Are cuttings a viable alternative to seeds for sweet basil production?©[a]

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INTRODUCTION

Sweet basil (*Ocimum basilicum*) is an herbaceous annual plant originating in India and tropical Asia, and now widespread in Asia, Africa, North America, South America, and the Mediterranean region (Pushpangadan and George, 2012; Wogiatzi et al., 2011). Sweet basil is one of the most commonly grown herbs in the United States with great flavor, antioxidative, and antibacterial properties due to its enhanced content of essential oils and phenolic compounds (Chiang et al., 2005; Fischer et al., 2011; Kruma et al., 2008). Thus, the concentration of essential oils and phenolic compounds in basil are important for their culinary and clinical practices.

The conventional basil production is via seed, which could be affected by poor germination rate, slow seedling growth, delayed yield production, and varied content of phytochemicals due to genetic and biochemical heterogeneity (El-Keltawi and Abdel-Rahman, 2006; Heywood, 1978; Lim and Eom, 2013). Cutting propagation is a common practice and an important tool for the production of many herbaceous and woody plant species, owing to relatively faster plant growth, high progeny uniformity, and ease of the process (El-Keltawi and Abdel-Rahman, 2006; Lim and Eom, 2013). Many studies have been conducted to test the viability of vegetative production on basil, using different explants, including nodal segments and axillary buds (Begum et al., 2002; Siddique and Anis, 2008), shoot tip explants (Siddique and Anis, 2007), leaf explants (Phippen and Simon, 2000), young inflorescences (Singh and Sehgal, 1999), and cotyledons (Dode et al., 2003). However, little is known of the differences between using cuttings and seedlings as starter plants in basil production. This trial was designed to characterize the effects of cutting and seed propagation, as well as effects of four different planting densities, on root formation, length of growth period, and biomass accumulation of basil - to evaluate the feasibility of using cuttings as starter plants in basil production.

MATERIALS AND METHODS

Plant materials and culture

Two greenhouse experiments were conducted in College Station from September 9 to October 30, 2016 (Experiment 1) and in El Paso from April 30 to May 31, 2017 (Experiment 2), respectively. 'Genovese' sweet basil (Johnny's Selected Seeds, Winslow, Maine) was used in both experiments.

Treatment and experimental design

In Experiment 1, 10 cm (4 in.) long basil cuttings were cut from mother plants and trimmed to two leaves, dipped in rooting hormone (Hormodin 2; OHP Inc., Mainland, Pennsylvania) and stuck into one plug cell of 72 cell trays with vermiculite (Vermiculite Premium Grade; Sun Gro Inc., Bellevue, Washington). Two basil seeds were sown in one plug cell of 72-cell trays with propagation mix (Propagation mix; Sun Gro Inc., Agawam, Massachusetts). All trays were put under mist in a greenhouse on day 0 after initiation (0 DAI). When roots were visible on the outside of the plug root ball, seedlings were transplanted into 15.3 cm (6 in.) BM7 pots (Berger, Watsonville, California, USA). Plants

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were harvested when growth reached 30 cm height. All plants were irrigated with a nutrient solution containing 1 g L^{-1} (150 ppm N) 15N-3.3P-12.5K fertilizer (Peters Professional, Everris NA Inc., Dublin, Ohio).

In Experiment 2, 10.2 cm (4 in.) long basil cuttings were cut from mother plants and trimmed to two leaves, then immediately dipped in diluted liquid rooting concentrate with 1,000 ppm concentration (indole-3-butyric acid, Dip'n Grow, Oregon, USA), and four planting densities of 1, 2, 3, or 4 cuttings (C1, C2, C3, or C4) were stuck into one plug cell of 72 cell trays with vermiculite (Thermo-O-Rock West Inc., Chandler, Arkansas, USA). Four planting densities of 5, 10, 15, or 20 seeds (S5, S10, S15, or S20) were sown in one plug cell of 72-cell trays with Metro-Mix 360 (SunGro Hort., Bellevue, Washington, USA). Plant management was the same as in Experiment 1.

Data collection and measurement

In Experiment 1, root fresh weight (FW) was measured before transplanting. Plant height and two perpendicular widths were measured after transplanting on 21, 31, 38, 45, and 51 DAI. Shoot FW and dry weight (DW) of basil were measured before harvest.

In Experiment 2, root FW and DW were measured before transplanting. Plant height, two perpendicular widths, and relative chlorophyll content (SPAD) of basil leaves were measured after transplanting on 27, 34, 41, and 48 DAI. Shoot FW and DW were recorded before harvest. Only the new growth of cutting plants was measured in both experiments. An analysis of variance was conducted using software JMP (Version 12, SAS Institute Inc., Cary, North Carolina, USA).

RESULTS AND DISCUSSION

Root formation

In Experiment 1, basil plants from cuttings were transplanted on 14 DAI when roots developed to root ball surface, compared with 21 DAI for seedlings. Basil plants from cuttings developed to a transplantable stage earlier than seedlings, which is in agreement with El-Keltawi and Abdel-Rahman (2006). For cuttings, a 100% rooting was observed, whereas seed germination rate was 90%. On 14 DAI, root FW of plants from cuttings and seedlings were 0.48 and 0.04 g, respectively.

In Experiment 2, basil plants from cuttings and seedlings with four planting densities developed to transplantable stage at the same time on 20 DAI. Plants from cuttings had greater root mass than seedlings, and the root FW and DW were the highest for C4, C3, followed by C2, and were the lowest for C1, S20, S15, S10, S5 (Table 1). Propagation of basil by either tip or middle stem cuttings resulted in similar root patterns with approximately 100% rooting. The faster root formation and growth of cuttings, compared to seedlings could be explained by translocated carbohydrate from leaves and stems for root development, as well as a higher concentration of endogenous root-promoting substances from apical tissues (Hartmann et al., 2011).

Plant growth and shoot biomass accumulation

In Experiment 1, plants from cuttings and seedlings reached to approximately 30 cm tall on 38 and 51 DAI, respectively. With similar height and growth index, shoot FW of seedlings were higher than plants from cuttings, while there was no significant differences on shoot DW or shoot FW accumulation rate. On the other hand, the shoot DW accumulation rate of plants from cuttings was 50% higher than seedlings, due to 13 days shorter of growth period (Table 2).

In Experiment 2, rooted cuttings and seedlings reached approximately 30 cm height on 46 and 41 DAI, respectively. After transplanting, plant height and growth index of plants were the highest for S20, S15, S10, followed by S5, and was the lowest for C4, C3, C2, and C1. However, the SPAD in plants from cuttings was approximately 12% higher than seedlings (data not reported).

Table 1. Root fresh weight (FW) and dry weight (DW) of basil plants from cuttings and seedlings on 20 DAI in Experiment 2.

Treatment	Density	Root FW (g)	Root DW (g)
Cuttings	C1	0.45 c[1] B[2]	0.050 c B
	C2	1.57 b A	0.111 b A
	C3	1.96 ab A	0.129 ab A
	C4	2.13 a A	0.146 a A
Seeds	S5	0.39 c D	0.028 c C
	S10	0.51 c C	0.030 c AB
	S15	0.70 c B	0.038 c AB
	S20	0.85 c A	0.043 c A

[1]Means followed by the same lowercase letters are not significantly different at $P<0.05$ between plants from cuttings and seedlings.
[2]Means followed by the same uppercase letters are not significantly different among four planting densities within plants from cuttings or seedlings.

Table 2. Growth index, shoot fresh weight (FW) and dry weight (DW), and shoot accumulation rate of basil from cuttings and seedlings in Experiment 1.

Treatment	Growth index (cm)	Shoot FW (g)	Shoot DW (g)	Shoot accumulation rate (g d^{-1}, FW)	Shoot accumulation rate (g d^{-1}, DW)
Cuttings	21.7a	18.4b	2.36a	0.48a	0.063 a
Seeds	22.6a	22.8a	2.17a	0.45a	0.042 b

Different lowercase letters indicate significant differences at $P<0.05$.

With similar plant height, shoot FW and DW of plants from cuttings were 49 and 71% higher than seedlings when plants were harvested on 48 and 41 DAI, respectively, which probably was associated with enhanced root formation (Lim and Eom, 2013). Shoot FW accumulation rate of S5 was much lower than the other treatments, and high planting density of seedlings such as 10 to 20 seedlings per pot compensated for low shoot biomass accumulation rate of low planting density and achieved similar biomass accumulation rate as cutting treatment (Table 3). Similarly, shoot DW accumulation rate was the lowest for S5 and increased by four cutting treatments, resulted in higher shoot dry matter content of plants from cuttings (Table 3). Shoot biomass accumulation of 10 seedlings per pot was similar or higher than 15 or 20 seedlings per pot, probably due to the inter-plant competition for sunlight and nutrients at higher densities.

Table 3. Shoot fresh weight (FW), dry weight (DW) and shoot accumulation rate of basil plants from cuttings and seedlings in Experiment 2.

Treatment	Density	Shoot FW (g)	Shoot DW (g)	Shoot accumulation rate (g d^{-1}, FW)	Shoot accumulation rate (g d^{-1}, DW)
Cuttings	C1	103.0 ab[1] A[2]	10.35 ab A	1.93 a A	0.19 abc A
	C2	100.3 a A	9.47 ab A	1.93 ab A	0.18 abc A
	C3	117.1 a A	11.02 a A	2.26 a A	0.22 a A
	C4	97.1 a A	9.42 a A	2.02 ab A	0.20 ab A
Seedlings	S5	53.7 d C	4.45 d C	1.31 c C	0.11 e C
	S10	77.7 b A	6.35 b AB	1.89 a A	0.16 cd AB
	S15	68.6 c B	5.77 c B	1.68 b B	0.14 de B
	S20	79.6 b A	7.03 b A	1.94 a A	0.17 bcd A

[1]Means followed by the same lowercase letters are not significantly different at $P<0.05$ between plants from cuttings and seedlings.
[2]Means followed by the same uppercase letters are not significantly different among four planting densities within plants from cuttings or seedlings.

CONCLUSION

Rooting of basil plants from cuttings was stronger and faster, and plants from cuttings achieved higher shoot FW yield, as well as higher dry matter content compared with seedlings at similar plant height. High planting density of 10-20 seedlings per pot achieved similar biomass accumulation rate as cuttings, and density of 10 seedlings per pot would be recommended due to savings on seeds and resource competition at higher densities. In conclusion, cutting propagation provided viable alternative for starting plants for sweet basil production.

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