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Variation in Postharvest Quality Attributes of Fresh Cowpea (*Vigna unguiculata* L.) Beans Harvested from Different Crop Mulching Regime

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ABSTRACT

Background: Present study, aimed to assess effect of organic and inorganic crop mulching on physical, physiological and biochemical quality of fresh cowpea beans.

Methods: Cowpea (cv. *Kashi Kanchan* bush-type) was grown during two consecutive seasons from April 2018 to July 2019 under four different mulching treatments. Mulching treatments included no mulch; wheat straw mulch (organic mulch); black mulch and silver mulch. Black and silver mulches were made of 25 microns LDPE sheet. Cowpea was grown as per standard agronomic practices and physical, biochemical and postharvest quality parameters of beans were evaluated.

Result: Results indicated that bean length (28.7cm) was highest under silver mulch whereas bean thickness (9.10mm), width (9.29mm) and 100 bean weight (1094.5g) were highest under organic mulch. Likewise, protein content (28.63%), total phenolic content (17.0µg GAE/100g) and total antioxidant activity (46.84µmol trolox equiv./100g) were found highest in beans produced under organic mulch. Overall results demonstrated that crop mulching could be used for enhancing the antioxidants, phenolic content of cowpea beans.

Keywords: Antioxidant activity, Crop mulching, Cowpea, Principal component analysis, Total phenolics.

INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is an edible legume used as food, feed, forage, fodder and green manure. In India, freshly harvested unripe cowpea beans are used as vegetables. Cowpea is known as black-eyed pea, southern pea, alubia, cowpea, caupi, *etc*. It is a rich source of protein, carbohydrate, fiber, vitamins, minerals, polyphenols and antioxidants (Whitebread and Lawrence, 2006; Boukar *et al*., 2015). Cowpea crop is a drought-prone, hardy crop and has a strong taproot system with different growth habits *viz*. erect, semi-erect, trailing, climbing or bushy (Nkoana *et al*., 2019). It is grown as a warm-season crop and can be grown under rainfed conditions of tropical and subtropical regions where the irrigation facility is poor. Moreover, it is the only legume crop suited to both arid and semi-arid regions and thrives better than other legumes. It also improves the soil's biological health by fixing the atmospheric nitrogen.

Although cowpea is best suited to arid and semi-arid regions, limited availability of irrigation water accompanied with high ambient temperatures in the regions adversely affects growth, health and yield of crop. Under such conditions, correct agro-technical interventions become helpful in providing a desirable microclimate to crop. Among various agro-techniques, crop mulching is one of the easiest and low-cost interventions. Literature reveals that mulching is beneficial in stabilization of soil temperature and reducing water loss through evaporation resulting in added availability of soil moisture (Shirgure *et al*., 2003). Besides, potential of mulching in improving crop yield, soil nutrient uptake, soil structure and soil organic matter has also been documented (Hatami *et al*., 2012). Organic mulches and inorganic mulch that includes plastic mulch of various colours are used in vegetable crops to conserve soil moisture, suppress weeds growth, moderate soil temperatures and plant disease propagules. Lower evaporation of moisture from soil surface due to plastic mulch provides cooling effects to soil, and thus higher soil microbial activity under plastic mulch was also reported (Abdel-Hafeez and Abu-Goukh, 1984). Mulching technology in conjunction with drip irrigation

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becomes helpful in growing various crops in arid and semi-arid regions.

Nowadays, crop mulching has become a common practice in many vegetables and fruits crops. But scanty information is available on use of mulching in production of legumes, especially in cowpea. Literature indicates that few studies have been conducted to understand effect of mulching on plant growth, yield and root growth parameters of cowpea (Dukare *et al*., 2017). These studies demonstrated that mulching increases yield and better growth of roots and root nodules of cowpea crop. However, in regards to post-harvest quality, no reportred information is available that reveals impacts of crop mulching on harvested cowpea beans. With this background, present study was conducted to assess effect of crop mulching regime on postharvest physicochemical quality of cowpea beans.

MATERIAL AND METHODS

Present study was conducted at research field of AICRP-PEASEM, ICAR-CIPHET, Abohar (Lat 30° 09′ N, 74° 13′ E, 185.6m above mean sea level), Punjab, India. Cowpea (cv. *Kashi Kanchan*) was grown in two seasons under four mulching treatments *viz.*, control (no-mulch); wheat straw mulch of 0.4 kg/m^2 of surface area (organic mulch); black polythene mulch of 25 microns and silver polythene mulch of 25 microns thickness from April 2018 to July 2019. Mulching treatments were replicated thrice and placed randomly in field. In each case, mulch was applied on a raised bed of 15m length, 1m width and 20cm height. Drip lines having inline drippers were placed below mulches. Plant to plant distance was 50cm whereas row to row distance was 1m. About 100 beans from each row were plucked randomly and used for postharvest quality evaluation.

Physical and physiological parameters

Average bean weight and weight of 100 beans from each treatment weighed individually using an electronic weighing balance with a maximum and minimum capacity of 300g and 0.2g, respectively. From each treatment, 100 beans with uniform size and maturity were plucked randomly and weighed to obtain weight of 100 beans. Physical dimensions of fresh beans were measured using a digital vernier caliper with an accuracy of ±0.01mm. Bean length was expressed in centimeters (cm) while width and thickness were expressed in millimeters (mm). Bean firmness was determined by using texture analyzer (model TA+Di, Stable Micro Systems, UK). Firmness was defined as maximum force during cutting and was expressed in Newtons (N).

Biochemical and functional parameters

Crude protein content of cowpea powder extracts was determined as per micro Kjeldahl method (AACC, 2000) by using fully automatic digester and distillation unit (KEL PLUS Classic DX VATS (E)). Total phenolic content of fresh beans was determined with some modifications as described by Kannaujia *et al*. (2020). The results were expressed in µg of Gallic acid equivalents (GAE)/100g of extract. Total antioxidant activity of fresh cowpea beans was determined by cupric reducing antioxidant capacity method (Apak *et al*., 2004) and results were expressed as µmol trolox equiv./100g.

Statistical analysis

Experiment was conducted in a completely randomized design with three replications of each mulching treatment. Results were statistically analyzed using Analysis of variance (ANOVA) and mean values were compared by Duncan's multiple range test (DMRT) at significance level of 5% ($p<0.05$). Principal component analysis (PCA) was performed by Addin software XLSTAT (version 2014.5.03) to identify relationships between quality parameters of cowpea beans and their association with mulching treatments.

RESULTS AND DISCUSSION

Individual and 100 bean weight

The highest individual bean weight was recorded under organic mulch (16.05g) followed by silver mulch (14.27g) and the least values were recorded under black mulch (11.98g). Similarly, Table 1 indicates that 100 bean weight was highest under organic mulch (1094.5g) followed by silver mulch (1021.6g).

Our results are in agreement with Mitchell *et al*. (2019) who explained that as soil moisture depleted under no-mulch condition, rate of nutrient absorption by plant roots and photosynthesis process reduced which led to reduced leaf area, cell size and intercellular volume which ultimately reduced bean moisture accumulation capacity. On the contrary, as soil surface was covered under mulching treatments, it caused higher availability of moisture to plants and increased weight of cowpea beans. Plant root parameters directly contribute to yield parameters during growth and developmental stages (Dukare *et al*., 2017).

Physical dimensions of fresh beans

Table 1: Effect of mulching treatments on physical parameters of cowpea beans.

Treatment	100 bean weight (g)	Bean length (cm)	Width (mm)	Thickness (mm)	Firmness (N)
No mulch	826.1^a	27.23^a	8.40^a	8.50^a	37.23^c
Black	898^b	28.70^b	8.97^b	8.32^a	35.21^b
Organic	1094.5^c	27.57^{ab}	9.29^c	9.10^b	32.08^a
Silver	1021.6^d	28.77^b	8.86^b	8.98^b	34.16^b

Values followed by same alphabet in a column do not differ significantly ($p \leq 0.05$).

Data presented in Table 1 shows that highest bean length was observed under silver mulch (28.77cm) followed by black mulch (28.70cm) whereas minimum bean length (27.23cm) was found under no-mulch. Although mulching treatments attributed variation in bean length, the difference was not statistically significant ($p \leq 0.05$). Results on bean width (Table 1) showed that organic mulch gave the highest width (9.29mm) followed by black mulch (8.97mm) and the least was observed in beans produced under no-mulch (8.40mm) treatment. Likewise, the highest bean thickness was found under organic mulch (9.10mm) followed by silver (8.98mm).

An increase in bean dimensions under plastic mulch was mainly attributed to sufficient soil moisture near root zone and minimized evaporation loss. Malik *et al*. (2006) reported that lower number of beans per plant of green gram was observed when crop was exposed to moisture stress during flowering and bean formation stage. They also reported that organic mulch followed by no-mulch has less water conservation capacity which is in accordance with results of our study. Moisture conservation in soil profile through plastic mulches has a greater role in cell division of plants and cell enlarging in fruits. This might be due to proper availability of moisture which increases cell expansion due to turgor pressure and increases photosynthesis rate (Al-Suhaibani, 2009).

Bean firmness

Usually, tender and succulent cowpea beans are preferred for vegetable purpose. But, sometimes green seeds obtained after discarding outer cover of bean are also used for a vegetable purpose. It is evident from Table 1 that the highest bean firmness was observed in beans produced under no-mulch treatment (37.23N) followed by black mulch (35.21N) whereas the least firmness was found in beans produced under organic mulch (32.08N). Here, it may be noted that firmness is the indicator of cutting force required to cut beans. Further, higher cutting force may also be attributed to fibrous structure of beans and vice versa.

Jha and Kumari (2015) evaluated effect of mulching on tomato fruit firmness under open and polyhouse conditions and reported that firmness increased due to plastic mulch. The highest fruit firmness was observed under open-field conditions in combination with black mulch followed by silver-black plastic mulch. Similarly, Helaly *et al*. (2017) reported that firmness of husk tomato increased by mulching treatment and white on black mulching gave the best results for better fruit firmness.

Protein content

Quality of cowpea beans may be decided based on protein content as it is a main essential nutritional component of all legumes. Our results showed a significant difference among protein contents of cowpea beans produced under different mulching treatments ($p \leq 0.05$). Data presented in Table 2 shows that the highest protein content was observed under organic mulch (28.63%) followed by silver mulch (27.01%) whereas the lowest values (24.16%) were found under no-mulch treatment.

Higher protein content in organic mulch followed by silver mulch treatment was mainly due to positive effect of these mulching treatments on root development and nodulation in cowpea plants. Highest number of root nodules per secondary/lateral root and total root nodules per plant was observed under organic mulching in cowpea (Dukare *et al*., 2017). Increased root development and nodulation in organic mulch treatment might be due to favorable effect of organic mulch in improving overall physical, chemical and biological attributes of soil and hence improving root symbiosis process with nodule rhizobacteria (Dukare *et al*., 2017; Joshi *et al*., 2016).

Total antioxidant activity

Results (Table 2) indicate that the highest antioxidant activity (µmol trolox equiv./100g) was recorded in beans produced under organic mulch (46.84) followed by silver mulch (30.0), while the least antioxidant activity was observed in the beans produced under no-mulch (24.56).

Variation in results was due to variation in soil temperatures and barrier properties offered by mulching. Soil temperatures under plastic mulching were comparatively higher than those under no-mulch. Some portion of solar radiation is transmitted through plastic sheets, trapped there and heats the soil. Higher temperature under mulch accelerates antioxidants enzyme which results in higher synthesis of antioxidant compounds in pods. It was also noted that phenolic compounds are mainly responsible for total antioxidants and other health-promoting compounds in cowpea (Apea-Bah *et al*., 2017).

Total Phenolic content

Table 2: Effect of mulching treatments on biochemical parameters of cowpea beans.

Treatment	Protein content (%)	Total phenolic content (µg GAE/100g FW)	Total antioxidant activity (µmol trolox equiv./100g)
No mulch	24.16[a]	11.83[a]	24.56[a]
Black	25.88[b]	13.98[b]	28.72[b]
Organic	28.63[d]	17.00[d]	46.84[d]
Silver	27.01[c]	15.00[c]	30.00[c]

Values followed by same alphabet in a column do not differ significantly ($p \leq 0.05$).

In this study, total phenolic content ranged from 11.83µg GAE/100g FW (black polythene mulch) to 17.0µg GAE/100g FW (organic mulch) depicting a 1.44-fold variation (Table 2). Results show that significant ($p \leq 0.05$) variation was observed in total phenolic contents with respect to different treatments.

Major phenolic compounds present in pulse crops, especially in cowpea crops, are phenolic acids and flavonoids (Awika and Duodu, 2017). Our results indicated that different mulching treatments significantly influenced synthesis of bioactive compounds in cowpea beans. The elevated temperature and different light conditions under different plastic mulch colour may explain higher contents of phenolic compounds (Wang and Zheng, 2001). Anttonen *et al*. (2006) reported that ≈6 and 7% higher total phenolics and ellagic acid were found in strawberry fruits grown under white mulch as compared to brown mulch.

Principal component analysis and principal component (PC) biplot

PCA was applied to bean length, width, thickness and 100 beans weight and summarized in Fig 1(a). The highest explained variance (PC1) was associated with width, thickness and 100 bean weight in one direction while bean length in opposite direction. PC1 explained 61.29% variance whereas the second factor (PC2) explained 28.85% variance. It is evident from Fig 1(a) that silver mulch was associated with bean length and bean width whereas organic mulch was associated with bean thickness and 100 bean weight. PCA was also performed for firmness, total phenolics, total antioxidant activity and protein content under different mulching treatments and results are presented in Fig 1(b). Results revealed that factor PC1 was associated with total phenolics and protein content whereas factor PC2 was associated with total antioxidant activity and firmness. PC1 explained 56.20% variance whereas 43.65% variance was explained by PC2. Fig 1(b) indicates that all biochemical parameters estimated during study are closely associated with organic mulch followed by silver mulch whereas firmness was associated with no-mulch treatment.

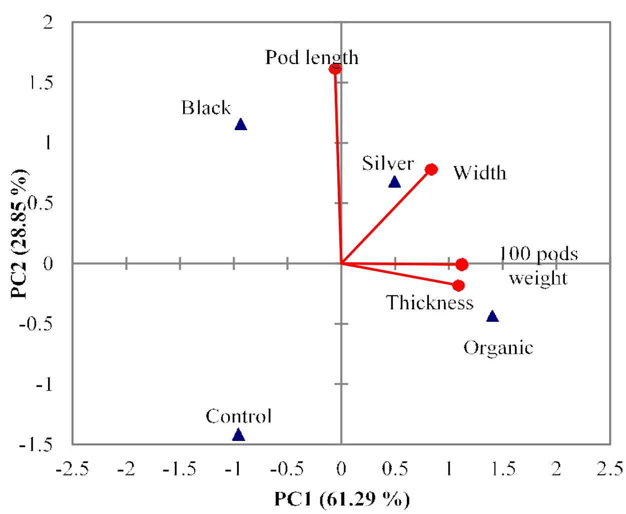

Fig 1(a): Bi-plots of first two principal components obtained for bean length, width, thickness and 100 bean weight of cowpea beans.

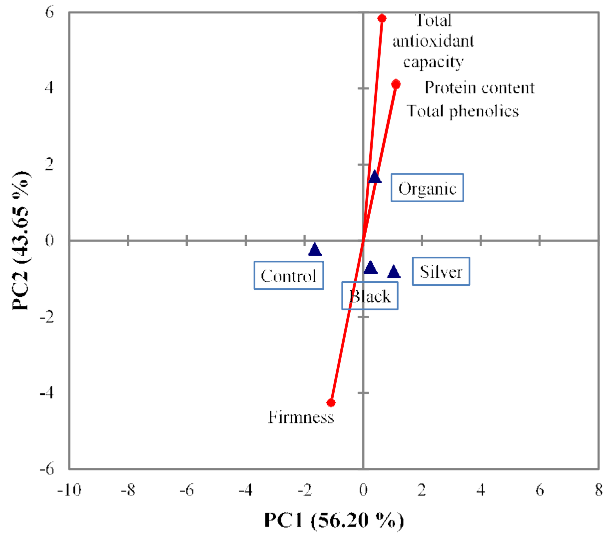

Fig 1(b): Bi-plots of first two principal components obtained for firmness, total phenolics, total antioxidant capacity and protein content of cowpea beans.

CONCLUSION

In nutshell, results indicated that mulching treatments significantly affect physical dimensions of cowpea beans. Total phenolics and total antioxidant activity were highest in cowpea beans plucked from organic mulch treatment. PCA analysis revealed that organic mulch was the best mulching treatment followed by silver mulch for higher accumulation of bioactive compounds and softer and lengthier beans.

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