Vegetative Growth
Annual shoot growth cycle

• Deciduous trees- End of winter buds start growing and initiate flower and/or vegetative growth
• Vegetative growth typically follows bloom
• Shoot growth at a rapid rate during spring
• Continue for a definite period through summer
• A period of growth cessation in fall
Shoot growth

• Growing shoots = a stem portion + leaves
  • Nodes and internodes

• Shoots elongate when:
  • A lateral bud opens and elongates
  • Expansion at apical meristems occurs

FIGURE 3.8. Vegetative shoot apex of grape. From Fahn (1967), with permission of Butterworth Heineman Ltd.

Source: Phys. Of woody plants (Pallardy)
Two components of vegetative growth

• Vegetative shoot growth:
  • provides the overall architecture of the canopy

• Spur production:
  • generates the tissues that give rise to the majority of fruit in subsequent seasons
  • All buds form during previous season.
  • Vegetative shoot growth started after bloom and occurs uniformly through the season
  • Spur elongation completes early in the season by May
Bud

• Most lateral buds initiated in the leaf axils

• Vegetative, or flower buds
  • Vegetative buds are small, pointy and triangular
  • Flower buds are thick, bigger and oval
  • Apical bud on a spur is always vegetative
Dormant and Adventitious Buds

- All the buds on a tree do not expand into shoots because some remain dormant, die, or produce flowers.
- Dormant buds, originally developed in leaf axils, subsequently are connected to the pith by a bud trace.
- **Adventitious buds**: Buds that form irregularly on older portions of a plant and not at the stem tips or leaf axils. These form on parts of the root or stem that have no connection to apical meristems.
- They may originate from either deep or peripheral tissues.
- Unlike dormant buds, adventitious buds do not have a bud trace all the way to the pith.
Buds

In deciduous tree species the buds are enclosed in a series of scales. These scales fall away when the bud expands, leaving scars where they were attached.
Buds

Each bud contains a compressed shoot with nodes and very short internodes. As the bud expands it does so by elongation of the internodes and expansion of the primordial leaves.
Spur Shoots

Spurs are short, compact shoots with several node and very short internodes.

Always form on last years wood, remain vegetative for 1-2 years before flowering.

Spurs can:

1. Produce a long shoot
2. Or stay vegetative (producing leaves)
Or 3. Bear flower and fruit

Figure 2. Spurs are always borne on the prior year’s wood. (Illustration: Tombesi, et al. 2016)
Almond Spur Shoot

Terminal Bud for Current Year.
Will produce next year’s growth.

Terminal Bud Scale Scars from Previous Years

Current Year’s Growth

Last Year’s Growth

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Almond Shoot with Spurs
Spurs and crop

80% crop on a tree is on the spurs. But in any year, only 15-20% of the total spurs bear fruit. So each spur bears fruit after a few years and remains vegetative in-between. The spurs rest and rejuvenate based on localized carbon supply. Life of the spur= light availability around that spur. Spurs will die under prolonged shading.
What that means for young tree growth

Young trees need to produce vegetative shoots. Those shoots will bear spur eventually. Those spurs will remain vegetative for 1-2 years before they flower. So it will take a few years before the spur population is sustained in a tree. These spurs need to store enough carbohydrates to start bearing fruit.
Epicormic shoots arise from dormant buds and not adventitious buds.
Cutting the trunk to a stump triggers formation of new branches from adventitious buds.
• These are very weak (remember they do not have connection to the pith!)
• So the trees are vulnerable to limb breakage.
Things that affect shoot growth

• Temperature/Heat unit accumulation during spring and summer
• Water and nutrient availability
  • Water stress reduced internode length in walnuts
• Position in the canopy: Outer canopy gets more light
• Crop load. Heavy crop: more stress on carbohydrate budget, so shoot growth is low
• As growers, we need to strike a balance between new growth and crop so that the tree produces enough fruitwood.
Crop Load and Water Stress on Peach Stem Growth

Figure 1. Diurnal growth rates of stems with 3-5 subtending fruit (F) and stems with no subtending fruit (NF). Absolute stem extension growth rate (AER) (A, C) and relative stem extension growth rate (RER) (B, D) on May 10, 1993 (A, B) and June 1, 1993 (C, D). Each point represents the mean growth rate of five stems. Error bars represent the standard error of the mean. Asterisks indicate significant differences between the stem types (Tukey’s means separation test, $P < 0.05$).

Figure 2. Daily growth parameters for stems with (F) (solid) and without (NF) (shaded) subtending fruit. Elongation zone length at the commencement of measurements on May 10, 1993 (A) and June 1, 1993 (C). Total extension growth over the 24-h measurement period on May 10, 1993 (B) and June 1, 1993 (D). Each value represents the mean of five stems. Error bars represent the standard error of the mean. Asterisks indicate significant differences between the stem types (Tukey’s means separation test, $P < 0.05$).
Deficit Irrigation in Nectarines
Shoot Organization: Node Organization

Leaves and buds form at the nodes each of which is more or less identical to every other node on the plant.

Nodes may have one, two or more leaves.

Buds form in the axil of the leaf (i.e. where the leaf joins the stem.)
Almonds: Spur Fruit Set is negatively correlated with Spur Leaf Area

Fig. 1. Mean spur leaf area (cm²) (A) and number of leaves per spur (B) in flowering spurs with zero, one, two, three, and four fruits from 2002 to 2006. Error bars represent se (0 fruit n = 4024; 1 fruit n = 580; 2 fruits n = 158; 3 fruits n = 25; 4 fruits n = 8). Bars with different letters are different at P < 0.05 (Tukey’s test).

Fig. 2. Relationship between mean spur relative fruit set (%) and spur leaf area in the current year (cm²) ($R^2 = 0.57$, $P < 0.001$). Each value is the mean of 10 spurs grouped by class of leaf area from 2002 to 2006. Error bars represent ± se.
Shoot Organization: Nodes and Internodes

All plant shoot systems are basically similar in their organization. They are made up of an axis, the stem, which has a series of repeating nodes separated by internodes.

The internodes vary in their length. Internode length may be several inches or more or as short as a few millimeters. Thus, a shoot with six or seven leaves could be as short as an inch or as long as a yard.
Anatomy of a branch

• Dead woody tissue provides structural support

• Within dead woody tissue are points of living tissue: The Meristem
  • Apical Meristem
  • Lateral Meristem
Apical Dominance

- The presence of apical meristem at the tip of a branch suppresses development of lateral meristem further down the branch.
- The suppression of lateral meristem by apical meristem is called apical dominance.
- Due to apical dominance, most of the lateral buds do not develop into shoots.
- If apical meristem is removed, the lateral buds produce growth next season.
Branch anatomy

• Most of the sugars travel only to the nearest sink
• Most of the photosynthates are allocated to shoot tip extension.
  • So the branches are tapered and no lateral branch will grow thicker than its parent branch.

• Branch anatomy and apical dominance determine tree architecture!