

## 4 Effects of Plant Growth Regulators on Fruit Uniformity

### 4.1 Regulation of fruit shape and size uniformity

In many cases, poor market appearance quality in eggplant is not caused by low average yield, but rather by excessive variation in fruit length, thickness, and curvature. Fruit shape uniformity is closely associated with hormonal balance within the plant. The study by Zhao et al. (2025) provides a relatively clear explanation of this process: exogenous auxin can regulate fruit shape-related genes such as *SmOVATE*, *SmSUN*, and *IQD*, and together with GA-related and cell wall biosynthesis pathways, promote longitudinal cell division and elongation. This indicates that whether a fruit is slender or straight is not determined solely by the genetic background of the cultivar; exogenous regulators may also amplify or reduce such variation. When regulation is appropriate, the distribution of fruit length tends to become more concentrated, whereas excessive regulation may induce excessive elongation or malformed fruits.

From the perspective of practical production, both NAA and GA<sub>3</sub> can improve fruit shape, but their regulatory emphasis differs. NAA tends to stabilize early fruit set and young fruit development, whereas GA<sub>3</sub> more clearly promotes fruit enlargement and longitudinal elongation. Patel et al. (2022) showed that under combined NAA and GA<sub>3</sub> treatment, fruit length, fruit diameter, and single-fruit weight all increased, and this improvement occurred synchronously rather than merely as simple fruit elongation accompanied by insufficient lateral growth. This phenomenon is highly meaningful in commercial production, because fruit grading is most negatively affected by unevenness such as “some fruits being too long while others are too thin”, whereas combined regulation is usually more effective than a single regulator in narrowing the range of fruit-shape variation. It should be noted that field studies directly evaluating eggplant uniformity using the coefficient of variation of fruit shape are still relatively limited. Therefore, the judgment of “uniformity” here is mainly inferred from the simultaneous improvement of fruit shape-related traits.

### 4.2 Regulation of fruit developmental synchrony

Another important aspect of fruit uniformity is whether the developmental rhythm remains relatively synchronized. If the flowering time within the same batch differs substantially, the subsequent fruit-setting and ripening processes usually also become clearly dispersed. The role of GA<sub>3</sub> in promoting earlier flowering and increasing the number of flowers per cluster already reflects a certain “synchronizing” effect. Combined with studies on heterostylous flowers in eggplant, it can be seen that when the proportion of long-styled and medium-styled flowers increases, early effective fruit set tends to become more concentrated, and the subsequent fruit developmental window also becomes more uniform (Dewangan and Jangre, 2024). This has strong practical value in production: for manual harvesting, it reduces the frequency of repeated picking rounds; for protected cultivation, it also facilitates the unified scheduling of water and fertilizer management as well as pest and disease control measures.

Uniformity of ripening is also closely related to whether “lagging fruits” appear under stress conditions. Once adverse environments such as drought, salinity stress, or low temperature cause some fruits to suspend development, clear stratification often emerges within the whole fruit batch. Although regulators such as SA, 6-BA, and EBR may not show yield-promoting effects as directly as GA<sub>3</sub>, they can maintain chlorophyll content, relative water content, membrane stability, and antioxidant capacity, thereby reducing the risk of growth stagnation during critical developmental stages (Mady et al., 2023). Under such conditions, fruit development is more likely to remain synchronized, and the ripening period also tends to become more concentrated. Although this effect may not be highly dramatic, it has considerable practical value in improving fruit uniformity.

### 4.3 Quality traits related to marketability

From the perspective of market evaluation, whether eggplant fruits are “uniform” is usually reflected in four major indicators: fruit size, color, firmness, and surface defects. Existing studies on marketability consistency have largely focused on these aspects. In the field trial conducted by Wakchaure et al. (2020), marketable fruit quality was defined in terms of average fruit weight, fruit diameter, sphericity, and firmness, and the study clearly