and 'T' tests were p= 0.05 as given by Fisher (1970).

Result and discussion

Effect of sulphur on quality parameters

Application of sulphur exhibited a significant influence on specific gravity of tubers. Maximum value (1.48 g cc^{-1}) was recorded with S_3 (60 kg S ha^{-1}) followed by S_2 (1.47 g cc^{-1}). Significantly lower value was recorded with S_0 (1.36 g cc^{-1}). Significantly higher SSC of 6.31 ^{o}Brix was recorded with S_3(60 kg S ha^{-1}) followed by S_2 (6.29 ^{o}Brix), S_1(5.68 ^{o}Brix) and control S_0(5.07 ^{o}Brix). Sulphur application @ 60 kg ha^{-1} recorded significantly higher value (16.58 mg 100 g^{-1}) of vitamin C content as compared to lower levels of sulphur and control. Maximum value of crude protein content (1.93%) was recorded with sulphur @ 60 kg ha^{-1} which was statistically at par with S_2(1.92%) but was significantly superior to S_1(1.90%) and S_0(1.77%). Dry matter content was significantly effected by sulphur application, maximum value (23.09%) was recorded with S_3 (60 kg S ha^{-1}) followed by S_2(22.79%) and S_1(21.92%). Application of sulphur resulted higher N(0.29%), P(0.45%) and K(0.52%) in tubers but impact of increasing levels of sulphur exhibited at par results among themselves, however S_3(60 kg S ha^{-1}) recorded a sulphur content of 0.34% which was significantly superior to other levels of sulphur. The improvement in above mentioned quality parameters can be attributed to the fact that sulphur is an integral part of sulphur containing amino-acids (Cysteine, cystine and methionine) which are sources of proteins. The increase in SSC might have been possible due to increased synthesis of photosynthates including sugars whose production increases with increase in levels of sulphur.The increase in vitamin C might be due to increased synthesis and translocation of photosynthates from leaves to tubers. The results corroborate well with the observations of Sriramachandrasekharan (2009) in okra, Kumar and Sing (2009) in black gram, Sharma *et al.* (2011) in potato, Hassan *et al.* (2012) in brinjal, Singh *et al.* (2016) in potato, Mudasir *et al.* (2017) in garlic and Muthana *et al.* (2017) in potato.

Table 1. Effect of different levels of sulphur on quality parameters

Sulphur	Specific gravity (g cc^{-1})	Soluble Solid Content (^{o}Brix)	Vitamin C (mg 100^{-1} g)	Crude Protein Content (%)	Dry matter Content (%)
S_0	**1.36**	**5.07**	**14.27**	**1.77**	**20.65**
S_1	**1.42**	**5.68**	**14.97**	**1.90**	**21.92**
S_2	**1.47**	**6.29**	**15.52**	**1.92**	**22.79**
S_3	**1.48**	**6.31**	**16.58**	**1.93**	**23.09**
C.D($p \leq 0.05$) S :	0.05	0.02	0.33	0.01	0.40

Effect of potassium on quality parameters

Specific gravity in tubers increased significantly with increase in the levels of potassium and higher specific gravity of 1.79 g cc^{-1} was recorded with K_3 (150 kg K ha^{-1}) which was significantly superior to the values 1.63 g cc^{-1}, 1.24 g cc^{-1} recorded with K_2 and K_1 and control (1.08 gcc^{-1}). Potassium applications exhibited significant influence in increasing soluble solid content in potato tubers. Maximum soluble solid content of 6.92 ^{o}Brix was recorded with K_3 (150 kg K ha^{-1}) which was significantly superior to other levels of potassium. Potassium was effective in increasing the vitamin C content in potato tubers and maximum value of 21.62 mg 100 g^{-1} was recorded with K_3 (150 kg K ha^{-1}) which was significantly superior to lower levels of potassium. Highest crude protein content of 2.35% was recorded with K_3(150 kg K ha^{-1}) and was significantly superior to crude protein content of 1.73%, 1.92% and 1.54% recorded with K_2(125 kg K ha^{-1}), K_1(100 kg K ha^{-1}) and control(K_0S_0) respectively. Increasing levels of potassium exhibited an increase in dry matter content in potato tubers with K_3(150 kg K ha^{-1}) recording 25.49% of dry matter content which was significantly higher than the values recorded with lower levels of potassium. Significant increase in N,P,K and S content in potato tubers was observed with application of potassium, with K_3(150 kg K ha^{-1}) recording N(0.35%), P(0.56%), K(0.79%) and S(0.353%) which was significantly higher than the values recorded with other levels of potassium. Higher specific gravity might be due to the availability of necessary nutrient inputs including potassium at the initial stages of growth as the plants did not face any stress during the crop growth. Potassium is also found to be effective for the enhancement of enzymatic activities, which in turns, helps in the synthesis of carbohydrates and amino acids, which in turn produce the quality tubers. The increase in N, P, K and S content of potato tubers due to application of different rates of potassium could be due to the increased uptake by the plant and increased availability of the nutrients, better root growth and increased physiological activity of roots to absorb nutrients. The results are in correspondence with the results of Das and Behara (1989) in sweat potato, Sing *et al*(1996) in potato, Hariyappa (2003) in onion, Al-Moshileh *et al.* (2005) in potato, Bryan *et al.* (2008) in potato, Prabhavati *et al*(2008) in chilli, Ahmed *et al.* (2010) in faba-bean, Abd El-Latifa *et al.*(2011) in potato, Yohana and Carlos (2011),Verma and Singh (2012) in onion, Mudasir *et al.* (2017)in garlic, Mohan *et al*(2017) in potato.

Table 2: Effect of different levels of potassium on quality parameters

Potassium	**Specific gravity (g cc^{-1})**	**Soluble Solid Content (^{o}Brix)**	**Vitamin C (mg 100^{-1} g)**	**Crude Protein Content (%)**	**Dry matter Content (%)**
S_0	**1.08**	**3.95**	**11.26**	**1.54**	**18.15**
S_1	**1.24**	**6.03**	**12.52**	**1.73**	**20.98**
S_2	**1.63**	**6.44**	**15.95**	**1.92**	**23.83**
S_3	**1.79**	**6.92**	**21.62**	**2.35**	**25.49**
C.D($p \leq 0.05$)	0.05	0.02	0.33	0.01	0.40

K :					

Interaction effect of Sulphur and potassium on quality parameters

Interaction among sulphur and potassium exhibited a significant influence on quality parameters of potato. Treatment combination K_3S_2(150 kg K+40 kg S ha^{-1}) recorded higher values for specific gravity (1.80), soluble solid content (7.63 ^{o}Brix), vitamin C (22.10 mg 100 g^{-1}), crude protein content (2.49%), dry matter content (25.92%) and N (0.38%), P (0.58%) and K (0.81%) content in tubers, which were significantly higher than the values recorded with other treatment combinations but exhibited at par results with K_3S_3(150 kg K+60 kg S ha^{-1}). Sulphur content in tubers was recorded maximum (0.387%) with treatment combination K_3S_3 (150 kg K+60 kg S ha^{-1}) which was significantly higher than the values recorded with other treatment combinations but exhibited at par results with K_3S_3(150 kg K+60 kg S ha^{-1}). This might be possible due to synergistic relationship between sulphur and potassium applications thereby increased uptake/translocation of N, P, K, S and other nutrients by crop and better translocation of photosynthates from source to sink occurred which improved quality traits of potato. Similar research work was done by, Moinuddin and Shahid (2007) in potato, Zengin *et al.* (2009) in sugar beets, Ahmed *et al.* (2010) in faba bean, El-Nemr *et al.* (2012) in tomato and Mudasir *et al.* (2017) in garlic.

Table 3: Interaction effect of different levels of potassium and Sulphur on quality parameters of potato

Treatment combination	**Specific gravity (g cc^{-1})**	**Soluble Solid Content (^{o}Brix)**	**Vitamin C (mg 100^{-1} g)**	**Crude Protein Content (%)**	**Dry matter Content (%)**
K_0S_0	1.06	3.14	10.87	1.50	16.21
K_0S_1	1.07	3.85	11.23	1.54	18.09
K_0S_2	1.08	4.33	11.33	1.55	19.05
K_0S_3	1.10	4.49	11.60	1.57	19.25

K_1S_0	1.16	5.40	11.87	1.69	19.43
K_1S_1	1.24	5.75	12.27	1.73	20.64
K_1S_2	1.27	6.38	12.13	1.74	21.58
K_1S_3	1.30	6.59	13.80	1.75	22.27
K_2S_0	1.44	5.72	13.67	1.87	22.07
K_2S_1	1.60	6.39	14.77	1.93	23.58
K_2S_2	1.74	6.79	16.50	1.93	24.61
K_2S_3	1.74	6.86	18.87	1.94	25.05
K_3S_0	1.77	6.00	20.70	2.03	24.90
K_3S_1	1.78	6.72	21.63	2.42	25.36
K_3S_2	1.80	7.63	22.10	2.49	25.92
K_3S_3	1.79	7.32	22.07	2.47	25.80
C.D($p \leq 0.05$) S × K :	0.10	0.50	0.66	0.02	0.80

Effect of Sulphur on storage parameters

Sulphur application @ 60 kg Sha^{-1} (S_3) recorded significantly lowest values for physiological weight loss (17.50%), sprouting (16.93%) and rotting (15.04%) after 4 months of storage as compared to lower levels of sulphur, while S_0 (control treatment) recorded significantly maximum value of physiological weight loss (20.69%), sprouting (18.63%) and rotting (20.72%) of potato tubers. Lowest cumulative loss of 16.49% was observed with S_3 (60 kg S ha^{-1}) which was 21.34% lower than the value recorded with control. This might be due to strong negative correlation between sulphur uptake and total weight loss. Lower sulphur applications reduces firmness of the skin of potato tubers which had adverse effects on storability. Due to sulphur applications reduction of microbial infection occurs in addition to imparting firmness to potato tubers. Similar results have been also observed by Nandi *et al.* (2002) in onion, Ullah *et al.* (2008) in onion, Tripathy *et al.* (2013) in onion, Mudasir *et al.* (2017) in garlic. The results are depicted in Table 4.

Effect of potassium on storage parameters

Application of potassium @ 150 kg ha^{-1} registered significantly lowest physiological weight loss (13.89%), sprouting (11.47%) and rotting loss (9.92%) after 4 months of storage as compared to lower levels of potassium. However, K_0 (control treatment) recorded significantly maximum value of physiological weight loss (26.09%), sprouting (23.12%) and rotting (23.93%) of potato tubers. Lowest cumulative loss of 11.76% was observed with K_3 (150 kg K ha^{-1}) which was 10.73% lower than the value recorded with control. This might be possible due to lower moisture loss from tubers due to thickening of cell wall and reduced rotting and sprouting of tubers. The favourable effect of potassium on storability of potato tubers might be possible from negative correlation between potassium uptake and total weight loss. Similar observations were also recorded by Nandi *et al.* (2002) in onion, Bryan *et al.* (2008) in potato, Singh and Lal (2012) in potato and Mudasir *et al.* (2017) in garlic. The results are depicted in Table 4.

Interaction effect of sulphur and potassium on storage of potato

Treatment combination K_3S_2 (150 kg K+40 kg S ha^{-1}) recorded significantly lower value for physiological weight loss (13.47%), sprouting (10.44%) and rotting (5.43%) but exhibited at par results with K_3S_3 treatment recording (13.49%) of physiological weight loss after 4 months of storage. Lowest cumulative loss of 9.78% was recorded with K_3S_2 (150 kg K+40 kg S ha^{-1}) which was 17.73% lower than the control (K_0S_0) The improvement in storage quality could be possible by synergistic relationship between sulphur and potassium which resulted in improvement of storage qualities of potato tubers because of increased uptake of nutrients like N, P, K and S which increased dry matter content of potato tubers. Similar findings have also been observed by Poornima (2007) in onion, Moinuddin and Shahid (2007) in potato and Mudasir *et al.* (2017) in garlic. Significant influence of sulphur application in enhancing specific gravity of potato tubers. A gradual increase was observed with increasing levels of sulphur recording a maximum of 1.48 g cc^{-1} with S_3 (60 kg S ha^{-1}) which was significantly superior to the values recorded with other levels of sulphur. The results are depicted in Table 4.

Table 4:Effect of different levels of sulphur, potassium and their combinations on shelf life of tubers

Sulphur Levels	PWL (%)	Sprouting (%)	Rotting (%)	Cumulative Loss (%)
S_0	20.69 (4.55)	18.63 (4.32)	20.72 (4.55)	20.01 (4.47)
S_1	19.34 (4.40)	17.20 (4.15)	16.89 (4.11)	17.93 (4.23)
S_2	18.27 (4.27)	16.94 (4.12)	15.56 (3.94)	16.93 (4.11)
S_3	17.50 (4.18)	16.93 (4.11)	15.04 (3.88)	16.49 (4.06)
C.D(p≤0.05)	**0.24**	**0.08**	**0.12**	**0.07**
Potassium Levels				
K_0	26.09 (5.11)	23.12 (4.81)	23.93 (4.89)	24.38 (4.94)
K_1	20.39 (4.52)	18.92 (4.35)	18.26 (4.27)	19.19 (4.38)
K_2	15.43 (3.93)	16.19 (4.02)	16.09 (4.01)	15.90 (3.99)
K_3	13.89 (3.73)	11.47 (3.89)	9.92 (3.15)	11.76 (3.43)
C.D(p≤0.05)	**0.24**	**0.08**	**0.12**	**0.07**
Interaction				
K_0S_0	28.90 (5.38)	24.11 (4.91)	28.35 (5.32)	27.12 (5.21)
K_0S_1	26.87 (5.18)	22.93 (4.79)	23.51 (4.85)	24.43 (4.94)
K_0S_2	25.25 (5.02)	22.81(4.78)	21.95 (4.68)	23.34 (4.83)
K_0S_3	23.36 (4.83)	22.64 (4.76)	21.91 (4.68)	22.64 (4.76)
K_1S_0	22.28 (4.72)	19.65 (4.43)	19.07 (4.37)	20.33 (4.51)
K_1S_1	21.00 (4.58)	18.92 (4.35)	17.95 (4.24)	19.29 (4.39)
K_1S_2	19.54 (4.42)	18.67 (4.32)	17.92 (4.23)	18.71(4.32)
K_1S_3	18.75 (4.33)	18.43 (4.29)	18.09 (4.25)	18.42 (4.29)
K_2S_0	17.30 (4.16)	17.10 (4.14)	18.09 (4.25)	17.50 (4.18)
K_2S_1	15.17 (3.90)	16.27 (4.03)	15.33 (3.92)	15.59 (3.95)
K_2S_2	14.87 (3.86)	15.83 (3.98)	14.85 (3.86)	15.18 (3.90)
K_2S_3	14.42 (3.80)	15.57 (3.94)	16.09 (4.01)	15.36 (3.92)
K_3S_0	14.28 (3.78)	13.64 (3.69)	17.36 (4.17)	15.09 (3.88)
K_3S_1	14.34 (3.79)	10.67 (3.27)	10.75 (3.28)	11.92 (3.45)

K_3S_2	13.47 (3.67)	10.44 (3.23)	5.43 (2.33)	9.78 (3.13)
K_3S_3	13.49 (3.67)	11.13 (3.34)	6.14 (2.48)	10.25 (3.20)
C.D($p \leq 0.05$)	**0.43**	**0.15**	**0.24**	**0.14**

Conclusion

It is concluded that conjugation of 150 kg K ha^{-1} K+ 60 kg S ha^{-1} recorded maximum values of quality traits specific gravity (1.80), soluble solid content (7.63 ^{0}Brix), vitamin C (22.10 mg 100 g^{-1}), crude protein content (2.49%) and dry matter content (25.92%), however S content of 0.367% was recorded with K_3S_3(150 kg K + 60 kg S ha^{-1}), besides significantly lower values of physiological weight loss (13.47%), sprouting (10.44%) and rotting loss (5.43%) followed by S_3K_3 treatment.

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