# The effect of light on adventitious root formation in blue grama

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**Abstract**

**Formation of adventitious roots in blue grama seedlings requires that the node between the subcoleoptile and the coleoptile be exposed to light at the 3-leaf or later stages of development. Thus, adventitious root formation will occur only at or near the soil surface. With continuous light, the subcoleoptile approximated zero length, but for those developed in darkness the usual length was about 1 cm. Under usual range conditions, the time between germination and the 3-leaf stage of development is such that it is rare that both of these events will occur with moist soil conditions, and seedling survival will be infrequent.**

**Key Words: light response, subcoleoptile, adventitious roots**

When a grass seed germinates, it first develops a primary root. During early development of the seedling, adventitious roots develop at the lower node of the shoot axis. In most mature grass plants, the root system consists entirely of adventitious roots. Survival of a grass seedling depends upon its ability to develop adventitious roots.

In the common perception of grass seedling development, the adventitious root node forms at essentially the same location as the origin of the primary root. Thus, a seed planted at 1-cm depth will originate adventitious roots at this depth. A lower planting depth may result in more soil moisture available for root development, and planting depth is ordinarily constrained only by the ability of the seedling to produce a coleoptile sufficient to reach the surface. For many grass species, improved seedling establishment can be obtained by selecting for larger seeded varieties that allow for deeper plantings.

In certain grasses, such as blue grama *(Bouteloua gracilis)*, the commonly perceived development does not occur. Instead, there is a subcoleoptile or internode between the point of emergence of the primary root from the caryopsis and the origin of the coleoptile (Hyder 1974). For these species, the adventitious roots do not begin at the seeding depth, but at a higher, and generally drier, point in the soil profile.

Blue grama is difficult to establish by seeding (Weaver and Albertson 1943; Riegel et al. 1963; Wilson and Briske 1978, 1979). The relationship of drought and adventitious roots has been studied by Wright (1971), Sims et al. (1973), Briske and Wilson (1977, 1978, 1980), Hassanyar and Wilson (1978), Wilson and Briske (1977, 1978), and Wilson et al. (1976). Because blue grama seedlings quickly elevate their subcoleoptiles (Stubbendieck and Burzlaff 1971, Hyder et al. 1971, Hyder 1974, Sluijs and Hyder 1974, Wilson et al. 1976), the adventitious roots typically begin formation in dry soil, and seedling mortality results. The primary or seminal root provides only about 2 ml of water per day (Wilson 1976), which is insufficient for seedling survival. However, if a seedling can develop just 1 adventitious root, this root can supply up to 10 ml of water per day (Wilson 1976).

For blue grama, the usual research approach of selecting larger seeded varieties will not be productive if the adventitious roots still form in the upper, and usually drier, soil layers.

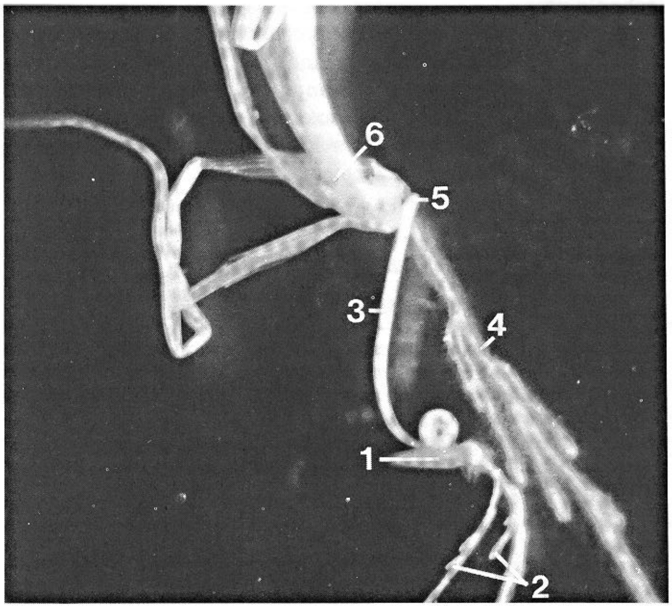


Fig. 1. Blue grama seedling developed in agar culture with 4 days of darkness followed by light: (1) caryopsis, (2) primary root, (3) internode, (4) adventitious root, (5) node, and (6) shoot.

## Materials and Methods

Initial studies on the effect of light on subcoleoptile lengths were conducted in agar culture. Agar was prepared for test tubes using 6.5 gm agar per liter of half strength MS nutrient solution (Murashige and Skoog 1962). The pH was adjusted to 5.7. Seeds of the Hachita variety (provided by the Soil Conservation Service Plant Materials Center, Las Lunas, New Mexico) were dehulled with a Woodward Laboratory Air-Seed apparatus (Dewald and Beisel 1984). Adequate sterilization was provided by immersing the seeds for 30 seconds in 70% ethanol, followed by 20% bleach for 3 minutes. Twenty replicated tubes with 3 seeds each were either placed in continuous light (21 watts/m$^2$), or in complete darkness for 4 days and then in the light.

For greenhouse studies, caryopses were prepared as for the agar culture studies. Planting was done in pots containing fine sandy loam soil. The caryopses were placed on the soil surface, and later covered with 1 cm of fine sand. Ten replicate pots with 20 caryopses each were prepared for treatment as follows: (1) covered immediately after sowing, (2) covered after 24 hours, (3) covered after 48 hours, (4) covered after 72 hours, (5) covered after 96 hours, and (6) uncovered. Water content of the pots was maintained by subirrigating to a predetermined pot weight that approximated field capacity.

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## Results

For seedlings grown in agar culture and continuous light, all the seedlings had essentially zero subcoleoptile length. The adventitious roots and primary roots grew from the same locations, and it was frequently difficult to distinguish between primary and adventitious roots. Seedlings kept in the dark for 4 days and then moved to continuous light developed elongated internodes, usually about 1 cm length (Fig. 1). Thus, light obviously was an important factor in controlling the length of the subcoleoptile and the point of formation of adventitious roots.

Even within the Hachita variety, the greenhouse-grown seedlings exhibited considerable morphological variation and had both upright and decumbent growth forms as reported by Painter (1987). However, this degree of variation did not extend to behavior of the subcoleoptile and development of adventitious roots; all of the seedlings that were covered with sand after sowing, regardless of the time of exposure, developed elongated internodes and the adventitious roots originated near the sand surface. Seedlings in pots that were left uncovered had internodes of essentially zero length, and adventitious roots originated at the surface of the original soil layer. This behavior was subsequently investigated in several studies with various seed covering treatments, using thin layers of sand at different stages of seedling development. Regardless of the covering treatment, adventitious root developed when the node at the subcoleoptile-coleoptile junction was exposed to light at the 3-leaf or later stages. Any earlier exposure to light, followed by darkness, was insufficient to develop adventitious roots. However, prolonged exposure of seeds on the soil surface did reduce overall survival even in the relatively moist conditions of the greenhouse.

## Discussion and Conclusions

These studies clearly show that continuous exposure of developing blue grama seedlings to light prevents growth of the subcoleoptile. A similar response has been reported for oat seedlings (Mandoli and Briggs 1981, Schafer et al. 1982, Schafer and Haupt 1983). The reduction in internode length is probably controlled by the phytochrome system (Salisbury and Ross 1985). Exposure of the coleoptile to light did not change the development of the subcoleoptile, which suggests that the response mechanism cannot be developed in one portion of the plant and translocated to another part. In addition, the response mechanism was not stored, i.e., even exposure of the developing seedling to light for 96 hours did not modify development. Without exposure to light at the 3-leaf or later stages, adventitious roots of blue grama simply do not form. These results support the observations of Newman and Moser (1988) for other species. In our study material, there was no genetic variation in this behavior. Regardless of seed size and planting depth, adventitious roots in our material formed only when the node was close enough to the soil surface that light was received directly on the node. The practical implications of these findings are that blue grama seedlings will only form adventitious roots at the soil surface. The usual time interval between planting and development of the 3-leaf stage is typically a few weeks; under usual range conditions, this also means that adventitious roots are initiated mostly in dry soil, and seedling mortality results.

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