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EFFECT OF HERBAL EXTRACTS ON POST HARVEST LONGEVITY AND QUALITY OF GLADIOLUS CUT SPIKES

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ABSTRACT

Present study was conducted on post-harvest handling of gladiolus where different herbal extracts were used as vase solutions viz; neem (*Azadirachta indica*) leaf extract, tulsi (*Ocimum sanctum*) leaf extract, brahmi (*Bacopa monnieri*) leaf extract, and turmeric (*Curcuma longa*) rhizome extract each @ 2% concentration along with untreated control containing distilled water only. Freshly cut spikes of four varieties (Nathan Red, Morning Gold, Black Star and Peter Pears) were placed in 600 ml of the herbal extract solution as per treatment laid out in completely randomized block design. Among all the treatments, neem (*Azadirachta indica*) leaf extract @ 2% was found to be superior for improving post-harvest quality traits in all the varieties of gladiolus. Among varieties, Peter Pears responded best to herbal extract treatments for improved post- harvest longevity and quality attributes. Post-harvest quality was recorded minimum in control treatment and in variety Black Star.

Keywords: Gladiolus, Herbal extracts, Quality, Varieties, Vase life

Cut flowers are employed in several occasions to increase aesthetics, create happiness, peace and expressing emotions. These long stemmed blooms are enjoyed after harvest in many ways; like making bouquets, in vases, theme based flower arrangements and many other. Among the different cut blooms, gladiolus provides vast display of color and different forms of majestic spikes. Sequential opening of its florets in the vases helps it to last longer in the vases. However, post-harvest processes likes, enzymatic breakdown, microbial proliferation in vases etc. deteriorate the flower quality and progresses the spikes towards senescence. As largest part of cut flowers arrives mainly by import into flower market which usually takes 5-7 days to arrive from growing country (Feigel-Terek, 2012), so, in that case vase life extension becomes most important for conservation of quality in order to compete in international flower market. Cut spikes of gladiolus often last for short in vases if not handled properly due to early failure of water relations resulting in wilting of florets and failure of floret opening. Early senescence in gladiolus cut spikes is induced by several factors like water stress, carbohydrate depletion, microorganisms and ethylene exposure (Pun *et al*., 1999). Several technologies are being used to retain their freshness after harvest for longer time in vases. Florists while handling flowers stems in vases, enrich vase solution with carbohydrate sources, acidifying agents, antimicrobial compounds, anti-ethylene compounds and growth regulators. Silver thiosulphate (STS) (Mor *et al.,* 1981), 8-hydroxyquinoline citrate (8-HQC) (Kumar and Gupta, 2014), silver nitrate (Kumar and Awasthi, 2012), etc. are commonly used chemicals in vase solutions to increase vase life of gladiolus spikes by retailers and wholesalers. However, these chemicals are not safe to use from health and environment perspective as poses potential risks to different life forms and our environment (Forget, 1993; Igbedioh, 1991; Jeyaratnam, 1985; Yu *et al*., 2013). Silver is highly phtotoxic, harmful heavy metal environment contaminant and its disposal can contaminate water bodies, thereby can become huge threat to aquatic fauna (Damunopola and Joyce, 2008; Jowkar *et al*., 2013; Howe and Dobson, 2002). In humans it can cause conditions like, argyria, sarcomas, anaemia, and heart enlargement (Irwin *et al*., 1997). Similarly, Co used in the form of $CoCl_2$ is a potential allergic compound and can cause asthma (Domingo, 1989). Other chemicals used such as, Aluminium sulphate, hydroxyquinoline sulphate can cause dermal and eye allergies (Arsenault, 2016; Anisha and Kumar, 2015). With potential health and environmental risks, use of chemicals in flower handling and in vase solutions has been highly discouraged and should be replaced with effective and safe alternatives so that flower quality is not compromised (Singh *et al*., 2022). Nowadays, several herbal or plant extracts has been explored for their role in improving shelf life of fruits and vegetables and some of the flower crops. Plant extracts are rich in bioactive compounds (glucosides, saponins, tannins, alkaloids, essential oils, organic acids) with potential growth regulatory, antimicrobial and antioxidant properties (Fraenkel, 1959; Chopra *et*

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al., 1992). Plant extracts can be widely used to prevent the microbial proliferation on the vase solution, which in turn will extend the vase life of cut flowers (Julia, 1992). Despite the potential of herbal extracts or plant extracts to act as natural germicide, very few studies have been done related to their use in extension of vase life and quality maintenance of cut flowers. Some notable studies were conducted by Marandi *et al*. (2011) in gladiolus with ajowan oil at 500 ppm concentration; Rahman *et al*. (2012) in carnation with leaf extracts of *Psidium guajava* and *Piper betle*; Gupta (2011) in Rose with 0.25 ppm azadirachtin + 2% sucrose and 200 ppm citric acid; Rehman *et al.* (2014) in orchids with leaf extracts of *Jatropha curcas, Andrographis paniculata* and *Psidium guajava*. Therefore, present studies were planned to understand the effect of herbal extracts as vase solutions on improving post-harvest quality traits of gladiolus and to find out the best treatment for recommending it to the flower growers, retailers and wholesalers.

MATERIALS AND METHODS

The present experiment was conducted at post-harvest laboratory, model floriculture centre, G.B. Pant University of Agriculture & Technology, Pantnagar, U.S. Nagar, Uttarakhand for two consecutive years. Healthy and disease free corms of gladiolus varieties Nathan Red, Morning Gold, Black Star, Peter Pears were planted in mid of October at the spacing of 20 x 30 cm. Routine cultural operations like; weeding, hoeing, irrigation, fertilization, spraying against insect-pests and diseases were followed as per crop requirements. The healthy spikes harvested early in the morning at a stage when basal floret just started showing color were used for conducting experiment.

Preparation of herbal extracts for vase solution

For preparation of herbal extracts, fresh mature leaves of neem, tulsi, brahmi and fresh mature rhizomes of turmeric were used. Raw material was washed thoroughly 2-3 times with distilled water and then sanitized with NaOCl @ 50 microgram/ml (Ritenour *et al*., 2002). Material was then shade dried and powdered for further use. Alcoholic extracts were prepared by dissolving the known weight (10g) of dried powder of herbs (Neem, Tulsi, Brahmi and Turmeric) in known solvent volume (100 ml of 95% ethanol) in conical flasks. Solution is mixed properly by keeping in rotary shaker (190-220 rpm for 24 hrs), then filtered and subsequently centrifuged at 5000 x g for 15 minutes. Supernatants were collected and stored for further use (Abubakar and Haque, 2020). These filtered extracts were taken in the study as 100% extract and diluted to desired concentration of 2% to be used in vase solution as per the experimental requirements. Major bioactive compounds reported to be present in used herbs are; Azadirachtin, nimbin and nimbidine in neem (Mondali et al., 2009); Eugenol, eugenic acid, urosolic acid, carvacrol, limatrol, caryophyllene, methyl carvicol in tulsi (Shah and Qadry, 1995; Pattanayak *et al*., 2010); curcumin in turmeric (Kocaadam and Sanlier, 2017); bacoside-A and bacoside-B in brahmi (Mathur *et al*., 2016).

Treatment of spikes

After recording the fresh weight and length of spikes, they were placed in glass bottles filled with 600 ml. vase solutions containing different herbal extracts @ 2% concentration, viz; neem (*Azadirachta indica*) leaf extract, tulsi (*Ocimum sanctum*) leaf extract, brahmi (*Bacopa monnieri*) leaf extract, and turmeric (*Curcuma longa*) rhizome extract along with the untreated control containing distilled water only. Neck of the glass bottles was covered with aluminium foil after placing the spikes to check evaporation of the solution.

Data collection and analysis of variance

Observations were recorded for the different parameters of post-harvest longevity and quality during both the years as per treatments and then subjected to analysis of variance (ANOVA) using Factorial CRD year wise and pooled analysis for both the years as described by Gomez and Gomez (1984).

Formula used for calculation of relative fresh weight (%)

Each spike was weighed on electronic weighing balance on 4nd and 8th day of vase life. Data were obtained to calculate fresh weight changes and consequently relative fresh weight (RFW) of the cut spikes according to following formula.

$$RFW\ (\%) = (Wt/Wt_0) \times 100$$

where Wt is the weight of stem (g) at t = 4th and 8th day of vase life. $Wt_{0\ is}$ the weight of same stem (g) at t= 0 day i.e. initial weight taken (He *et al*., 2006; Liu *et al.,* 2009).

RESULTS AND DISCUSSION

Pooled results of data recorded for two years have been presented and discussed here under. Slow opening of floret is the desired character for cut spikes to last long in vases. Treatment with neem extract showed slow opening of basal floret among all (4.81 days) which was found to be at par with Tulsi extract (4.56 days), whereas, control resulted in early opening of basal floret (2.58 days). Among varieties, Peter Pears (V_4) took maximum time (4.31 days) for basal floret opening which is observed to be at par with Morning Gold (V_2) and Black Star (V_3) showed earliest opening of basal floret (3.43 days). Among

Table 1. Effect of herbal extracts on opening of basal floret (days) and size of basal floret (cm) in different varieties of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Opening of basal floret (days)					Size of basal floret (cm)				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	4.60	5.21	4.39	5.08	4.81	11.40	10.50	9.82	12.42	11.04
H_2	4.31	5.00	4.08	4.86	4.56	10.72	10.02	9.40	11.73	10.47
H_3	3.42	4.09	3.07	3.88	3.62	10.09	9.37	8.37	11.04	9.72
H_4	3.92	4.51	3.26	4.68	4.10	10.33	9.76	8.66	11.33	10.02
H_5	2.31	2.58	2.36	3.06	2.58	9.13	8.10	7.27	10.52	8.75
Mean	3.71	4.28	3.43	4.31		10.33	9.55	8.70	11.41	
			S.E.±		CD (5%)		S.E.±		CD (5%)	
Variety			0.119		0.340		0.119		0.340	
Herbal extract			0.133		0.380		0.133		0.380	
Varieties × Herbal extracts			0.266		N.S.		0.266		0.761	

interaction, H_1V_2 (Morning Gold spikes treated with Neem extract) showed slow opening (5.21 days) and H_5V_1 (untreated spikes of Nathan Red) showed early opening of basal florets (2.31 days) (Table 1). Slow opening of florets in the vases which is highly desired for the extended longevity of spikes in gladiolus and same was observed in spikes treated with *A. indica* extract (neem) @ 2%. This could be due to the fact that neem extract might have guided the slow depletion of carbohydrates keeping the reserves for further opening of florets whereas in case of control the depletion of carbohydrates would have been more for basal floret opening leading to its rapid opening as flower opening has been reported to be dependent upon carbohydrates reserves available in the cut flowers (Van Doorn *et al.,* 1991). Varied response of different varieties could be attributed to the variations in their ability in utilisation of food reserves that is directly correlated to the genetic differences among them (Maguvu *et al*., 2013). Variety peter pears might have better genetic constitution that enables it to use its resources effectively that ended up in slow opening of florets.

Larger basal floret (11.04 cm) was found in treatment of neem extract (H_1) whereas, minimum (8.57 cm) in Control (H_5). Among varieties, Peter Pears recorded maximum basal floret size (11.41 cm), whereas, minimum (8.70cm) was observed in Black Star. Interaction of neem extract @ 2% and Peter Pears (H_1V_4) resulted in bigger basal floret (12.42 cm) which was found to be at par with H_2V_4 (11.73 cm), whereas, smallest basal floret was observed in untreated spikes of Black Star (H_5V_3) (7.27 cm) (Table 1). Inclusion of the antibacterial compounds like the herbal extracts in the vase solution inhibit the vascular blockage and enhance the soluble carbohydrates absorption by the spikes which might be the reason for increased size of basal floret with *A. indica* (neem) extract @ 2% . The results found support from findings of Eshaghdavatgar *et al.* (2013) who recorded highest flower diameter in rose when cut stems were treated with 0.1 ppm thyme extracts. Maximum size of the basal floret was achieved in Peter Pears which is attributed to the inherent genetic potential of the variety. The findings of Babarabie *et al.* (2015) were also consistent with our study where they have recorded that Rosemary essential oil significantly increased the flower diameter of alstroemeria cut Flowers. The results of Karimi *et al.* (2011) showed that the treatment of 600 and 800 mgl^{-1} rosemary essential oil increased the cut rose diameter.

Number of florets remained open at a time were maximum in neem extract @ 2% (6.56) and in untreated (H_5) spikes it was minimum (4.64). Among varieties, Peter Pears (V_4) showed maximum (6.30) and variety, Black Star (V_3) showed minimum (5.02) florets remained open at a time. Among interactions, maximum florets remained opened at a time (7.02) in H_1V_4 which was found to be statistically at par with H_1V_2 (6.83), H_2V_4 (6.64), H_1V_1 (6.57), H_4V_4 (6.43) and H_2V_2 (6.42). However, minimum florets remained open at a time (4.21) in H_5V_3 (Table 2). Display of maximum number of floret at a time depicts better quality and in the vase solution containing neem extract, it could be attributed to the better water uptake that helped in maintaining the turgidity and freshness of florets for long time (Memon *et al*., 2012; Sharma *et al*., 2016). Increased water uptake helps in proper substrate distribution and increases the capability of young floret sinks resulting in more floret opening (Hutchinson *et al*., 2003). It might be due to the slow depletion of carbohydrates in the neem extract treated spikes which ensure its proper utilization by the opening florets to last long on a spike. Another possible reason could be the exclusion of pathogens that damage the florets as *A. indica* extract (neem) possess

Table 2. Effect of herbal extracts on number of florets remained open at a time and increase in spike length (cm) in different varieties of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Number of florets remained open at a time					Increase in spike length (cm)				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	6.57	6.83	5.84	7.02	6.56	15.10	16.71	12.47	17.49	15.44
H_2	6.10	6.42	5.25	6.64	6.10	14.16	16.00	11.72	16.61	14.62
H_3	5.49	5.59	4.70	6.19	5.49	11.27	14.45	10.89	14.65	12.81
H_4	5.64	5.91	5.11	6.43	5.78	12.21	15.23	11.30	16.02	13.69
H_5	4.72	4.42	4.21	5.21	4.64	9.69	12.34	9.67	12.38	11.02
Mean	5.71	5.84	5.02	6.30		12.49	14.95	11.21	15.43	
			SE.±		CD (5%)		SE.±		CD (5%)	
Variety			0.102		0.293		0.224		0.641	
Herbal extract			0.114		0.327		0.251		0.717	
Varieties × Herbal extracts			0.229		0.655		0.502		1.435	

antifungal and antibacterial properties which protect the spikes from harmful bacteria and fungus in vase solution leading to retention of florets on spike for long. Better results with herbal extracts can be correlated to the findings of Hegazi and Gan (2009) where they recorded highest number of open florets when fennel oil was added to preservative solution containing $AgNO_3$ as compared with control. Significantly higher number of opened florets in variety Peter pears could also be attributed to its better genetic makeup that enables it to uptake more in comparison to other varieties and also to its thicker stems that indicates more food reserves and ability to withstand limiting conditions in vases.

Maximum increase in spike length (cm) was observed in spikes treated with neem extract @ 2% (15.44 cm) and found be statistically at par with spikes treated with tulsi extract @ 2% (14.62 cm), whereas, control resulted in minimum increase in spike length (11.02 cm). Under the effect of varieties, increase in spike length was recorded maximum in Peter Pears (15.43 cm) followed by Morning Gold (14.95 cm), where both found at par. However, increase in spike length was recorded minimum (11.21cm) in Black Star variety. Among interactions, increase in spike length was found maximum (17.49 cm) in H_1V_4 which was found to be at par with H_1V_2 and H_2V_4. However, it was recorded minimum (9.67 cm) in H_5V_3 (Table 2). Increase in spike length indicates the floret opening and maximum floret expansion of the spike with better hydration status. Increased elongation of spike may be attributed to more water uptake in spikes treated with neem extract @ 2%. Similar findings have been reported by Kumar *et al*. (2008) where maximum water uptake correlated with maximum increase in spike length at senescence. Due to better stem thickness and more surface area for water absorption, variety Peter Pears led to maximum water uptake and attained maximum increase in length of spike.

Herbal extract treatments and varieties also showed significant variations for relative fresh weight (RFW) (%) (Table 3). Vase solution containing neem extract (2%) and tulsi extract (2%) showed higher RFW (on 4th day) than other treatments (117.14% and 114.81% respectively), whereas it was observed least (105.86%) in control (H_5). Varieties showed non-significant differences for RFW on 4th day. Where, maximum RFW (113.93%) was attained in Peter Pears and minimum (112.09%) in Black Star. Interaction of herbal extracts x varieties were also non-significant where H_1V_4 recorded maximum (118.68%) and (H_5V_3) recorded minimum (105.10%) RFW on 4th day. On 8th day RFW was recorded significantly maximum (104.60%) in Neem extract and minimum (88.90%) in control. Among varieties, it was maximum (101.05%) in variety Peter Pears which was statistically equivalent with Morning Gold (100.23%) and Black Star variety recorded lowest RFW on 8th day (97.17%). Interaction of treatments x varieties was found non- significant, where in H_1V_4 maximum RFW (105.75%) and in H_5V_3 minimum RFW (84.62%) was recorded on 8th day. Relative fresh weight indicates the water status of the cut spikes and it need to be higher in order to maintain quality of spikes for longer duration. Increase in relative fresh weight was observed during the first four days and then it showed decreasing trend till end of the experiment. Similar changes in relative fresh weight were also reported in cut alstroemeria by Soleimany-Fard *et al.* (2013) and for cut roses by Lu *et al*. (2010). Fresh weight is attributed to highest uptake of water and better development of corolla (Hajizadeh et al., 2012). As Sharma *et al.* (2016) reported higher water uptake in gladiolus spikes kept in vase solution containing neem extract, in present experiment also,

Table 3. Effect of herbal extracts on relative fresh weight (RFW) (%) at 4th day and 8th day in different varieties of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Relative fresh weight (RFW) (%) at 4th day					Relative fresh weight (RFW) (%) at 8th day				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	115.97	117.08	116.83	118.68	117.14	104.05	104.72	103.86	105.75	104.60
H_2	115.26	114.54	113.67	115.75	114.81	102.64	102.80	100.54	103.79	102.44
H_3	112.34	112.94	111.90	114.02	112.80	99.02	100.36	96.87	102.29	99.63
H_4	113.76	113.14	112.92	115.10	113.73	101.05	101.22	99.98	102.85	101.28
H_5	105.40	106.81	105.10	106.11	105.86	88.37	92.05	84.62	90.56	88.90
Mean	112.55	112.90	112.09	113.93		99.03	100.23	97.17	101.05	
			S.E.±		CD (5%)		S.E.±		CD (5%)	
Variety			0.733		N.S.		0.553		1.580	
Herbal extract			0.819		2.342		0.618		1.766	
Varieties × Herbal extracts			1.638		N.S.		1.235		N.S.	

neem extract might have enhanced the relative fresh weight through improving water uptake by spikes. Consequent decrease in relative fresh weight with time can also be correlated to decrease in water uptake by cut spikes (Serek *et al*., 1995). Similar findings were reported by Alaey *et al*. (2011) with cut rose stems where they found highest relative fresh weight in vase solutions which observed highest water uptake. Varietal difference for relative fresh weight where peter pears had highest RFW and Black star had lowest can also be attributed to their varying potential to water uptake.

Inclusion of herbal extracts in vase solution remarkably improved the vase life of gladiolus spikes where, Neem extract performed better in comparison to other treatments and recorded maximum vase life (11.76 days) that is 2.49 days more than control which recorded minimum vase life (9.27 days). Varieties performance also affected vase life as Peter Pears lasted longer in vases with maximum vase life (11.46 days) and variety Black Star lasted shorter with minimum vase life (10.39 days). Among interactions, highest vase life (12.50 days) was observed in Spikes of H_1V_4 treatment which was found to be at par with H_2V_4 and H_1V_1. Vase solution comprising of only distilled water in case of Black star variety (H_5V_3) recorded minimum vase life (8.65 days) (Table 4). Vase life extension is the ultimate aim of florist's as it marks the enjoyment of flowers in vases for longer time. Different Plant extracts can be widely used to prevent the microbial proliferation on the vase solution, which in turn will extend the vase life of cut flowers (Julia, 1992). The results obtained are supported by findings of Anisha (2013) where she found

Table 4. Effect of herbal extracts on vase life (days) and total blooming period (days) in different varieties of gladiolus (*Gladiolus grandiflorus* L.)

Treatment	Vase life (days)					Total blooming period (days)				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
H_1	11.81	11.51	11.22	12.50	11.76	16.73	17.32	15.50	17.97	16.88
H_2	11.33	11.07	10.95	12.09	11.36	16.50	16.73	14.90	17.72	16.46
H_3	10.12	10.42	10.42	11.16	10.53	15.26	15.57	13.52	16.35	15.18
H_4	10.80	10.67	10.72	11.60	10.94	15.93	16.55	14.05	16.93	15.86
H_5	9.07	9.40	8.65	9.97	9.27	10.58	10.94	10.32	11.74	10.90
Mean	10.63	10.61	10.39	11.46		15.00	15.42	13.66	16.14	
			S.E.±		CD (5%)		S.E.±		CD (5%)	
Variety			0.118		0.338		0.107		0.307	
Herbal extract			0.132		0.378		0.120		0.343	
Varieties × Herbal extracts			0.264		0.757		0.240		0.687	

*V- Varieties; V1- Nathan Red, V2- Morning Gold, V3- Black Star, V4- Peter Pears

**H- Herbal extracts; HI- Neem (*Azadirachta indica*) leaf extract @ 2%, H2- Tulsi (*Ocimum sanctum*) leaf extract @ 2%, H3- Brahmi (*Bacopa monnieri*) leaf extract @ 2%, H4- Turmeric (*Curcuma longa*) rhizome extract @ 2%, H5- Control.

maximum zone of inhibition for bacterial activity with 10% betel leaf extract followed by 10% neem extract and 10% garlic extract whereas no zone of inhibition in control which could be the reason for increased vase life with neem extract. Pulsing of flowers with 4% sucrose + 0.25 ppm azadirachtin for four hours resulted in increased vase life in case of rose (Gupta, 2011). Another possible reason is the enhanced water uptake with neem extract with maintenance of maximum fresh weight in this treatment led to better vase life. Significant differences in varieties for vase life appeared due to correlation among different associated factors of vase life and quality viz., relative fresh weight, size of basal floret, increase in length of spike.

Blooming duration of spikes was observed longest in neem extract treated spikes (16.88 days), whereas, untreated spikes showed shortest blooming duration (10.90 days). Among varieties, Peter Pears displayed blooms for longest duration (16.14 days) and variety Black Star observed shortest blooming period (13.66 days). Among interactions, H_1V_4 displayed largest total blooming period (17.97 days) and found to be statistically at par with H_2V_4 (17.72 days) and H_1V_2 (17.32 days). However, in H_5V_3, blooming period remained shortest (10.32 days) (Table 4). Display of maximum florets for longer duration in vases indicates the quality of spikes and is observed from first floret opening to last floret wilting on the spike. Spikes treated with *A. indica* (neem) extract @ 2% recorded maximum blooming period which means the nearly all the buds in these spikes opened up. Neem extract have extended the blooming period by delaying the senescence. This could be due to antagonising the effect of ethylene or by delaying the natural rise in ethylene. This can also be correlated to the sequential opening of the florets at slower rate that enable the opening of maximum florets that lasted longer. Genetic differences among the different varieties could be considered as reason for variation in total blooming period due to varieties as genetics play a major role in variety performance (Nell and Leonard, 2005).

Overall, Herbal extracts treatments displayed better post-harvest keeping quality in vases than the untreated spikes. In vases, major proliferating bacteria are; Enterobacteriaceae, *Pseudomonas sp*., *Delftia sp*., *Agrobacterium* sp., *Sphingobacterium multivorum*, *Acinetobacter johnsonii*, and Clostridiaceae. Their proliferation blocks xylem vessels and it restricts the water uptake by stems causing, wilting and early senescence. Neem leaf extract have been a proven antimicrobial agent against many of these microbes (Valarmathy *et al*., 2010) due to the presence of numerous bioactive compounds, especially limonoids. This clearly indicates that if neem extract is added in vase solutions it can prevent the harmful microbial build up in vases and can keep better post-harvest quality. Buildup of reactive oxygen species (ROS) and low antioxidant activities causes oxidative stress to the flowers and deteriorate quality. Phenolic compounds present in plant extracts acts as strong antioxidants and scavenges ROS. Neem extract have also been reported to be a rich source of phenolic compounds with antioxidant properties (Lores *et al*., 2014), therefore in the present studies, post-harvest quality traits were found better in spikes treated with neem extract and also in other extracts compared to control.

From the recorded results, it is evident that herbal extracts can be used as ecofriendly alternative to the harmful vase solutions. Among all, neem (*A. indica*) leaf extract @ 2% can be recommended for use and variety Peter Pears can be used for display and decoration purposes due to better vase life and quality traits.

Authors' contribution

Conceptualization and designing of the research work (SK); Execution of field/lab experiments and data collection (RS); Analysis of data and interpretation (RS); Preparation of manuscript (RS).

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