THE DEVELOPMENT AND KEEPING QUALITIES OF FLOWERS AFTER PICKING

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If one realizes that at least fourteen commercial preparations for prolonging the life of cut flowers have found their way onto the market one must accept that there exists an important function for such compounds. One group of these compounds is based on scientific research amongst others that of Arnold (2), Laurie (14), Martens (16), and Pastac and Driguet (20). The results of this research give absolutely no idea as to what formula or method of synthesis which may be generally applicable. In addition, an explanation for the varying results is absent. Therefore we desire to get a deeper insight into the life processes of the flower after cutting and the possibility of influencing these favorably.

1. Introduction

The flowers do not all lose their attractiveness in the same way. Some work suddenly (Tigridia) or gradually (Dahlia), others drop their flowers complete (Lupinus) or partially (Tulipa). Roughly speaking, one can divide the causes of wilting as follows: (a) obstructions in the water supply; (b) loss of osmotic pressure of the cell; (c) change in the plasma structure because the metabolism is disturbed when one substrate is absent, or because of the uptake or accumulation of harmful substances.

In the physiology of the cut flower all these processes play a role. The following factors have great influence on the abscission of plant parts: temperature, water content, low oxygen tension, too high carbon dioxide tension, nitrogen and calcium deficiency and carbohydrate and growth substance deficiencies.

2. Prevention of wilting

2.1 Improvement of water supply. When bacteria develop in water, one usually observes a quick blocking of the vascular bundles. By the addition of the bacteriacide, this can usually be avoided. The most important difficulty here is that the substance must not be damaging to the plant, yet must stop the development of the bacteria completely.

The best results are obtained with silver nitrate--0.003 per cent plus calcium nitrate 0.1 per cent, plus very small amounts of an organic mercuric compound, e.g., AAradon 0.001 per cent. For the prevention of mold development one must add a fungicide, e.g. Captan or 2-4 dinitrochodane benzine without spreader. (Cladox filtrate 1-40 of a saturated solution).

By the addition of these chemicals, the blocking of the vascular bundles is delayed if not completely prevented. Also the plant itself can actually block its vascular bundles. These blocks occur much higher in the stem and are of less importance.

2.2 The prevention of other causes of wilting. Little is known about the causes of wilting of uncut flowers. In some cases the flower drop is

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hastened by pollination, e. g. in Phalaenopsis (11), but according to Fitting the opposite also occurs, e.g. in Zygopetalum mackaii, Z. crinitum, Lycaste skinneri, Lystera ovata, and other orchids. Application of growth substances to the style and damaging of the style can likewise lead to the death of the flower (13). Also, ethylene, illuminating gas and a too high carbon dioxide tension can frequently shorten the life (8, 9, 10).

A lengthening of the life span by growth substances is obtained by Whiteman (13) in Paeonia and Convallaria and by Wester and Marth (3), in varieties of Prunus serrulata and in Cornus florida. Griesel (12) found in a favorable influence of maleic hydrazide. Growth substances do not behave differently only as wilt inducing substances and the so-called anti-growth substances are not necessarily inhibitors of the flowering process. Also, chamical analysis of the flower before, during and after wilting gives us li knowledge. Combes found that in Lilium croceum mineral substances (5), nitr compounds (6), and also carbohydrates (7) disappeared from the flower shortl before wilting. Schumacher (25) shows an increase until shortly before the wilting of the flower and a strong decrease during the wilting. This decre is not the cause, but rather the result of the wilting and it is explained one compares the results Van Herk (26) obtained with the spadix of Sauromat with those of James and Beevers (14) with the spadix of Arum. They find d the wilting a strong increase in respiration as a result of an increase en activity chiefly of flavor proteins. Nothing was definitely known about t ultimate cause of the increased enzyme activity.

In certain experiments no definitely favorable effects on the keepi qualities of the flowers were found with the growth substances, anti-growt substances and enzyme inhibitors which are generally used; also, the influence of mineral salts was small or absent. However, it was observed in a large number of cases that sugar had a favorable influence. The influence of sugar apparently resides in the fact that the sugar normal lost in respiration is supplemented and the decrease in osmotic pressure of the cell sap is prevented. The cell can thus maintain its osmotic tension. Besides this one can prevent a decrease in the respiration by the application of sugar so that the plant does not have to make any demands on its own tissues. Also, the application of sugar frequently forms the building block for flowers that have not yet fully developed, so that no sugar needs to be taken away from mature flowers for this development.

That sugar is primarily used as a respiratory substrate is not surpri ing, since the sugar requirement is greatest when the respiratory rate is highest; and, for many flowers, this is at the time of development shortly before the flower opens.

3. The prevention of flower drop.

3.1 Influence of growth substances and water.

The flower drop of beans (11), tomatoes (23), Begonia (28) and Lupi (27) can be prevented by spraying with growth substances. The results of (27) with lupins can be substantiated if in sunny weather the flowers are sprayed with the potassium salt NAA (0.05%) one day before they are cut. the drop of male catkins of Alnus glutinosa and Corylus avellana can be p by growth substances (Fig. 1).

Table 1 gives a summary of certain results with Alnus glutinosa. It can be seen that NAA in water in concentrations of 0.00% and higher retard the

normal development of the catkins. The remaining treatments had no influence on the development of the catkins. The immersion or spraying thus gives better or just as good results as the application in the water medium. In this test it was sufficient to immerse the stems without wetting the catkin. After application with growth substances the catkins remain hanging freely and some were turgid even after 3 months. The potassium salt of NAA was effective in lower concentrations than IAA (Table 1).

The application of maleic hydrazide in the water (0.005%) or by immersion (0.001 and 0.02%) did not have any influence on the drop of the catkins, and had no influence on the efficiency of the growth substances.

If the catkins are cut shortly before opening and then suddenly exposed to very strong sunlight and high temperature, a preceding vacuum infiltration with pure water had a favorable effect on the fall of the catkins.

* related to rose under stress

3.2 Influence of sugar

Although Wester and Marth (29) could lengthen the flowring period of Prunus serrulata and Cornus florida by spraying with various growth substances and Whiteman could prevent the crown drop of Paeonia with 50 parts per million NAA this does not seem to be possible with Antirrhinum majus, Digitalis purpurea, Tulipa stellata and Delphinium ajacis. Application by spraying (NAA 0.01 and 0.05%) or by way of stem (0.0001/0.002%) had no influence. With Tulipa stellata, Rosa (Tea hybrids) and Lathyrus odoratus the crown fall can be overcome by spraying with sugar. With Tulipa stellata variety eclipse all the petals and anthers fall off when no sugar is given; with 4% saccarose the sepals began to wilt after 18 days but did not fall off. With cut branches of Ribes sanguineum and Laburnum anagyroides the flowers fall off completely after 5 or 6 days; by the application of 2% saccharose the blossom fall is completely prevented and finally the dried-up flowers remain on the fruits developed from these flowers (Fig. 3).

4. Application in the home.

Often the vascular bundles are completely blocked after 2 or 3 days. Therefore, the addition of a bactericide to most plants that are kept longer than four days has a favorable effect.

If the flowers are not fully developed at the time of cutting a combination of sugar and a bactericide is almost always beneficial (Fig. 4). It thus seems to us to be fairly good for all composite flower types and also for Rosa hybrids, Dianthus caryophyllus, Dahlia variabilis, composite chrysanthemums and other cut flowers. This series can be expanded with cwops which are cut when open as well as Pyrothrum, Chrysanthemum and Lathyrus.

But if one wants to prepare a general working mixture, then one comes to the difficulty that the optimal sugar concentrations differ for the different crops and developmental stages (Table 2).

5. The flower during storage at low temperature.

Thanks to the work of Neff (18, 19), Neff and Loomis (20), Post and Fischer (23), Mastalerz (16) and Bunemann and Dewey (4) it is now possible to store a large variety of cut flowers at low temperatures for a long time.

Very good results are obtained, especially with carnation and Tagetes patula, when dry stored in an air tight space at 0.5 degrees C. This was

confirmed in our experiments with carnations but with Freesia dry storage in air tight spaces at 0.5° C. led to severe damage.

The keeping of Dahlia is very much improved by the addition of sugar when stored in water at 2.5° C.

Preliminary experiments with Freesia showed that the oldest flowers which had already developed, or developed during storage, were moderately damaged, and the youngest developed normally after storage if they had stood in a sugar solution at least during the storage (Fig. 6).

The experiment was repeated with very young buds of Freesia. For this purpose, thin side branches of cut Freesia, variety Prinses Marijke in a normal condition were used. Such normal development of the buds is only possible if they are given sufficient sugar (7). After four weeks at 0.5° C. it seems that the development and keeping qualities of these buds can be freely compared with fresh buds, provided they received as much sugar (16%) as possible during the time of cooling (Fig. 7).

If, during the period after the storage, no sugar is added, the influence of sugar during the storage is very noticeable, but the development was still more noticeable if the flowers were placed in saccharose (8%) after the storage (Fig. 8).

The stems which were cut in normal condition drooped during storage in 16% saccharose (plasmolyse). The oldest flowers wilt shortly after the cooling and only the youngest buds develop if they have received sugar during the cooling.

In the case of a carnation cut when open, the application of sugar (16 to 8%) during the storage at 0.5° C. had no effect and noticeably better results were obtained with dry storage in an air tight cylinder.

6. The forcing of lilac branches.

The vascular bundles of lilac are very narrow, and their water conductivity is slight (Table 3). Besides, the rough stem hinders the disinfection with chemical compounds. To keep water free of bacteria at a temperature of 20 to 25° C. it was necessary with all bactericides tested to change the water after one week. Next in importance to the addition of a bactericide, the addition of sugar was necessary. The optimal concentration was about 3% (Figs. 9 and 10).

Especially with the variety Madame Florent Stepman, just before and during the development of the white of the corolla, black brown necrotic spots appear on the corolla, stigma, and ovary. Thus the flower development is r

By the application of boric acid (0.0025 - 0.02%) the appearance of spots can be prevented. In high concentrations (0.01 to 0.02%) boric acid tards the development but lengthens the keeping quality (Fig. 10).

In one experiment begun on 19/2/57 no necrotic spots developed without boric acid but there appeared to be a favorable influence of boric acid on the keeping qualities. Glycerine 0.2%, especially in combination with boric acid, had a favorable effect (Fig. 10). Inorganic salts and urea had no effect on the development of lilac. The limiting factors for the good development of lilac branches are thus: (2) blocking of the vascular bundles. (b) sugar.

(c) boric acid. (d) winter rest (to be broken by low temperatures, warm water baths, etc.).

Conclusions:
If one analyzes the causes of wilting in flowers one comes to the following conclusions:

1. To prevent wilting an unrestricted water supply is necessary. The development of bacteria in the water must therefore be prevented.

2. Next, it is necessary that the sugar level of the cells must be maintained. One thereby prevents a shortage of oxidizable substrates and the loss of the osmotic pressure of the cell is prevented.

Slowing down of the respiratory rate with growth substances, inhibitors or enzyme poisons was not possible. The only remedy against wilting at the moment appears to be the administration of sugar through the stem.

3. The effect of sugar is the greatest if it is applied in the young flower stage. On one hand the need of sugar is greatest, and on the other hand the possibility for the uptake of sugar is most favorable.

4. The optimal sugar concentration for the different crops varies greatly.

During cooling, sugar has a favorable effect with Dahlia and Freesia. Especially here, the aging pressures must not be too advanced.

For the forcing of lilacs as cut branches boric acid as well as a bactericide and sugar is necessary.

Against early flower fall growth substances can be applied in isolated cases. With tulip, Lathyrus, rose, red berries, and golden rain, sugar alone has a favorable effect against flower drop.

Discussion:
Dr. P. N. L. Tammes: To what degree does the osmotic concentration of the sugar play a role? The osmotic concentration of glucose, for example, when compared on an equal weight basis is about twice as great as that of saccharose.

Answer: The effect of saccharose and glucose in equal weight per cc is approximately the same according to Said (Nature, Vol. 162, 1948: 496). Saccharose is hardly taken up in barley leaves after hydrolysis. The influence of equal weights of glucose and saccharose on the osmotic concentration of the cell sap of the flower was also approximately equal.

Dr. J. Wasscher:
1. In practice a lot of chlorine water is used. Alsmeer advises against this because of the accompanying injury when sugar is deficient.

Answer: Chlorine loses its bactericidal action in combination with sugar and isinjurious to the undeveloped flowers. With fully developed flowers one can sometimes observe a favorable effect.

2. You suggested that a higher CO_2 is injurious while Van Stuivenberg sometimes gets good results.

Answer: The carbon dioxide storage (dry in an airtight container) must never be longer than 6 to 7 days, and above all, as Mr. R. H. De Haan noticed, the treatment was only favorable at a low temperature. This was also mentioned by Bunemann and Dewey (14) with tulips.

3. During the cooling of dry flowers at 31 degrees Fahrenheit, does the turgidity of the flowers and the humidity have an influence?

Answer: According to Neff (18) one slows down the development of carnations by allowing the turgor to be partly lost without further drying arts. The development still carries on when stored in water at 31° F.

4. Do only ripening, or also ripe fruits, give off ethylene?

Answer: The ethylene production of repening fruit reaches its maxi during the climacteric, but can also remain at a high level thereafter.

5. With some flowers (roses) a concentration of commercial preparations is favorable for the flowers but sometimes injurious to the leaf.

Answer: Injurious precipitates often accumulate at the end points of the sap stream in the leaves, and in young flower buds. Open flowers do not transpire much and are therefore not often quickly damaged.

6. In England, people pack flowers in plastic bags filled with nitroge Do you know an explanation for this?

Answer: Possibly one slows down the normal respiration with the chance apart from that of an injurious anaerolic breakdown.

R. H. De Haan

1. W hat influence do the various substances have on the petal of th cut flowers?

Answer: Silver nitrate in the given concentrations was never injuri to the petal; with sugar and a strong light, the petal frequently becomes yellow or even white, but remains turgid. Inorganic salts and bactericides high concentrations frequently result in petal damage.

2. What is the influence of hot water on the leaf stalks of wilted

Answer: Possibly the air bubbles are driven out of the vascular bu by this treatment. Thereafter the ensymes which play an actual role in th blocking of the vascular bundles are broken down.

Ir. D. Bloemsma

1. Have you calculated the cost of the sugar-bactericide combination?

Answer: No, the bactericide is used in low concentrations and is, therefore, inexpensive. Sugar mainly determines the price.

2. By spraying with NAA the fruit set is strongly promoted. Later this increased flower set falls off.

Answer: With holly no new knowledge is gained. Later there possibly develops a deficiency in assimilation.

Prof. Dr. Ir. S. J. Wellensiek:

What is the influence of the amount of water in the vase?

Answer: The active blocking of the vascular bundles by the plant itself is an aerobic process. In deep water less oxygen is available and less blockage is measured. On the other hand, it is found that with some crops, the chance of infection by fungi, even above the water level, becomes greater if the water level is high e.g. with soft-stemmed tissues.

A. J. Vander Graaf: Can more silver nitrate be added when the water contains more chloride? Does silver chloride have bactericidal action?

Answer: Silver chloride has no physiological influence on bacteria and plants. Enough silver nitrate must be added that + 0.001% silver nitrate still remains in solution.