ABSORPTION DYEING OF CUT CARNATIONS [1]

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Flowers can be readily colored when the cut stem ends are placed in certain water-soluble dyes. The blossoms become colored when dye molecules which are carried along in the water of the transpiration stream accumulate in the petals. The speed and extent of flower coloration can be affected by the chemical nature of the dye molecule, the rate of transpiration of the cut flowers and the ease of dye uptake and translocation. This technique of flower coloring, called absorption dyeing, is popular with carnation growers for several reasons:

(a) Unnatural colors can be achieved for special occasions, such as green flowers for St. Patrick's Day.

(b) A single white variety can be grown for dyeing. This avoids the oversupply or shortage of certain colors at different times of the year.

(c) There is less likelihood of clothing being stained by absorption-dyed flowers than by flowers which are dyed by dipping or spraying.

In spite of the widespread use of absorption dyeing, the technique has by no means been perfected. For example, there is no available reference list of dyes which are taken up by carnations, and no way of predicting which dyes will be taken up by examining their structural formulas. Many dyes are taken up by cut carnations very slowly and some dyes produce an uneven intensity of coloring among different flowers in the same lot.

In two previous papers on the subject of absorption dyeing, the importance of the pretreatment of the cut flowers before dyeing has been emphasized. An Ohio Florists' Bulletin article (3) recommends wilting cut flowers for three to four hours before dyeing in a warm dye solution (80° - $100^{\circ}F$) for 30 to 60 minutes. Holley, in a recent article (2) also recommended either wilting freshly cut flowers or using cut flowers from dry storage. In either case it is recommended that the stems be freshly recut before dyeing. Wilting the flowers creates a rather uniform moisture stress which, along with recutting the stems, predisposes the cut flowers to a rapid and uniform uptake of dye.

The use of flowers from a uniform, well grown crop, as further recommended by Holley, would also contribute to the uniformity of the dye uptake.

Materials and Results

Screening dyes:

Over 100 water soluble dyes were tested for their speed of uptake, color, and ability to move on filter paper. The mobility of dyes on paper was found to be closely associated with their mobility in the carnation stems as will be described further.

Table 1 shows a summary of results of dye screening along with the generic Colour Index hue names, common names of the dyes, and the Colour Index numbers.

[1]Paper No. 1177 Misc. Journal Series of the Minnesota Agricultural Experiment Station, University of Minnesota

The Colour Index hue name and numbers (1) are useful in ordering dyes because it avoids the confusion resulting from duplicate common names. It is advisable to order a substantial quantity of a suitable dye from a single dye lot because different lots of the same dye vary somewhat in color even when made by the same manufacturer.

The procedure used to screen the dyes listed in Table 1 was uniform in all cases. White Sim carnation flowers from dry storage were warmed to room temperature; stems were recut and the cut stem ends were placed in the dye solution at 75°F for 40 minutes. Stems were recut after dyeing and plants were held over night at 75°F in water prior to visual evaluation.

The mobility of the dyes on Whatman No. 1 filter was established by running each dye on a one-dimensional descending chromatogram (4) using either water or a carnation stem slurry as a solvent. The mobility ratings listed in Table 1 are based on the slurry technique which involves grinding equal volumes of carnation stems and ice (to prevent excessive heating) in a Waring blender. The resulting mixture was filtered through cheesecloth and the liquid filtrate was allowed to move over the filter paper by capillarity, carrying with it the mobile dyes which were previously spotted on the paper.

Table 1 shows that the dyes which moved well on the filter paper also moved well in flower stems and that the dyes which did not move on paper were equally immobile in flowers. This technique is a very convenient means of screening a large number of dyes for their suitability for flower dyeing.

In general, basic dyes were immobile as compared to dyes of a more acidic nature. It has been theorized that many dyes which are not taken up by flowers are of such a large molecular size that their movement in the conducting elements of the plant stem is restricted. This was not found to be the case. Many dyes of large molecular size worked well while many dyes of small molecular size did not move at all in the flower stem.

An attempt was made to determine whether certain groups on the dye molecule were correlated with the mobility of dyes in the plant. Many of the dyes which worked well had a monoazo dye nucleus with assorted active chemical groups attached to the rings. When the benzene rings were substituted with halogens such as bromine and iodine, or when = (double bonded) oxygen or rings containing sulfur were present in the molecule, the dyes were generally not translocated in the plant. There is no simple chemical explanation for this. Although the relationship is interesting, it is still easier to find out which dyes will work by trying them than by looking at their structural formulas.

Another useful feature of the chromatographic technique is that it reveals the presence of impurities in dyes and separates the different dyes in a mixture. This is useful in identifying the various dye components in commercial mixtures of dyes used to produce special shades. It is interesting that all of the commercial dye mixtures tested were made up of various proportions of a limited number of the same dyes, such as those listed in Table 1. This makes it difficult to accept a published statement (2) that commercial dyes from a certain company "for one or more reasons are most satisfactory".

The dye solution:

Stock solutions of dye made up at a concentration of 60 grams (about 2 ounces) of dye per gallon of water were found to be satisfactory. This makes a solution of about 1.6 percent dye which is considerably more dilute than the 16 grams per gallon used by Holley (2).

Proper storage is very important if the dye solutions are to be reused. Dyes are organic in nature and are subject to attack by microorganisms as attested to by the bad odor and slimy consistency the dye solutions develop if allowed to remain at room temperature. Such "spoiled" solutions should be discarded. Refrigeration (32° to 40° F) has proven very effective for preserving dyes in our tests. Properly handled dye solutions have been used successfully after a year of storage.

Environmental factors:

The procedure for evaluating the effect of various environmental factors on dyeing was as follows: Twenty-five flowers of the White Sim variety were included in each treatment. Four dyes of different capillarity were used for each test. These dyes were Basic Violet 10, a pink dye of moderate capillarity; Acid Red 33, a deep pink dye of high capillarity; Acid Yellow 23, a yellow dye of low capillarity; and Acid Green 3, a green dye which varies considerably in capillarity under different conditions. The concentration of each dye was 1.6 percent. The length of the flower stems was uniform within each test and ranged from 12 to 15 inches over all tests.

Following dyeing, the flowers were scored by a panel of three impartial judges for uniformity of coloration by rating individual flowers in each treatment as normally colored, or abnormally light or dark. All experiments were repeated on several different dates with different lots of flowers.

The general results of these evaluations can be stated briefly as follows:

1. Temperature of the Dye Solution and the Air

   When both warm dye solutions (90° to 100° F) and warm air temperatures (80° - 90° F) were used, as is generally recommended, a rapid coloration of petal veins occurred, but there was general lack of uniformity of coloration within individual blossoms and among different blossoms in the same treatment.

   When both the dye solution and the air were at room temperature (74° - 80° F), the coloration was somewhat slower than at higher temperatures, but the coloration was more uniform within single blossoms and whole treatments.

   When flowers were dyed overnight at low temperature (35° F), the degree of coloration was about the same as at room temperature, but Acid Yellow 23, a dye of low capillarity, gave more uniform coloration at the lower temperature. It appears that rapid dye uptake and uniform coloration are not wholly compatible. More uniform coloration was generally attained at lower temperatures than those commonly recommended.

DYE NAMES AND CHARACTERISTICS

Table 1.

Generic Colour Index Hue Name	Commercial or Common Name	Speed of Flower Dyeing	Colour Index Number	Color of Flowers	Dye Mobility on Paper
Acid Red 26	Acid Scarlet 2R, Amacid Scarlet 2R[a] Colcocid Scarlet 2 RL[b], Ponceau R	1	16150	Pink	B
Orange 10	Orange G. Food orange 10, Amacid Chyutal Orange[a]	1	16230	Orange	B
Violet 3	Victoria Violet[a]	3	16580	Violet	B
Red 33	Acid Fuchsine[2], Good Red 12	1	17200	Deep Pink	A
Red 1	Amacid Azo Phloxine G. Extra[a] ,	1	18050	Pink	A
Violet 7	Amacid Fuchsine 6 B[a]	1	18055	Deep Pink	A
Yellow 34	Amacid Light Yellow 3 GL[a] Fast Wool Yellow 3 GL	2	18890	Yellow	A
Yellow 23	Amacid Yellow T[a], Calcocid Yellow MCG[b] Fast Wool Yellow Tartrazine	2	19140	Yellow	A
Red 73	Amacid Brilliant Croceine Scarlet[a], Brilliant Scarlet LR and R	2	27290	Pink	A
Blue 7	Alphazurine A[c]	2	42080	Blue	B
Green 3	Acid Green 2, 2G, L[c], S, Amacid Green B[a] Calcocid Green G conc., Food Green 1.	1	42085	Green	A
Blue 9	Brilliant Blue, Amacid Blue FG conc., Food Blue 2	1	42090	Blue	B
Green 5	Light Green SF, Light Green SF Yellowish	1	42095	Green	A
Blue 22	Soluble Blue 2B[c], Calcocid Blue[R] conc.[b]	2	42755	Blue	B
Basic Violet 10	Amacid Rhodamine B[a], Red BX	2	45170	Fluores-cent Pink	A
Acid Blue 20	Analine Blue	2	50405	Blue	B
Blue 74	Indigo Carmine	3	73015	Blue	B
Acid Yellow 24	Martins Yellow	4	10315	----	C-D
Basic Orange 1	Calcozine orange R.S.*	4	11320	----	C-D
Basic Orange 2	Croceine orange Y[c*]	4	11720	----	C-D
Acid Red 2	Methyl Red	4	13020	----	C-D
Acid Orange 52	Methyl Orange	4	13025	----	C-D
Acid Red 37	Calcomine Scarlet B	4	17045	----	-D

Table 1 (continued)

Generic Colour Index Hue Name	Commercial or Common Name	Speed of Flower Dyeing	Colour Index Number	Color of Flowers	Dye Mobility on Paper
Direct Yellow	Clayton Yellow	4	19540	----	C-D
Direct Black 33	Erie black GXOO	4	30235	----	C-D
	Fast Red BL	4	37125	----	C-D
Basic Yellow 2	Yellow OX*	4	41000	----	C-D
Basic Green 4	Malachite Green*	4	42000	----	C-D
Basic	Methyl Green*	4	42590	----	C-D
Acid Blue 93	Methyl Blue, Methyl Blue Chloride	4	42780	----	C-D
Basic Violet 1	Methyl Violet, Dahlia*	4	42535	----	C-D
Basic Violet 2	Crystal Violet, Gentian Violet*	4	42555	----	C-D
Acid Red 87	Eosin Y	4	45380	----	C-D
Acid Red 51	Erythosine B	4	45430	----	C-D
Acid Yellow 3	Chinoline Yellow	4	47005	----	C-D
Direct Yellow	Chinoline Yellow P	4	47035	----	C-D
Basic Red 5	Neutral Red*	4	50040	----	C-D
Basic Red 2	Safranin*	4	50240	----	C-D
Basic Blue 6	Calcozine Navy Blue MB*	4	51175	----	C-D
Basic Blue 9	Calcozine Blue G.XX, Methylene Blue	4	52015	----	C-D
Neutral Red 24	Brazilin	4	75280	----	-D

Speed of flower dyeing:
1. Rapidly
2. Satisfactorily
3. Slowly
4. No dyeing

Code for the movement of dyes on paper chromatograms. Carnation sap solvent:

A - Dye moves with the solvent front
B - Movement of the dye from origin, but not as far as the solvent front
C - Dye moves only slightly from the origin
D - Dye fixed at origin

* - Basic dyes

a Provided by Koppers Company, Inc. Pittsburgh 19, Pa.

b Provided by American Cyanamid Co. Bound Brook , New Jersey

c Provided by National Aniline Division Allied Chemical Corporation Chicago 54, Illinois

2. The Type of Water:

Distilled water is preferable in making up the stock solutions because both hard water or soft water of the Culligan exchange type caused the formation of precipitates of dye and with ions such as Ca^{++}, Mg^{++}, and Na^{+} in the water. Such solutions work but waste dye. It is also advisable not to use metal containers for the dye solution because metal ions such as Fe^{+++} precipitate the dyes readily.

3. Water pH:

Water with a pH near neutral (7.0) was found to give better uptake of dye than water of lower pH. The pH of the water had little effect on the longevity of the flowers.

4. Wetting Agents:

The addition of wetting agents, especially in hard water, was found to greatly improve the uptake of dyes. Ortho X-77 used at a concentration of 4 milliliters per quart of dye gave good results. Powdered Dreft and liquid detergents did not enhance uptake even in hard water. Holley (2) has recommended Glowmore, Multifilm X77 and Musler in the order listed at concentrations of 2 to 6 milliliters per quart of dye.

5. Rate of Transpiration During Dyeing:

Environmental factors such as direct sunlight, low humidity, and ample aeration around the blossoms all contribute to a rapid loss of water from the flowers and hence to rapid dye uptake. Just as in the case of high temperature, however, this rapid uptake of dye often contributed to a lack of uniform coloration of flowers within the same lot. Flowers dyed in a dark, cool, humid location with little aeration took longer to dye but were generally more uniformly colored.

Summary

More than 100 water-soluble dyes were tested for their absorption-dyeing properties with cut carnations. The data of these tests are presented in tabular form for easy reference. Basic dyes were not readily translocated in carnations. Acidic dyes with a monoazo dye nucleus were in general readily translocated. There seemed to be little relationship between the size of the dye molecule and its ease of translocation.

Chromatographic technique revealed that dyes which move readily on filter paper in a cell sap solvent also move readily in cut flowers. Commercial flower tints were found to be mixtures of relatively few dyes.

Two ounces of dye per gallon of water gave satisfactory dyeing. Dyes stored under refrigeration were usable after a year. Hard water and metal ions from metal containers precipitate dye molecules and should be avoided whenever possible.

Flowers from dry storage which were uniformly on the dry side dyed well. The stems should always be recut before dyeing.

When the dye and air temperature were 90° to 100° F. flowers dyed faster than when they were at room temperature (74° - 80° F) or cooler room temperature (32° - 40° F) but the coloration of flowers was generally less uniform when the rate of dyeing was fast.

Water of pH near neutral (7.0) gave better dyeing than more acidic water but the longevity of flowers at all pHs was about the same.

Wetting agents such as Ortho X-77 (4 ml. per quart of dye solution) improved the uptake of dyes.

Factors which increased the rate of water loss from the flowers increased the rate of dye uptake but tended to give less uniformly colored flowers.

The technique of absorption dyeing works well on cut carnations and appears to be a simple and practical means for florists to color flowers as the demand dictates.

Literature Cited

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The Department of Horticultural Science expresses appreciation to the Busch Brothers Greenhouses for supplying the carnations used in these experiments and to the Koppers Company, American Cyanamid Company, National Aniline Division of Allied Chemical Corporation, and the A. L. Randall Company for supplying dyes.

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