PHENOTYPIC MANIFESTATION OF ANTHOCYANIN COLOR

Ya.B.Tursunov, Sh.L.Yuldasheva
Andijan State University, Andijan City, Republic of Uzbekistan
E-mail: tursunovyaxyobek029@gmail.com

Abstract. This article analyzes the genetic and environmental factors that influence the phenotypic expression of anthocyanin pigments. The mechanisms involved in the biosynthesis, transcriptional control, and phenotypic expression of anthocyanins in plants are reviewed based on scientific sources.

Key words: anthocyanin, pigmentation, gene expression, flavonoid, transcription factor, phenotype, plant physiology, genotype

Introduction

Anthocyanins are water-soluble pigments belonging to the flavonoid class that produce blue, red, and purple colors [5]. They are not only aesthetically important, but also have a protective function. The expression of anthocyanins in plant phenotype is a complex process involving genetic and environmental factors [9].

Anthocyanin biosynthesis and genetic control

Anthocyanins are produced by the phenylpropanoid and flavonoid biosynthetic pathways. This pathway involves the following key enzymes:

- Phenylalanine ammonia-lyase (PAL)
- Chalcone synthase (CHS)
- Chalcone isomerase (CHI)
- Flavanone 3-hydroxylase (F3H)
- Dihydroflavonol 4-reductase (DFR)
- Anthocyanidin synthase (ANS)
- UDP-glucose:flavonoid 3-O-glucosyltransferase (UFGT)

The structural genes encoding these enzymes require coordinated control of gene expression. This control is mediated by transcriptional complexes consisting of MYB, bHLH, and WD40 proteins [7]. Example: In Arabidopsis thaliana, the MYB transcription factor PAP1 (Production of Anthocyanin Pigment 1) activates anthocyanin synthesis [2].

Phenotypic manifestations

Anthocyanins can be accumulated in various parts of plants - leaves, buds, fruits, roots. The phenotypic appearance of these pigments is as follows:

- In flowers: attraction of pollinators [11].
- In fruits: stimulation of seed dispersal by animals[5].
- In leaves: protection from UV rays and antioxidant activity[3].

Phenotypic expression has a hereditary basis, and in some cases is the result of polygenic inheritance. For example, in corn (Zea mays) anthocyanin synthesis is controlled by the R, B and C1 genes [8].

As a result of genetic observations of many objects, it has been established that the basic structure of anthocyanins depends on individual genes. Also, the coloring of flower petals and other parts of the flower is due to a mixture of various anthocyanins and flavones in their composition. After this genetic analysis, 3 groups of genes were identified: the main gene for the presence or absence of flower color (P-p), the gene for the type of color - anthocyanin quality (V-v), the pigment intensity (Int-int), the gene for the location of pigments (L-l). The nature of the functioning of genes was determined by crossing sages of different colors. For example, in the cross between ulba (white) x carnea (salmon-red), the first generation was red, and in the second generation - in a ratio of 9:3:4 (158 red; 57 salmon-red; 61 white). When analyzing the second generation of plants, that is, the genotype of F2 plants was determined [1]. (Table 1)

Results of genetic analysis of sage flower color

Plant F_2 phenotype	F_3 generation	plant F_2 genotype
Red	Inserable	PP vv LL
	Red and white separates	Pp vv LL
	Red and brownrish red separates	PP vv Ll
	Red, brownrish red and white separates	Pp vvLl
Brown-red	Inserable	PP vv ll
	brownrish red and white separates	Pp vv ll
white	Inserable	Pp vv ll

Influence of environmental factors

The level of anthocyanin pigments varies not only genetically, but also under the influence of environmental factors:

- Light: strong light increases anthocyanin expression[10].
- Temperature: pigment accumulation increases under cold conditions[4].
- pH: anthocyanins are red in acidic conditions and blue in alkaline conditions[12].
- Abiotic stress: drought, UV and nutrient deficiency activate anthocyanin synthesis (Schaefer & Rolshausen, 2006).

Practical significance

The phenotypic expression of anthocyanins is of great importance not only in the natural environment, but also in the fields of breeding, food technology and pharmaceuticals. For example, high-anthocyanin varieties are valued for their antioxidant properties[6].

Conclusion

The phenotypic expression of anthocyanins is the result of a complex combination of genetic and environmental factors. Although their biosynthesis is under strict genetic control, environmental factors can significantly alter their expression. The fact that anthocyanin color is expressed in different organs of the plant also makes it difficult to study this gene control. However, the genes controlling these pigments are of similar importance in plant organs. The functional role of these pigments in plant life requires their fundamental and practical study.

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