

Spike proliferation in black pepper (*Piper nigrum* L.)

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Abstract — Introduction. Black pepper (*P. nigrum* L.), the major world spice, is a climbing vine of historical, religious and economic importance. Landraces or farmer's cultivars constitute the major component of this tropical vine's diversity. **Normal spike formation.** Berries of *P. nigrum* are produced in solitary, unbranched, axillary spikes. The apical bud of the plagiotropic branches transforms into an inflorescence (spike). **Spike variant.** Mutation in the floral meristem of black pepper could result in inflorescence proliferation. A variant with 100% of proliferating spikes was collected from a farmer's plot, and then propagated by cuttings. The proliferating spikes are of indeterminate growth habit. **Benefits.** This natural mutant of *Piper nigrum* resulted in improved socioeconomic status of the farmer through sale of the rooted cuttings at a premium price. The variant can also be used as a donor for improvement of black pepper, besides as a novelty in potted pepper culture. Since berries of varying maturity are produced due to indeterminate growth, and since immature berries are rich in oleoresin, a single harvest will be yielding matured berries, which can be traded as black pepper of commerce, and half-matured berries suited to the value-added industry. **Discussion.** Mutations in the floral organ identity genes and their effect on altered flower/inflorescence development have been reported in the literature. In the case of spike proliferation, the transformation of the floral primordia in the mutant spike into inflorescence primordia has resulted in the modified spike architecture.

India / *Piper nigrum* / pepper / mutants / inflorescence / spike

Prolifération de l'épi du poivre noir (*Piper nigrum* L.).

Résumé — Introduction. Le poivre noir est une liane d'importance historique, religieuse et économique. Les variétés primitives ou les cultivars locaux sont à la base de la diversité de cette vigne tropicale. **Formation normale des épis.** Les baies de *P. nigrum* sont produites sur un simple épi, non ramifié, axillaires. Le bourgeon apical des branches plagiotropes se transforme en inflorescence (épi). **Variation de l'épi.** Une mutation dans le méristème floral du poivre noir a pu avoir comme conséquence la prolifération d'inflorescences. Un variant présentant 100 % d'épis avec prolifération a été trouvé chez un cultivateur, puis propagé par boutures. Les épis avec prolifération présentent une croissance indéterminée. **Avantages.** Cette mutation naturelle de *P. nigrum* a induit une amélioration du statut socio-économique du cultivateur par la vente des boutures enracinées à un prix intéressant. Le variant peut être également utilisé comme générateur pour l'amélioration du poivre noir et comme une nouveauté pour la culture en pot. Puisque des baies de maturité variable sont produites du fait de la croissance indéterminée, et puisque les baies non mûres sont riches en oléorésine, une seule récolte peut donner des baies mûres commercialisées en tant que poivre noir et des baies à demi-mûres adaptées à une industrie à valeur ajoutée. **Discussion.** Des mutations dans des gènes codant pour les organes floraux et leur effet sur le développement modifié de la fleur/inflorescence ont été rapportés dans la littérature. Dans le cas de la prolifération d'épi, la transformation du primordium floral dans l'épi du mutant en primordium d'inflorescence a entraîné une architecture modifiée de l'épi.

Inde / *Piper nigrum* / poivre / mutant / inflorescence / épi

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Figure 1.
Normal spikes of *Piper nigrum* L.



Figure 2.
Proliferating spikes of a new variant of *Piper nigrum* L.



Figure 3.
Mature proliferating spike with persistent bracts of a new variant of *Piper nigrum* L.

1. Introduction

Black pepper (*Piper nigrum* L.), the major world spice, is a climbing vine of historical, religious and economic importance, often referred to as 'King of spices' [1]. Landraces or farmer's cultivars constitute the major component of diversity of this tropical vine.

2. Normal spike formation

Berries, the black pepper of commerce, are produced in solitary, unbranched, axillary

spikes (figure 1). Flowers (50–150) are borne in the axils of ovate, fleshy bracts of the long pendant spikes appearing opposite to the leaves on the plagiotropic branches. The apical bud of the plagiotropic branches transforms into an inflorescence (spike). The inflorescence in its early stages of development has a convex apical meristem, subtended by a leaf and a bract [2]. The inflorescence meristem appears to be terminal so that the growth is sympodial. As the inflorescence grows in length, its apical meristem diminishes. The apical meristem of the inflorescence grows in length before any organs form.

3. Spike variant

Mutation in the floral meristem of black pepper could result in inflorescence proliferation. A new spike variant with 100% of proliferating spikes (figure 2) was collected from a farmer's plot. This vine, closely resembling the popular black pepper cultivar 'Karimunda', was originally spotted by a farmer in the Idukki district of Kerala, a few years ago. A rooted cutting of the vine procured from his nursery about 3 years ago and conserved at the *ex situ* gene bank of the Indian Institute of Spices Research, Calicut, India, has now spiked, conforming to its true-to-type nature. The spike length measured about 18 cm (figure 3) with about 150 berries per spike as against 7–10 cm length and about 30–70 berries in the normal spike. The proliferating spikes were of indeterminate growth habit. Some spikes looked like grape bunches (figure 4). Another feature of the spike was persistent and large bracts (figures 3, 5).

4. Benefits

Though considerable variation in spike length, floral composition, fruit number and size are reported in black pepper [3], spike proliferation is a very rare phenomenon. It is a rare case of a natural mutation in a horticultural plant, resulting in improved socio-economic status of a traditional farmer in a

remote village of Kerala, India, through the sale of the rooted cuttings at a premium price.

This variant can be used as a donor for improvement of black pepper, besides as a novelty in potted pepper (bush pepper) culture. Spike area in black pepper is an important yield component. A genotype with proliferating spikes may result in more berries per spike, besides its ornamental value.

It is true that indeterminate growth may be producing berries of varying maturity. However, since the immature (half-mature) berries are rich in oleoresin, this will not be a handicap. A single harvest will be yielding matured berries, which can be traded as black pepper of commerce, and half-matured berries suited to the value-added industry.

5. Discussion

Mutations in the floral organ identity genes such as *cauliflower* (*cal*), *apetala 1* (*ap1*) and *leafy* (*lfy*) and their effect on altered flower/inflorescence development have been reported [4]. *lfy* or *ap1* locus mutations result in partial transformation of flowers into inflorescences. In the case of spike proliferation, the transformation of the floral primordia in the mutant spike into inflorescence primordia has resulted in the modified spike architecture (figure 6).

In *Arabidopsis*, mutations in *ap1* loci along with *cal* mutation result in conversion of the floral meristem into an inflorescence meristem, giving rise to indeterminate flowers in a spiral phyllotaxy, leading to a cauliflower phenotype with an extensive proliferation of meristems at each position. This way, second- or even third-order inflorescence meristems may develop from the first-order (normal inflorescence) inflorescence meristem [4].

From the studies on floral development and floral meristem identity genes in *Arabidopsis*, *Antirrhinum majus*, cauliflower, maize, rice, etc., it is now known that floral genes are highly conserved in the plant kingdom [5, 6] and the genes determining the inflorescence development in *Piper nigrum* may be orthologs of the same.



Figure 4. Close up of proliferating spikes of a new variant of *Piper nigrum* L.

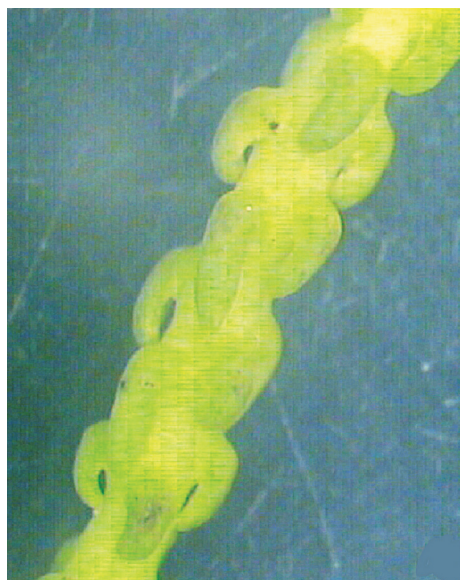


Figure 5. Immature proliferating spike with pronounced bracts ($\times 4$).

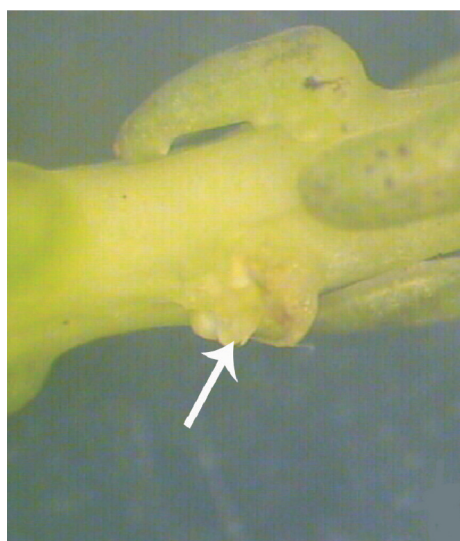


Figure 6. Conversion of floral primordia into inflorescence primordia (arrow) in a variant of *Piper nigrum* L. ($\times 6.25$).

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Proliferación de la espiga de la pimienta negra (*Piper nigrum* L.).

Resumen — Introducción. La pimienta negra es un hito con una importancia histórica, religiosa y económica. Las variedades primitivas o los cultivares locales están en la base de la diversidad de esta viña tropical. **Formación normal de las espigas.** Las bayas de *P. nigrum* se producen en una simple espiga, no ramificada, axilares. El brote apical de las ramas plagiótropas se transforman en inflorescencia (espiga). **Variación de la espiga.** Una mutación en el meristema floral de la pimienta negra pudo tener como consecuencia la proliferación de inflorescencias. Se encontró en un cultivador una variante que presentó el 100% de espigas con proliferación, la cual se propagó mediante esquejes. Las espigas con proliferación presentan un crecimiento indeterminado. **Ventayas.** Esta mutación natural de *P. nigrum* indujo una mejora socio-económico del cultivador gracias a la venta, a un precio interesante, de injertos enraizados. Debido a que se producen bayas de madurez variable por causa del crecimiento indeterminado; y, debido a que las bayas inmaduras son ricas en oleorresinas, tan sólo una única cosecha puede aportar bayas maduras comercializadas en tanto que pimienta negra, así como bayas medio maduras adaptadas a una industria de valor añadido. La variante puede emplearse asimismo como genitor para la mejora de la pimienta negra y como una novedad para el cultivo en maceta de pimienta negra. **Discusión.** Se reportaron en la literatura mutaciones en los genes que codificaban para los órganos florales así como su efecto sobre el desarrollo modificado de la flor/ inflorescencia. En el caso de la proliferación de la espiga, la transformación del primordio floral en la espiga del mutante en primordio de inflorescencia conllevó una arquitectura modificada de la espiga.

India / *Piper nigrum* / pimienta / mutantes / inflorescencia / espiga