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Understanding the Biochemical Changes in the Macromolecules during Stem Bending of Cut Gerbera (*Gerbera jamesonii* Bolus) cvs Stanza and Rosalin

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ABSTRACT: A lab experiment on understanding the biochemical changes in the macromolecules during stem bending of cut gerbera (*Gerbera jamesonii* Bolus) cvs Stanza and Rosalin were carried in the laboratory, Department of Floriculture and Landscape architecture, Bidhan Chandra Krishi Viswavidyalaya during the year 2021-2022. The experiment was laid out in a factorial Completely randomized design with 8 treatments, replicated thrice. The treatments include two varieties (V_1 and V_2) and four stages of bending (S_1, S_2, S_3 and S_4). The results of the present study demonstrated that significantly maximum reducing sugars (0.26%) and non reducing sugars (2.61%) was recorded in cv Stanza at the initiation of bending stage. Wherein, the accumulation of starch, protein and phenol at the point of bending was recorded maximum at no bending stage in both the cultivars and declined gradually with advancement of bending stages in stems. The maximum starch (16.34%) was found in cv Rosalin at no bending stage, maximum protein (28.72 mg/g FW) and phenol content (5.64 mg/g FW) was found in cv Stanza at no bending stage.

Keywords: Reducing sugars, starch, stem bending, Stanza, cultivars, phenol.

INTRODUCTION

Gerbera (*Gerbera jamesonii* Bolus) is a well-known commercial cut flower belonging to the family Asteraceae and is native to South Africa and Asia. It is a herbaceous perennial herb with daisy-like flowers of different colors ranging from pink, white, yellow, orange, red, crimson and many other combinations and shades except blue and has the chromosome number 2n =50. In Gerbera, the inflorescence type is capitulum which is the composite terminal flower head and the stem is known as scape. The most important quality criteria for cut gerbera flowers are non-defective petals, appropriate stem length, stem toughness, and stem straightness. Bending of the scape is often the main postharvest disorder of cut gerbera flowers that induces shortening of vase life (Perik *et al.*, 2012). Post-harvest longevity and quality have been the key issues for gerbera export and commerce thereby limiting their market value. (Shabanian *et al*., 2018). Cut gerberas are affected by normal senescence, and vase life is normally limited by dropping, wilting, curling, and discoloration of petals (De Jong, 1978), premature senescence folding, stem break (Van Meeteren, 1978a), and stem bending (Abdel-Kader and Rogers 1986), terms that are used to describe the sudden bending of the stems, similar to bent neck in roses (Marousky, 1973). The blockage of openings by bacteria in the pit membranes of the xylem is mostly because of the production of polysaccharides into the extracellular spaces. The introduction of bacteria to freshly plucked stems in vase water resulted in rapid stem bending, validating the theory that bending can be caused by bacteria in the vase water. Water intake was shown to be low in bent stems. (Cheng *et al*., 2020).

MATERIALS AND METHODS

The cut gerbera flowers of cultivars 'Stanza' and 'Rosalin' used for this study are grown under standard greenhouse conditions and were procured from AICRP on floriculture, BCKV, Mondouri. Flowers were collected between 6.30 to 7.30 a.m. when they reach commercial maturity, *i.e.* displaying mature stamens on the outer two whorls of the flower. Hand harvesting is done, by pulling the stem base sideways. Then flowers are moved to the laboratory after harvesting. It took less than an hour from harvest to arrival in the laboratory. The flowers were quickly utilized for experiment upon arrival. Flowers were chosen for homogeneity, including same length of stem. A section of the stem at the ends (6-11 cm) were clipped so that all stalks are 45cm. After cutting, a central hollow cavity is usually evident at the basal end of stem.

The experimental flowers were held at 22±2°C (ambient room temperature) and 60±5% relative humidity (RH) and 40W/84 white cool fluorescent tubes, using a 12 hours photoperiod. Cut stems were put separately in vases holding 150 ml of DI water. The vases are wrapped with aluminum foil to reduce evaporation as well as contamination. In the laboratory the vases, are arranged on the bench.

The experiment was laid out in a factorial Completely randomized design with 8 treatments, replicated thrice. Factor I: Varieties (Stanza and Rosalin), Factor II: Different stages of stem bending (No bending, Initiation of bending (≥20°), Medium bending (≥60°) and Full bending (≥90°)]. The treatment combinations comprising of T_1: Stanza + No bending, T_2: Stanza + Initiation of bending (≥20°), T_3: Stanza + Medium bending (≥60°), T_4: Stanza + Full bending (≥90°), T_5: Rosalin + No bending, T_6: Rosalin + Initiation of bending (≥20°), T_7: Rosalin + Medium bending (≥60°) and T_1: Rosalin + Full bending (≥90°).

RESULTS AND DISCUSSION

A. Changes in reducing sugars (%)

The data represented in Table 1 showed that the two varieties differed significantly with respect to reducing sugar content at different stages of bending. The graphical representation in Fig. 1(A) depicted that cv Stanza recorded higher reducing sugar than cv Rosalin in all the stages of bending. Reducing sugar in cv Stanza and cv Rosalin was recorded to be 0.19% and 0.16 % respectively. There is an increase in reducing sugar content (0.25%) at the initiation of bending which shows that there is a synthesis of reducing sugars at the initiation of the bending stage and the accumulation of reducing sugars declined at medium and full bending stages indicating that there is the consumption of reducing sugars at medium and full bending stages. The interaction between varieties and bending was found significant in which the highest reducing sugar was found in Stanza at the initiation of bending (0.26%) which is on par with Stanza at no bending stage (0.25%) and Rosalin at the initiation of bending stage (0.24%). The lowest reducing sugars were found in Rosalin at full bending (0.05%).

During the vase life period, the reducing sugars increased till the cut flowers initiated bending and then decreased as stem bending curvature increased towards the senescence stage and this might be due to the depletion of sugars and hence, triggering the bending, consequently leading to senescence. The present findings are similar to the findings of Van Doorn (2004) in which they highlighted the relationship between the gradually decreasing levels of stored sugars and the senescence in flowers. This correlation has also been found in the conclusions given by Soad *et al*. (2011) in gerbera.

B. Changes in non-reducing sugars(%)

The data presented in Table 1 showed that the two varieties differed significantly with respect to non-reducing sugar content at different stages of bending. The graphical representation in Fig. 1(B) depicted that cultivar Stanza accumulated maximum non-reducing sugars than Rosalin in all the stages of vase life. cv Stanza accumulated (1.45%) and cv Rosalin accumulated (1.08%) of non-reducing sugar. It can be noted that both varieties recorded an increase in non-reducing sugar content till the initiation of the bending stage and a gradual decline in the remaining medium bending and full bending stages. Stages differed significantly and the non-reducing sugar content increased (2.25%) at the Initiation of bending from the no bending stage and decreased thereafter towards the (0.1%) full bending stages. The interaction between varieties and stages of bending on the non-reducing sugar content of gerbera cut flowers during vase life differed significantly. The highest non-reducing sugars were found in Stanza at the initiation of bending (2.61%) followed by Stanza at the no bending stage (1.97%) which is on par with Rosalin at the initiation of bending stage (1.88%). The lowest non-reducing sugars were found in Rosalin at full bending (0.05%)

The non-reducing sugar content declined as bending stages progressed towards senescence. So increased bending can be due to the declining non-reducing sugars. The findings are similar to those of Van Doorn (2004) in which he reported that flower senescence could be related to gradually declining levels of sugars and Perik *et al.* (2012) concluded that adding sucrose to the vase solution often increased flower longevity where it served as a source of energy. Non-reducing sugars besides sucrose were noted as the main constituents of the sugar pool of mature petals (Nichols, 1975). The changes in sugars are accompanied by starch hydrolysis (Ho and Nichols 1977).

C. Changes in starch (%)

The data on starch content presented in table 1 and fig. 1(C) showed that the varieties differed significantly with respect to starch in which cv Stanza recorded (10.38%) while cv Rosalin recorded (12.78%) and starch was found to be maximum in cv Rosalin in all the stages of bending compared to cv Stanza. The starch content in both the varieties declined gradually from initiation to full bending stages. There were significant differences in the starch content during different stages of bending and the highest starch content was found at no bending (14.89%) and the lowest (7.86%) in Full bending stage. The interaction effect of starch between varieties and stages of bending was found significant in which the highest starch content was recorded in Rosalin at no bending stage (16.34%) followed by Rosalin at the initiation of bending stage (14.20%), Stanza at no bending (13.45%). The lowest total starch content was found in Stanza at full bending (6.18%).

Starch declined as the bending stages progressed towards the termination of vase life, the findings were in accordance with (Ho and Nichols 1977) who concluded that during petal ageing there is a decline in the level of macromolecular components like starch and Ried *et al.* (2012) concluded that the longevity of some cut flowers was correlated with carbohydrate level in the flower.

D. Changes in protein (mg/g FW)

The data presented in Table 1 showed that the varieties differed significantly with respect to protein content at different stages of bending. The graphical representation in Fig. 2(A) depicted that cultivar Stanza recorded the maximum protein content than cv Rosalin. It can be noted that both varieties recorded a decline in protein content from no bending to full bending stages. Varieties differed with respect to protein content in which cv Stanza recorded (18.64 mg/g FW) and Rosalin recorded (10.96mg/g FW). There were significant differences in the protein content during different stages of bending in which the highest total protein (25.02 mg/g FW) content was found to be recorded at no bending stage and the lowest (6.49mg/g FW) in Full bending. The interaction effect of protein between the varieties and different stages of bending was found significant. The highest total protein content was found in Stanza at no bending **(**28.72mg/g FW), followed by Rosalin at the initiation of bending stage (21.32mg/g FW) which is on par with Stanza at the initiation of bending (20.89 mg/gFW). The lowest total protein content was found in Rosalin at full bending (2.68mg/gFW).

Higher protein content in Stanza than that of Rosalin might be attributed to the lesser degree of stem bending in the former variety. It was found that the protein content declined as the degree of stem bending increased. This present finding is in agreement with the results given by Shahri and Tahir (2011) in Ranunculus and Borochov *et al.* (1990) in carnation where they concluded that protein content declined as the flowers progressed towards senescence.

E. Changes in total phenol(mg/g FW)

Data on total phenols influenced by varieties and different stages of bending are presented in Table 1 showed that the varieties differed significantly with respect to total phenol content at different stages of bending. The graphical representation in Fig. 2(B) depicted that cultivar Stanza recorded the maximum total phenol content than cv Rosalin in all the stages of bending. The phenol content recorded in cv Stanza was (3.08 mg/g FW) and in cv Rosalin was (2.26 mg/g FW). The stages differed significantly in the total phenols content which gradually decreased from Initiation of bending to Full bending at successive intervals of observation. The highest total phenol content (5.00 mg/g FW) was found in no bending, and the lowest (0.72 mg/g FW) in Full bending. It can be noted that both varieties recorded a decline in phenol content from no bending to full bending stages. The interaction effect of total phenols between varieties and different stages of bending was found significant. The maximum total phenol content was found in cv Stanza at no bending stage (5.64 mg/g FW) followed by Rosalin at no bending stage (4.36 mg/g FW), Stanza at initiation of bending (3.54mg/g FW). The lowest total phenol content was found in Rosalin at full bending (0.41 mg/g FW).

It was observed that as the degree of stem bending increased, the phenol content in cv Stanza declined and this phenol content in all bending stages was also comparatively higher than cv Rosalin. The results were in agreement with the findings of Ferrante and Serra (2009), who reported that total phenols were higher in the cultivars that showed lower stem bending incidence in Gerbera.

Table 1: Understanding the biochemical changes in macromolecules during stem bending of cut gerbera (*Gerbera jamesonii* Bolus) cvs Stanza and Rosalin.

Treatments	Reducing sugars (%)	Non Reducing sugars (%)	Starch (%)	Protein (mg/g FW)	Total phenol (mg/g FW)
Varieties(V)					
V_1	0.19^{a}	1.45^{a}	10.38^{b}	18.64^{a}	3.08^{a}
V_2	0.16^{b}	1.08^{b}	12.78^{a}	10.96^{b}	2.26^{b}
S Em ±	0.004	0.01	0.09	0.20	0.02
LSD	0.012	0.04	0.29	0.61	0.07
Stages of bending (S)					
S_1	0.23^{b}	1.82^{b}	14.89^{a}	25.02^{a}	5.00^{a}
S_2	0.25^{a}	2.25^{a}	13.45^{b}	16.29^{b}	3.19^{b}
S_3	0.14^{c}	0.88^{c}	10.10^{c}	11.42^{c}	1.79^{c}
S_4	0.06^{d}	0.10^{d}	7.86^{d}	6.49^{d}	0.72^{d}
S Em ±	0.006	0.02	0.14	0.29	0.03
LSD	0.018	0.07	0.42	0.87	0.10
V × S Interaction					
T_1	0.25^{a}	1.97^{b}	13.45^{c}	28.72^{a}	5.64^{a}
T_2	0.26^{a}	2.61^{a}	12.71^{d}	20.89^{b}	3.54^{c}
T_3	0.15^{c}	1.05^{d}	9.18^{f}	14.65^{c}	2.14^{e}
T_4	0.08^{d}	0.16^{f}	6.18^{g}	10.31^{e}	1.02^{g}
T_5	0.21^{b}	1.68^{c}	16.34^{a}	21.32^{b}	4.36^{b}
T_6	0.24^{a}	1.88^{b}	14.20^{b}	11.68^{d}	2.84^{d}
T_7	0.13^{c}	0.71^{e}	11.03^{e}	8.19^{f}	1.44^{f}
T_8	0.05^{e}	0.05^{g}	9.56^{f}	2.68^{g}	0.41^{h}
S Em ±	0.008	0.03	0.19	0.41	0.05
LSD	0.025	0.09	0.59	1.23	0.15
Factor 1: varieties Stanza (V_1) Rosalin (V_2)			**Factor 2: Stages of bending** S_1: No bending S_2: Initiation of bending (≥20°) S_3: Medium bending (≥60°) S_4: Full bending (≥90°)		

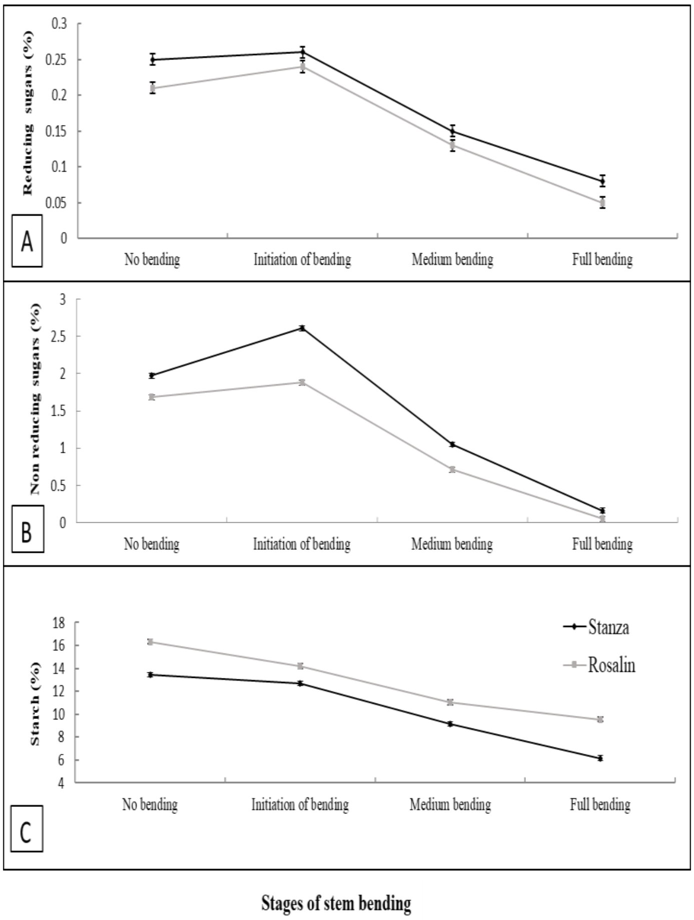

Fig. 1 (A) Changes in reducing sugars (%) (B) Changes in non reducing sugars (%) and (C) Changes in starch (%) during different stages of bending.

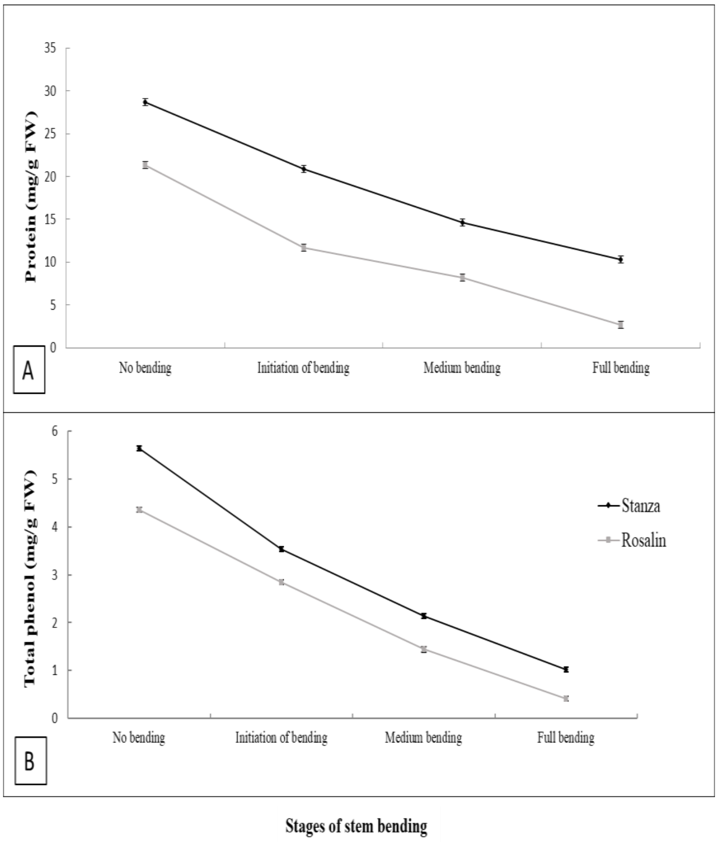

Fig. 2. (A) Changes in Protein (mg/g FW) and (B) Changes in total phenol (mg/g FW) Sduring different stages of bending.

CONCLUSIONS

It can be clearly concluded that increased stem bending is caused and associated by the steady depletion of starch, protein and sugars in the stem. Stem bending causes the degradation of protein and starch leading to the development of oxidative stress in fully bent stems causing senescence.

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