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Post-harvest quality of Potato Genotypes under different Types of Mulching Materials

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ABSTRACT: Mulching is an effective method of manipulating crop growth environment to increase yield and improve product quality by controlling weed growth, reducing soil temperature, conserving soil moisture, improving soil structure and enhancing organic matter content of the soil. The locally available paddy straw and coconut coir are selected as mulching materials for studying the post-harvest quality of different heat tolerant breeding lines of potato under coastal zone of Andhra Pradesh. The experiment was carried out during *rabi* season (November 2021-february 2020) in split-plot design with two replications using two locally available mulching materials (paddy straw and coconut coir) along with control (earthing up) as main plot treatments and eleven genotypes of potato (HT/21-1, HT/21-2, HT/21-3, HT/21-5, HT/21-7, HT/21-11, HT/21-15, HT/21-16, HT/21-17, HT/21-18 and HT/21-20) along with control Kufri Surya as sub-plot treatments. Among genotypes, HT/21-2, HT/21-5, HT/21-16, HT/21-17, HT/21-18 and Kufri Surya with shallow eye depth, round to oval shaped tubers, desirable skin and flesh colour were found to have superior external tuber quality traits for fresh and processing market. On the basis of desirable nutritional/compositional quality traits, the genotypes HT/21-2 (20.91%) and HT/21-17 (20.17%) with dry matter content >20% and HT/21-11 (0.13%), HT/21-5 (0.14%) and HT/21-17 (0.15%) having reducing sugars (%) which is within the limits of desirable variety were found to be highly suitable for processing into crisps. Based on the storage studies, HT/21-7 showed significantly longer shelf life of storage with lowest sprouting (1.35%) and rotting (2.13%) of tubers under room temperature. Among mulching materials, paddy straw mulch was found to be significantly superior for dry matter content (19.45%), sprouting (2.44%) and rotting per cent (4.41%) followed by coconut coir mulch when compared to control with earthing up.

Keywords: Potato, Genotypes, Mulching materials, Quality, Dry matter content.

INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae. It is native of Peru-Bolivia in the Andes, South America (Luthra *et al.*, 2006). Potato is one of the world's most important non-cereal and high yielding horticultural food crops. It is considered to be the fourth major food crop after rice, wheat and maize (Zhang *et al*., 2016). Production is oriented principally towards internal consumption, approximately 81% of the national production is commercialized fresh for household consumption and potato processing industries use the rest to make crisps and French fries.

In the case of tuber potatoes, quality can be defined as the sum of favourable characteristics of the tuber, which is a subjective and dynamic concept that depends on consumer's lifestyles and food habits (Richards *et al*., 1997) and the industrial process used. A complex set of external and internal quality traits are required for fresh and processed potatoes. External quality traits include tuber shape, eye depth, skin and flesh color (Jansky, 2009). These characters are especially important for fresh market potatoes, but they may also impact processing quality. Nutritional/compositional quality parameters includes dry matter content, reducing sugar, enzymatic discoloration and vitamin C content (Storey, 2007).

Tuber dormancy (resting period) of potato tubers is the physiological state after harvest, during which tubers do not sprout (Wiltshire and Cobb 1996) even when stored under conditions favorable for sprouting (Van den Berg *et al*., 1996). Premature sprouting and rotting are major causes of losses during post-harvest storage of potatoes, since it reduces the number of marketable tubers.

MATERIALS AND METHODS

An experiment was carried out to study the effect of mulching on post-harvest quality in different genotypes of potato at Centre of Excellence for Protected Cultivation, Horticultural Research Station, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh during *rabi*season (November 2021-February 2022). The experiment was laid out in split plot design with two replications using two locally available mulching materials (paddy straw and coconut coir) along with control (earthing up) as main plot treatments and eleven heat tolerant breeding lines of potato (HT/21-1, HT/21-2, HT/21-3, HT/21-5, HT/21-7, HT/21-11, HT/21-15, HT/21-16, HT/21-17, HT/21-18 and HT/21-20) along with control (Kufri Surya) as sub-plot treatments with plot size of 3m × 1m. The tubers were planted at a spacing of 60 × 20 cm. To supplement the nutritional requirement of the crop, recommended dose of fertilizers for plateau region *i.e.*,125:100:125 kg NPK ha^{-1} was applied. Foliar spray of water-soluble compound fertilizer such as 19-19-19 kg $N\text{-}P_2O_5\text{-}K_2O$ was given one month after sowing. Second spray was given at 45 days after sowing with the above fertilizer and third spray was given with water soluble fertilizer 13-0-45 kg $N\text{-}P_2O_5\text{-}K_2O$ for better tuber growth. Weeding was done manually at regular intervals. First irrigation was given immediately after planting of tubers to ensure better emergence. Subsequent irrigations were given depending upon moisture status of soil retained as per requirement of plants. Observations on external tuber quality traits (tuber shape, eye depth, skin colour and flesh colour) were recorded as per the minimal descriptors of potato (Huaman *et al.*, 1977). Nutritional/compositional quality traits like dry matter content (%) was estimated as per the procedure given by Luthra *et al*., 2013. Dry matter content was calculated using the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Final dry weight of sample}}{\text{Initial fresh weight of sample}} \times 100$$

Reducing, non-reducing and total sugars were estimated by Lane and Eynon (1923) method as described by Ranganna (1986). Vitamin C content was determined by following the procedures given by Ranganna (1986). Observations on sprouting and rotting of tubers were recorded.

RESULTS AND DISCUSSION

The analysis of variance revealed that main effects of potato genotypes were significant for dry matter, vitamin C content, reducing, non-reducing and total sugars (%), sprouting and rotting (%). Main effects of mulching materials were significant for dry matter content, sprouting and rotting (%). Interaction effects between genotypes and mulching materials were significant for dry matter content.

A. Post-harvest quality of potato genotypes

Tuber shape, eye depth, skin and flesh color are crucial aspects for consumers, as they are immediately obvious while making the purchase (Werij, 2011). These characters are especially important for fresh market potatoes, but they may also impact processing quality. Internal quality includes dry matter content, reducing sugar, enzymatic discoloration and nutritional quality such as vitamin C content (Storey, 2007). These characters are especially important for processing quality.

1. External tuber quality traits.

External quality traits like tuber shape, eye depth, skin and flesh colour of different genotypes were presented in Table 1.

Tuber shape. The shape of the tuber is one of the most eye-catching traits of the potato. To minimize waste during processing, varieties with long tubers are preferred for french fries and varieties with round tubers are preferred for chips. Five genotypes *viz*., HT/21-2, HT/21-7, HT/21-18, HT/21-20 and Kufri Surya produced oval shaped tubers, while HT/21-3, HT/21-5 and HT/21-11 produced oblong shaped tubers which are good for making french fries. HT/21-1, HT/21-15, HT/21-16 and HT/21-17 produced round shaped tuber which are suitable for making chips.

Table 1: External tuber quality traits of different genotypes of potato.

Sr. No.	Genotype	Tuber Shape	Depth of eyes	Tuber skin colour	Flesh colour
1.	HT/21-1	Round	Medium	Brown	Yellow
2.	HT/21-2	Oval	Shallow	Brown	Cream
3.	HT/21-3	Oblong	Medium	Brown	Yellow
4.	HT/21-5	Oblong	Shallow	Yellow	Yellow
5.	HT/21-7	Oval	Shallow	White -Cream	White
6.	HT/21-11	Oblong	Medium	Brown	Yellow cream
7.	HT/21-15	Round	Medium	White -Cream	White
8.	HT/21-16	Round	Shallow	Brown	Cream
9.	HT/21-17	Round	Shallow	Brown	Cream
10.	HT/21-18	Oval	Shallow	Yellow	Yellow cream
11.	HT/21-20	Oval	Medium	Brown	Yellow cream
12.	Kufri Surya	Oval	shallow	Brown	Yellow

Eye depth. Eye depth is an important quality trait because deep eyes affect the appearance of tubers and add to the cost of peeling in processing industries. So, shallow eyed potato tubers are preferred for processing. Seven potato genotypes *viz*., HT/21-2, HT/21-5, HT/21-7, HT/21-16, HT/21-17, HT/21-18 and Kufri Surya had shallow eyed tubers while remaining genotypes had medium eyed tubers.

Tuber skin colour. Skin colour is one of the most easily noticeable traits of potato tuber. Potato genotypes under study showed lot of variability in skin colour as it ranged from white-cream (HT/21-7 and HT/21-15) to brown (HT/21-1, HT/21-2, HT/21-3, HT/21-11, HT/21-16, HT/21-17, HT/21-20 and Kufri Surya). Most of the genotypes *viz*., HT/21-1, HT/21-2, HT/21-3, HT/21-11, HT/21-16, HT/21-17, HT/21-20 and Kufri Surya had brown skin colour tubers. HT/21-5 and HT/21-18 had yellow skin colour. HT/21-7 and HT/21-15 had white cream colour skin.

Tuber flesh colour. Tuber flesh colour in potato varied from yellow (HT/21-1, HT/21-3, HT/21-5 and Kufri Surya) to cream colour (HT/21-2, HT/21-16 and HT/21-17). The variation in tuber flesh colour is mainly due to two naturally occurring pigments, *i.e*., anthocyanins and carotenoids. The higher content of lutein, violaxanthin and total carotenoids are present in yellow-fleshed potatoes. HT/21-1, HT/21-3, HT/21-5 and Kufri Surya produced yellow-fleshed tubers. HT/21-2, HT/21-16 and HT/21-17 produced cream colour fleshed tubers. HT/21-11, HT/21-18 and HT/21-20 produced yellow cream colour fleshed potatoes.

2. Nutritional/compositional quality traits.

Dry matter content (%). For the processing industry dry matter content is a critical component, it is a measure of the internal quality of tubers. Main effects of genotypes, mulching materials (Table 2, 3) and their interaction effects (Table 4) were significant for dry matter content in potato. Dry matter content in potato genotypes varied significantly from 15.78% (HT/21-18) to 20.91% (HT/21-2). Dry matter content was highest in genotype HT/21-2 (20.91%), followed by HT/21-17 (20.17%) and HT/21-5 (19.38%).Dry matter content was highest in genotypes under paddy straw mulching (19.45%), followed by coconut coir mulching (18.47%) when compared to control without mulching (16.80%). Genotypes and mulching materials had significant interaction effect on dry matter content. Dry matter content was highest in genotype HT/21-2 under paddy straw mulching (22.58%) and lowest in HT/21-18 under no mulching (15.23%). Dry matter content in potato is affected by environmental factors during growth of the crop, such as solar radiation, soil temperatures, soil moisture, fertilizers and haulm killing (Haverkort, 2007).

Table 2: Quality parameters of potato in different genotypes of potato.

Genotypes	Dry matter content (%)	Vitamin C (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sprouting (%)	Rotting (%)
HT/21-1	17.53	15.39	0.62	0.27	0.88	4.60	7.10
HT/21-2	20.91	17.23	0.27	0.18	0.44	2.87	3.37
HT/21-3	18.77	22.79	0.23	0.16	0.39	1.35	6.08
HT/21-5	19.38	22.18	0.15	0.10	0.25	2.05	2.35
HT/21-7	19.23	18.24	0.20	0.13	0.33	1.67	2.13
HT/21-11	17.89	18.90	0.13	0.08	0.21	3.12	4.06
HT/21-15	18.51	16.78	0.30	0.18	0.48	2.95	6.57
HT/21-16	16.17	17.60	0.23	0.14	0.37	3.10	2.48
HT/21-17	20.17	16.11	0.14	0.10	0.24	1.84	9.33
HT/21-18	15.78	19.64	0.51	0.29	0.81	2.46	7.37
HT/21-20	17.44	22.91	0.34	0.21	0.56	4.60	2.22
Kufri Surya	17.10	17.70	0.18	0.12	0.30	2.87	2.87
S.E.(m)±	0.02	0.02	0.02	0.01	0.04	0.11	0.03
CD at 5%	0.05	0.06	NS	NS	NS	0.32	0.08

Table 3: Effect of mulching materials on quality parameters of potato.

Mulching materials	Dry matter content (%)	Vitamin C (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sprouting (%)	Rotting (%)
Paddy straw	19.45	18.81	0.26	0.16	0.42	2.44	4.41
Coconut coir	18.47	18.79	0.28	0.16	0.44	2.68	4.64
Control (earthing up)	16.80	18.77	0.29	0.17	0.46	2.98	4.93
S.E.(m)±	0.03	0.11	0.03	0.01	0.02	0.05	0.01
CD at 5%	0.17	NS	NS	NS	NS	0.33	0.03

Potato tubers with high dry matter content >20% are preferred to achieve good colour chips and less oil absorption during frying (Kirkman, 2007). Therefore, among the 12 potato genotypes under study, HT/21-2 (20.91%) and HT/21-17 (20.17%) having high dry matter content were found to be promising for chip making. The variation in the dry matter content among the genotypes might be due to difference in their inherent characteristics. Similar results were reported by Sadawarti *et al.* (2018). The increase in dry matter content under mulching materials might be due to congenial root zone temperature which leads to better crop growth and increased biomass accumulation. Similar findings were reported by Dhakal *et al.* (2011); Banerjee *et al.* (2016).

Table 4: Interaction effect of mulches and genotypes on quality parameters of potato.

Treatment	Dry matter content (%)	Vitamin C (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sprouting (%)	Rotting (%)
M_1G_1	18.51	15.41	0.60	0.26	0.86	2.21	6.84
M_1G_2	22.58	17.24	0.24	0.17	0.41	3.82	3.12
M_1G_3	20.31	22.80	0.21	0.15	0.36	4.27	5.81
M_1G_4	20.88	22.20	0.13	0.10	0.23	2.48	2.01
M_1G_5	20.56	18.26	0.18	0.13	0.31	1.12	1.86
M_1G_6	19.12	18.92	0.11	0.07	0.18	1.84	3.89
M_1G_7	19.78	16.80	0.29	0.17	0.46	1.47	6.42
M_1G_8	16.82	17.62	0.22	0.13	0.35	2.86	2.23
M_1G_9	21.84	16.14	0.12	0.09	0.21	2.61	9.12
M_1G_{10}	16.26	19.66	0.48	0.31	0.79	2.84	7.07
M_1G_{11}	18.47	22.93	0.32	0.25	0.57	1.52	1.94
M_1G_{12}	18.24	17.73	0.16	0.11	0.27	2.24	2.62
M_2G_1	17.63	15.39	0.62	0.26	0.88	2.32	7.06
M_2G_2	21.48	17.23	0.27	0.18	0.45	3.96	3.36
M_2G_3	18.94	22.79	0.24	0.16	0.40	4.61	6.08
M_2G_4	19.87	22.18	0.15	0.10	0.25	2.94	2.31
M_2G_5	19.66	18.24	0.20	0.13	0.33	1.26	2.08
M_2G_6	17.89	18.89	0.13	0.08	0.21	1.96	4.01
M_2G_7	18.63	16.78	0.31	0.18	0.49	1.62	6.52
M_2G_8	16.32	17.60	0.22	0.14	0.36	3.12	2.46
M_2G_9	20.61	16.10	0.14	0.10	0.24	2.97	9.34
M_2G_{10}	15.84	19.64	0.52	0.28	0.80	3.14	7.36
M_2G_{11}	17.46	22.91	0.35	0.21	0.56	1.84	2.26
M_2G_{12}	17.31	17.70	0.18	0.12	0.30	2.47	2.84
M_3G_1	16.46	15.37	0.63	0.28	0.91	2.56	7.40
M_3G_2	18.67	17.22	0.29	0.18	0.47	4.28	3.64
M_3G_3	17.06	22.77	0.25	0.16	0.41	4.93	6.34
M_3G_4	17.38	22.17	0.17	0.11	0.28	3.18	2.73
M_3G_5	17.47	18.22	0.21	0.14	0.35	1.68	2.44
M_3G_6	16.66	18.88	0.15	0.09	0.24	2.34	4.28
M_3G_7	17.12	16.76	0.31	0.19	0.50	1.93	6.78
M_3G_8	15.36	17.59	0.24	0.15	0.39	3.38	2.74
M_3G_9	18.06	16.09	0.16	0.10	0.26	3.26	9.53
M_3G_{10}	15.23	19.63	0.54	0.29	0.83	3.33	7.68
M_3G_{11}	16.38	22.89	0.36	0.18	0.54	2.17	2.46
M_3G_{12}	15.74	17.68	0.20	0.13	0.33	2.66	3.16
S.E.(m)±	0.03	0.03	0.02	0.01	0.04	0.19	0.05
CD at 5%	0.09	NS	NS	NS	NS	NS	NS

Vitamin C (mg/100 g). Simple effect of genotypes was significant (Table 2) but the main effects of mulching materials and their interaction effects were non-significant for vitamin C content (Table 3, 4).

Vitamin C content in potato genotypes varied significantly from 15.39 mg/100 g (HT/21-1) to 22.91 mg/100 g (HT/21-20). Vitamin C content was highest in genotype HT/21-20 (22.97 mg/100 g), followed by HT/21-3 (22.79 mg/100 g) and HT/21-5 (22.18 mg/100 g). Potato is considered as a good source of antioxidants such as vitamin C. Diets rich in antioxidants have been associated with a lower incidence of atherosclerotic heart disease, certain cancers, macular degeneration and severity of cataracts (Cook and Samman 1996). The most important factor which influences the vitamin C content of potato is variety (Hrabovska *et al.*, 2021). The variability of the vitamin C content among genotypes might be due to the difference in their genetic constitution. Similar findings were reported by Rizvi *et al.* (2020).

Reducing, non-reducing and total sugars (%). Significant variation in reducing sugars, non-reducing sugars and total sugars was observed among the genotypes (Table 2) while among mulching materials and their interaction effect, it was found to be non-significant (Table 3, 4).

Reducing sugars in potato genotypes varied significantly from 0.62% (HT/21-1) to 0.13% (HT/21-11). Reducing sugars was lowest in genotype HT/21-11 (0.13%) followed by HT/21-17 (0.14%) and HT/21-5 (0.15%). Hence, for manufacturing good quality potato chips, optimum reducing sugars should be less than 0.15 % or 150 mg/100 g of tuber fresh weight (*Sowokinos and Preston*, 1988). Therefore, HT/21-11, HT/21-5 and HT/21-17 genotypes of potato under study having reducing sugars (%) which is within limits of desirable variety are suitable for processing into chips.

Non-reducing sugars in potato genotypes varied significantly from 0.08 % (HT/21-11) to 0.29 % (HT/21-18). Non-reducing sugars was lowest in HT/21-11 (0.08%), followed by HT/21-5 and HT/21-18 (0.10%) and Kufri Surya (0.12%). The sugar content of the harvested crop is important for the fresh market and the sucrose levels above 1% were reported to give an unacceptably sweet taste to the boiled potatoes (Storey, 2007). None of the potato genotypes under evaluation were found to have non-reducing sugars above 1%.

Total sugars in potato genotypes varied significantly from 0.21% (HT/21-11) to 0.88% (HT/21-1). Total sugars content was lowest in genotype HT/21-11 (0.21%) followed by HT/21-17 (0.24%) and HT/21-5 (0.25%). Majority of the potato genotypes except HT/21-11, HT/21-17, HT/21-5 had significantly highest total sugars when compared to control Kufri Surya (0.30%).

Sugar levels in a potato tuber are conditioned by several factors, which include genotype, the environmental conditions and cultural practices during growth, and several post-harvest factors including storage (Kumar *et al*., 2004). Variability in the sugars (%) might be due to the difference in their genetic makeup. Similar findings were reported by Lavanya *et al.* (2021).

3. Sprouting and Rotting (%).

Sprouting and rotting of tubers during storage after 60 days of harvest under normal storage conditions were significantly influenced by both genotypes and mulching materials but non-significantly influenced by the combination of genotypes and mulching materials (Table 4). Sprouting varied significantly among potato genotypes from 1.35% (HT/21-7) to 4.60% (HT/21-3). Sprouting was lowest in genotype HT/21-7 (1.35%), followed by HT/21-15 (1.67%) and HT/21-20 (1.84%). Sprouting was lowest in potato genotypes under paddy straw mulching (2.44%) followed by coconut coir mulching (2.68%) when compared to control without mulching (2.98%).

Rotting in potato genotypes varied significantly from 2.13% (HT/21-7) to 9.33% (HT/21-17). Rotting was lowest in genotype HT/21-7 (2.13%), followed by HT/21-20 (2.22%) and HT/21-5 (2.35%). Mulching materials had significantly influenced rotting of potato genotypes. Rotting was lowest under paddy straw mulching (4.41%) followed by coconut coir mulching (4.64%) when compared to control with earthing up (4.93%). There was no significant interaction between genotypes and mulching materials on sprouting and rottingof tubers. The variations in sprouting and rotting percentage among potato genotypes might be due to the difference in their genetic makeup. Due to the presence of lower maximum temperatures under mulching materials might have increased the dormancy period and reduced sprouting and rotting in potato tubers during storage. Similar results were reported by Pulok *et al*. (2014). On the whole, the genotypes HT/21-7 and HT/21-20 with significantly lower sprouting by 45.12 and 35.11%, respectively and rotting by 25.78 and 22.65%, respectively after 60 days of harvest during storage under normal storage conditions compared to control Kufri Surya were found to be highly suitable for long-term storage.

CONCLUSION

On the basis of desirable external tuber quality traits like eye depth (shallow), shape (round and oval), skin colour (brown and yellow) and flesh colour (yellow and yellow cream and cream), the genotypes HT/21-2, HT/21-5, HT/21-16, HT/21-17, HT/21-18 and Kufri Surya were of superior tuber quality traits for fresh and processing market. On the basis of nutritional/compositional quality traits like dry matter content (>20%), the genotypes HT/21-2 (20.91%) and HT/21-17 (20.17%) and reducing sugars (>0.15%), the genotypes HT/21-11, HT/21-5 and HT/21-17 having reducing sugars (%) which is within limits of desirable variety were found to be highly suitable for processing. Based on the storage studies, HT/21-7 showed significantly longer shelf life of storage. Hence, it can be recommended for storage under room temperature for longer period. Based on the desirable quality parameters, the mulching material paddy straw mulch was found to be superior for dry matter content, sprouting (2.44%) and rotting percentage (4.41%) followed by coconut coir mulch compared to control without mulching.

FUTURE SCOPE

These breeding lines need to be tested under multiple environments of the state in order to test their stability, adaptability and sensitivity to different environments. Further studies should be carried out to know the effects of paddy straw and coconut coir on weed growth, soil temperature, soil moisture, soil micro flora and microfauna. Further studies should be carried out to investigate the effect of other locally available crop residues on quality of potato.

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