Propagation of *Tronchuda* (*Brassica oleracea* var. *tronchuda* Bailey) from Cuttings

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Abstract. A system to propagate *tronchuda* (*Brassica oleracea* var. *tronchuda* Bailey syn. *costata* L.) from main stem and side shoot cuttings was developed by removing the main stem (three to four leaves) and, later, side shoots from 5-week-old plants, transplanting them into small pots, and growing them under a mist system for 4 weeks. New root growth appeared on cuttings within 3 weeks. Rooting frequency varied among cultivars and explant types. For all cultivars, side shoot cuttings rooted better than main stem cuttings (99.7% vs. 84.8%). For all cultivars, seed-propagated plants and side shoot cuttings produced leaves with significantly higher fresh weight than the main stem cuttings for three of the five cultivars. The average number of leaves per plant for four cultivars was, however, not significantly affected by propagation method. Average leaf count and fresh weight per plant were significantly higher for 'Portuguesa' than for 'Ana Maria', 'Couve Penca', 'Vilinda', and 'Penca de Chaves' for all three propagation sources.

Leafy cruciferae vegetable crops such as *tronchuda* are traditionally propagated sexually from seed. A disadvantage of sexual propagation is the lengthy reproductive cycle for biennial species. A long reproductive cycle is particularly undesirable if few seeds are produced and there is a need to rapidly increase seed stock. Tissue culture can reduce the time required to multiply plants (Mura-shige, 1974); however, it is complicated by the need to develop an appropriate tissue culture propagation system. Conventional vegetative propagation using cuttings can provide a simple, rapid, and inexpensive alternative.

Tronchuda is a biennial, leafy vegetable crop believed to be a cross between *Brassica oleracea* var. *capitata* and *B. oleracea* var.

acephala (Msikita and Skirvin, 1989). *Hortus Third* describes it as "a cabbage-like plant, without compact heads of leaves, with fleshy petioles and broad midribs" (Liberty Hyde Bailey Hortorium, 1976). Other than Portugal, where it is native (Miguel, 1957), *tronchuda* is cultivated in contiguous areas with Portuguese influence (Msikita and Skirvin, 1989). *Tronchuda* has wide adaptation, producing 1.6 t seed/ha in a subtropical climate (Msikita and Mnzava, 1988); it has resistance to turnip mosaic virus, an ubiquitous pathogen (Asian Vegetable Research Center, 1985) of *Brassica* and other plant species (Mingochi and Jensen, 1988).

In preliminary studies, we observed that *tronchuda* can be propagated from side shoots without the use of root-inducing chemicals. This study was undertaken to ascertain the potential of using *tronchuda* main stem and side shoot cuttings to asexually propagate the plant.

Seeds of five cultivars of *tronchuda* ('Portuguesa', 'Vilinda', 'Couve Penca', 'Penca de Chaves', and 'Ana Maria'), obtained from Zambia (the Vegetable Crops Research Team, Mazabuka), were sown (1 cm deep) in a growth medium of 1 sterilized peat : 1 perlite : 1 soil (by volume), contained in 0.15-liter plastic pots maintained in a greenhouse (25C, natural light), and watered as needed to maintain a moist medium.

Three weeks after germination, 18 vigorous seedlings of each cultivar were selected and transplanted into 10-liter plastic pots containing the growth medium described

above plus a 14N-14P-14K slow-release Osmocote (Sierra Chemical, Milpitas, Calif.) fertilizer (1 g/liter of medium).

Two weeks after transplanting, the apical region, including three to four nodes, was excised with a sterilized scalpel that had been immersed in 80% ethanol. The cuttings (main stem) were trimmed until only the two youngest leaves remained. Each shoot was transplanted into a 0.15-liter plastic pot containing the growth medium and maintained for 4 weeks under moist conditions using an overhead mist system (5 sec mist every 5 min). Twelve main stem cuttings were obtained for each cultivar.

Rapid Gro (Chevron Chemical, San Ramon, Calif.) plant nutrient solution (2 g 23N-19P-17K/liter, 100 ml/pot) was applied bi-weekly to each of the intact (seed-propagated) control plants and remnants of the decapitated plants (stumps) for the entire experimental period. Control plants and stumps were regularly watered to maintain a moist medium.

Two vigorous side shoots on each stump were removed at the three- to four-leaf stage, transplanted, and grown under the moist conditions as described for main stem cuttings. After 3 weeks, cuttings were observed for root formation. Rooted cuttings were transplanted into 10-liter pots (one transplant per pot), and Rapid Gro plant solution was applied 1 week later as described above. When necessary, insecticidal soap was applied to control aphids and white flies.

Mature, nonsenescent leaves from all treatments were first harvested ≈4 weeks after transplanting to large pots. Leaves were harvested weekly thereafter, until plants senesced or produced small-sized leaves. Leaf yield for each of the five cultivars was recorded as the number of leaves and the total fresh weight per plant.

The experimental unit consisted of three to six plants per observation for each cultivar, replicated four times in a split-plot design with cultivars assigned to main plots

Table 1. Rooting ability of *tronchuda* cultivars propagated from cuttings.

Cultivar	Cuttings with roots (%) ²	
	Main stem ¹	Side shoot ³
Portuguesa	80.2	100
Vilinda	80.0	98.6
Couve Penca	96.0	100
Ana Maria	90.0	100
Penca de Chaves	88.0	100
LSD (0.05)	9.4	1.2

¹n = 96 cuttings/cultivar for two experiments.

²n = 24 cuttings/cultivar for two experiments.

³Percentage of cuttings rooted (at least 1 cm long) after 4 weeks under misting.

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Table 2. Analysis of variance for fresh leaf weights of tronchuda (n = 360 to 720).

Source	df	SS	MS	F	P
Replication	3	34,445	---	---	---
Cultivars	4	2,429,736	607,434	77.3	0.0001
Rep. × cultivar (Error A)	12	688,974	57,414	---	---
Propagation methods	2	78,357	39,179	4.9	0.013
Cultivars × propagation	8	115,987	14,498	3.1	0.017
Rep. × propagation + rep. × propagation × cultivar (Error B)	30	138,963	4,632	---	---

Table 3. Mean fresh leaf weight per plant of tronchuda propagated asexually or by seed (n = 360 to 720).^a

Cultivar	Propagation method		
	Seed	Main stem	Side shoots
	Leaf wt (g)		
Portuguesa	1041	984	1009
Vilinda	621	441	576
Couve Penca	555	484	477
Penca de Chaves	495	500	361
Ana Maria	621	490	638
Cultivar × propagation method	*		

^aData are means of the fresh weight (g) of all leaves on a stem. LSD (0.05) = 311.9 for comparing cultivars using the same propagation method. LSD (0.05) = 98.3 for comparing the propagation methods for each cultivar.

Table 4. Mean number of leaves per plant of tronchuda propagated asexually or by seed (n = 360 to 720).^a

Cultivar	Propagation method		
	Seed	Main stem	Side shoots
Portuguesa	64	60	52
Vilinda	26	25	28
Couve Penca	23	23	24
Penca de Chaves	19	23	19
Ana Maria	32	31	29
Cultivar × propagation method	*		

^aLSD (0.05) = 17.36 for comparing among cultivars using the same propagation method. LSD (0.05) = 11.48 for comparing the propagation methods for each cultivar.

*Significant at $P = 0.05$.

Table 5. Mean leaf size of tronchuda propagated asexually and by seed (n = 360 to 720).

Cultivar	Propagation method		
	Seed	Main stem	Side shoots
	Leaf size ^a		
Portuguesa	16.3	16.4	19.4
Vilinda	23.9	17.6	20.6
Couve Penca	24.1	21.0	20.0
Penca de Chaves	26.1	21.7	19.0
Ana Maria	19.4	15.8	22.3

^aRatio of mean fresh leaf weight to mean number per plant. LSD (0.05) = 1.07 for comparing among cultivars using the same propagation method. LSD (0.05) = 5.37 for comparing the propagation methods for each cultivar.

and propagation methods to subplots. Among- and within-cultivar comparisons were made for the number of leaves and the mean fresh leaf weights for each of the control, main, and side shoot cuttings. The experiment was repeated, data were analyzed using analysis of variance, and means were separated using the appropriate error terms according to Carmer and Walker (1982).

All cultivars produced roots that attained a length of >5 cm within 19 to 21 days after transplanting. The percentage of cuttings that rooted was 10 to 20 percentage points higher for side shoots than for main-stem cuttings for all cultivars (Table 1). From main stems, 'Couve Penca' rooted significantly better than the other cultivars. After being transplanted into 10-liter pots and receiving nutrient solution, all three propagative types grew vigorously, and their leaves were of good quality (size, fresh weight).

Cultivars differed significantly in leaf fresh weight (Tables 2 and 3). Seed-propagated plants mostly produced heavier leaves than main and side shoot-derived plants. 'Penca de Chaves' and 'Ana Maria' produced leaves of slightly higher fresh weight per plant from main and side shoots, respectively, but the differences were nonsignificant. Mean fresh leaf weight for main shoot-derived plants for 'Penca de Chaves' was similar to that of seed-propagated plants, but higher than that for side shoot-derived plants, in contrast to treatment hierarchies among other cultivars. 'Portuguesa' consistently produced significantly heavier (Table 3) leaves than the other four cultivars for each propagation method. With the exception of 'Portuguesa', the interaction of cultivars and propagation methods were nonsignificant for leaf fresh weight per plant (Tables 2 and 3).

The mean number of leaves per plant was similar for each of the three propagation methods for all cultivars, except 'Portuguesa', which produced about twice as many leaves per plant as any other cultivars (Table 4). With the exception of 'Portuguesa', the interaction of cultivars and propagation methods was nonsignificant for leaf count per plant (Table 4).

Variation in leaf size (fresh leaf weight per leaf) among the cultivars was observed (Table 5). The greatest variation was with seed propagation. With this method, 'Penca de Chaves' produced significantly larger leaves than any other cultivar. Using the main stem, the leaf sizes produced by 'Couve Penca' and 'Penca de Chaves' were similar, but significantly larger than those of the other cul-

tivars. For side shoot-propagated plants, 'Ana Maria' produced leaves significantly larger than any other cultivar, and 'Penca de Chaves' produced significantly smaller leaves than all but 'Portuguesa' and 'Couve Penca'.

Only two cultivars responded differently in terms of leaf size to the three propagation methods. 'Penca de Chaves' produced significantly larger leaves using seed than side-shoot propagation, and 'Ana Maria' produced significantly larger leaves with side-shoot than with main-stem propagation (Table 5).

Cultivars varied in their ability to root from cuttings; main stem cuttings rooted less often than side shoots. Main stem cuttings were generally large in diameter and succulent at the time of transplanting compared with side shoot cuttings. Succulence might account for the low rooting frequency from main stem cuttings. The manipulation of moisture or nutrients in the rooting medium or the use of exogenous growth regulators could increase the rooting capacity of main shoots (Creelman, 1989).

The subsequent leaf yields of plants propagated from cuttings varied significantly by cultivar and propagation method. Overall, 'Portuguesa' was the best yielding in both leaf count and fresh leaf weight per plant. The high performance of 'Portuguesa' was consistent with earlier reports from field studies (Msikita and Mnzava, 1988) and might indicate the cultivar's wide adaptability and/or its short plastochron and efficient use of photosynthate to initiate new leaves.

The variation in the number of leaves per plant among the propagation sources and the interaction of cultivars and propagation method were nonsignificant for most cultivars, except 'Portuguesa'. This result might indicate that others have good potential as propagative materials. However, the significant variation among cultivars and propagation sources in leaf sizes might be due to variation in developmental status and/or cultivar response to management factors at the time of explanting.

This study demonstrates the potential for propagating tronchuda from main stem and side shoot cuttings. We recommend side shoot and main stem cuttings as alternative propagation materials for tronchuda. Propagation from side shoot and main stem cuttings is potentially useful to growers and breeders who may wish to rapidly produce true-to-type, uniform plants without waiting for seed to form and mature. This system also is relatively inexpensive, as it does not require the use of rooting agents.

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