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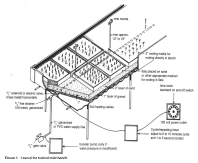

Mist propagation

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Cutting is the easiest method of vegetative propagation employed in horticulture. Several species of plants root easily while others fail to root or show a very low percentage of rooting from cuttings. large number of fruit and ornamental plants are commercially propagated by layering, budding or grafting and all these methods are more expensive and laborious than multiplication from cuttings. Successful rooting of cuttings or germination of seeds requires proper temperature, moisture supply and light intensity. Of these, moisture supply is usually the most difficult to control adequately. It is well known that increase in relative humidity prevents desiccation of cuttings and provides more favorable environmental condition for root formation. As the humid condition facilitates root formation in cuttings and layers, plants are usually propagated in the monsoon. Plants which fail to root from cuttings or develops low percentage of rooting under ordinary condition or even in a alkathene chamber have shown satisfactory rooting under mist.

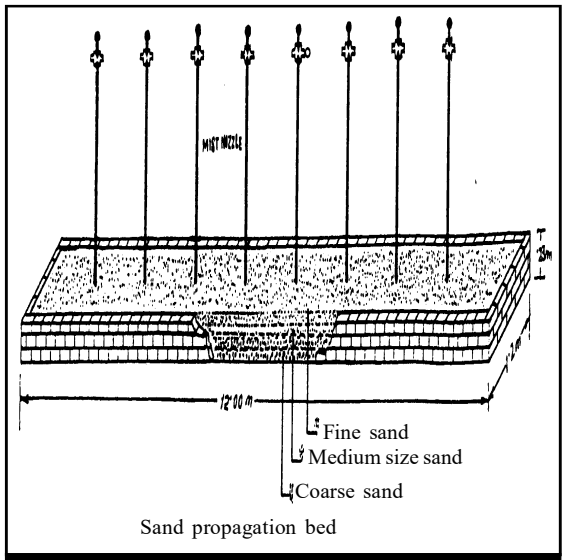

Fig. 1: Water distribution through mist nozzle

How to minimize water loss of cuttings?

– Place cuttings in cool, humid area - for leafless cuttings.
– Spray cuttings with antitranspirants. Antitranspirants-chemicals that decrease transpiration by forming a film on the leaf surface or by physiologically closing stomata.
– Place cuttings in a humidity chamber - enclosed chamber with very high humidity.
– Place cuttings under an intermittent mist system.

Intermittent mist system: A propagation system that periodically (every 5 to 30 minutes) sprays a fine mist of water on the cuttings to keep the foliage moist and minimize water loss.

In 1950s, the use of the mist propagation system for plant production was realized and this plant propagation method was considered to be revolutionary (Hudson, 1997). The system, which maintains the atmosphere with low evaporative demand, reduces water loss through transpiration (Hartmann *et al.,* 1997; Osterc and Spethmann, 1998). Water mist, or mist propagation, is a means of automatically maintaining moisture supply near optimum, on a small or large scale."Mist propagation system" is effective in increasing the amount of rooted cuttings and is an economic system that is widely used for cutting propagation in the nursery.

Mist propagation requires a very fine mist or fog of high quality water, bottom heat, and a porous propagation media to provide the high humidity, warmth, and oxygen needed for leafy cuttings to root. Cuttings are taken from actively growing plants and work best with at least two nodes and two lateral (prompt) buds.

Rapid propagation techniques most often use herbaceous plant material ranging from apical meristems to partially lignified, 25 cm shoot cuttings. Propagation from herbaceous material must be done in very high humidities utilizing mist propagation or tissue culture technique (Mullins *et al.,*1992).

Aim of mist propagation: It maintains a film of water on the plant pieces. As a result it,

– Maintains high humidity thereby reducing loss by evaporation and transpiration, and
– Maintains a cooling effect which reduces respiration rate.
– Keep the cuttings turgid until rooting
– Increases endogenous root promoting substances
– May decrease disease
– Promote rooting in difficult-to-root plant.
– Reduce the time for root initiation and development of roots.

The mist also tends to lower the temperature of the shoot, through:

– The evaporation of mist which cools the air;
– The small drops of water acting as a screen to the sun's rays;
– The water temperature often being lower than the propagator.

This combination of effects means that physiologically the plant material can synthesize food in light to a degree and slow down the rate of stored food utilization which will help the initiation and development of roots.

Mist propagation method for rooting hardwood cuttings of the vine variety Black Shiraz is described by Doelle and Mitchell (1964) in this method hardwood cuttings taken at the normal pruning time and planting the rooted cuttings out 3-4 months later resulted in a firstcrop of about 1 ton per acre in the second season and a further advantage of this method is the uniformity in growth and low failurerate of 1 per cent in the field or 5 per cent during the whole propagation period.

Planting environment inside mist chamberz:

Temperature: Temperatures of 65°F (18°C) to 75°F (24°C) should be maintained in the medium. Air temperatures of 50°F (10°C) to 69°F (15°C) are satisfactory. Higher air temperatures are not detrimental, but lower temperatures may cause injury. If the temperature of the water used for mist propagation is low, the temperature in the medium will be below optimum, and rooting or germination will be delayed or cease. To remedy this situation, use soil heating cables under the pots or flats.

Light : Use light intensity equivalent to open or diffused shade. Mist propagation may be used out of doors under light shade, in greenhouses and indoors under fluorescent lights. Under lights indoors, use 40 watt, warm, white fluorescent tubes suspended 12 inches (30.5 cm) above the tops of the cuttings. Two tubes in a standard fixture would be sufficient for a space 3 feet (1 m) wide and as long as the tubes. The electrical system and the fluorescent tubes should be shielded from mist.
– If very high light intensity- scorching
– If very low light intensity- less growth

Humidity: Humidity should be 85-90 per cent.

Component of mist system :

Water supply: This should be reliable, with adequate flow and with sufficient pressure.

Water quality: The water should not be hard and alkaline; also water containing iron should be avoided. Uncontaminated rain water is excellent.

Water distribution : Water needs to be distributed as evenly as possible over the propagation bed. This needs a pressure of at least 30 lb; low pressure will provide a coarse mist and a fine mist is required. Water supply is through a main feeder pipeline along the centre of the bed with 90 cm long uprights with baffle-type nozzles spaced lm apart (Fig. 2).

Medium :The medium for the germination of seeds or the rooting of cuttings should be porous, well aerated and well drained. Usually, peat moss mixed with an equal amount of fine sand, perlite or pumice is excellent for growing rooted cuttings or seedling. Sand or perlite may be used alone but is not as good as the above mixtures.

Mist duration : The correct duration and interval of mist is critical to the ability of the cuttings survival and success at rooting. Too little mist or too much time between mists will result in the cuttings drying out, wilting and dying. Too little mist will also result in the cuttings overheating which will also result in the cuttings dying. Too much mist or too little time between mists will result in a constantly wet cutting and constantly wet rooting medium. This will result in leaf drop, stem rot and fungus and diseases. A good basic starting point is a 5 to 10 second misting period every 5 to 10 minutes.

How is the mist produced? By passing water under pressure through *mist jets*, which are very small, specially made holes. A complete system consists of:
– A water supply (river, well, reservoir, large tank or piped mains);
– An electric or diesel pump capable of supplying enough water at a pressure of at least 15 m head, plus a pressure switch and controls;
– A filtration system which removes particles that would block the mist jets and can be routinely cleaned;

A mist controller: (mains- or battery-operated) with a *timer* that allows adjustment of:
– The length of each burst of mist (2–15 secs);
– The frequency of the bursts (every 2–60 mins);
– A different regime for day and night;

Alternatively, some controllers have an *electronic sensor* which detects the evaporation of the mist (or whether the sun is shining) and controls the frequency and length of bursts.

A set of mist jets, preferably with valves to turn off those that are not needed.

How should the propagation beds be constructed?
– So that the top of the rooting medium is at least 30 cm above the level of the paths;
– Construct the sides of the bed out of durable wood or concrete blocks, leaving plenty of space for water to drain out at the bottom;

– Fill the bed with the same materials as for polythene propagators (A31), but:
– Without polythene sheeting;
– With a thicker layer of both stones and of gravel;
– Without flooding the filler/drainage material with water;
– With a rooting medium that does not easily become waterlogged (A35).

Method of mist propagation : For mist propagation, cuttings are made usually from top shoot 20-30 cm in length depending on the type of the plant and 4-6 leaves are retained in each cutting. Basal cut is given by a sharp knife about 0.5 cm below the node. In order to examineroot formation in cuttings and also to facilitate removal of the rooted cuttings they are planted in 12-16 cm earthenware pot containing coarse washed sand placed on raised platforms or propagation frame in mist chamber. The cuttings can also be planted directly in sand bed. Planting of cuttings in potaaccalarates rooting due to aeration through the pores of the pot. Depending on the length of the cutting 5-10 cm basal portion should be inserted in the sand and very close planting should be avoided for exposing maximum leaf surface to receive the fine spray of water.

Season of mist propagation : As the humidity in the mist chamber is under control, cuttings can be planted throughout the year, if the temperature inside the glasshouse or alkathene chamber is higher than in the open. In the summer months, temperature can be minimized considerably by covering the top with a sunblind made of gunny cloth painted green. Cuttings can be taken from the evergreen plants at any time of the year, while in case of deciduous plants, dormant and leafless shoots show less rooting even when the temperature of the mist chamber is favourable. Under local conditions, satisfactory root formation in cutting has been recorded during 9 months in a year except in January, April and May. As most of plants develop roots in 4-6 week in mist chamber, 4-5 sets of cuttings can taken during a year.

Care of a rooted cutting : After the cuttings have developed roots, the frequency of mist should be gradually reduced to begin hardening off the cuttings and to get them accustomed to normal growing conditions. Over the period of a month or so, the water should be reduced to a once a day watering. The cutting are now ready to be transplanted into pots, grow beds or planted into the landscape. Potted plants should continue to be watered once a day. The new plants in grow beds or planted in the landscape should be watered once a day for a few weeks, then once every two or three days for a few weeks. After about a month, the plants should established enough to be watered only during long dry spells.

Disadvantage:

Leaching : The loss of nutrients and other compounds from inside leaves and stems.

During intermittent mist propagation upto half of some of the nutrients in the leaf can be leached out. This causes the cuttings to be nutrient deficient. The problem can be corrected with nutrient mist.

Nutrient mist : Addition of dilute fertilizers to the mist; replaces nutrients lost to leaching. Use 2-6 oz. of a 20-20-20 or equivalent soluble fertilizer per 100 gallons of water.

Harmones used on cuttings:

Auxin : Stimulates adventitious root formation on stem cuttings - IBA (most commonly used), NAA (frequently used), 2, 4-D (less used).

Cytokinin : Stimulates adventitious shoot formation on leaf or root cuttings- kinetin (commonly used), benzyladenine (BA) (commonly used), zeatin (seldom used), pyranylbenzyladenine (PBA) (used in research).

Interaction B/W moisure and regulators: Ersoy *et al*. (2010) studied the effects of "Mist propagation system" high air relative humidity levels, plant growth regulator (IBA) dose applications and perlite media on rooting of M_9 clonal rootstock cuttings and found the interaction of moisture X IBA doses in M_9 softwood cuttings was found statistically significant ($P<0.05$) and also observed that the highest ratio of cutting callus formation was found in control group (58%) in 95-100 per cent humidity level and 2500 ppm IBA hormone dose application in 85 - 90 per cent humidity level. The highest rooting ratio was obtained from control group (46%) in 95-100 per cent humidity level; the lowest one was 3500 ppm IBA dose application (17%) in 85 - 90 per cent relative humidity level. The highest rooting surface lenght was found in 1500 ppm hormone dose (0.53 cm) in 95-100 per cent and 2500 ppm IBA dose application (0.42 cm) in 85-90 per cent humidity level. With respect to root numbers, the highest value was from 1500 ppm IBA application (1.29 number/cutting) in 95 - 100 per cent relative humidity, and 500 and 2500 ppm IBA doses (1.04 number/cutting) in 85-90 per cent relative humidity level. The longest root was obtained from control group (2.03 cm) in 95-100 per cent humidity level and 500 ppm IBA hormone dose (1.80 cm) in 85-90 per cent humidity level. The shortest root was obtained from 2500 ppm IBA hormone dose application (0.09 cm) in 85-90 per cent humidity level. The highest root branching value was obtained from 1500 ppm hormone dose application (0.88 number/cutting) in

Table 1: Effects of moisture level and hormone dose applications in the softwood top cuttings of M_9 clonal apple rootstock cuttings

Cutting properties	Humidity ratio (%)	IBA hormone doses (ppm)					
		0 (control)	500	1500	2500	3500	Average humidity
Cutting length	95-100	21.23(1.173)	20.20(0.560)	21.04(20189)	20.65(0.546)	20.91(1.367)	20.81(1.170)
(cm)	85-90	21.15(0.977)	21.50(0.817)	20.29(1.512)	21.21(0.469)	21.81(0.325)	21.20(0.940)
Average hormone		21.19(0.967)	20.85(0.945)	20.66(1.733)	20.93(0.550)	20.36(1.018)	21.00(1.061)
Callus	95-100	58a* (19.00)	25bc(12.500)	17c(14.400)	13c(0.000)	46ab(10.100)	32(21.200)
formation (%)	85-90	49a (7.200)	46a(31.400)	43a(14.200)	58a(7.200)	33a(19.000)	45(17.400)
Average hormone		52.(14.600)	35(24.200)	30(19.200)	35(25.500)	40(15.200)	38(20.300)
Rooting ratio	95-100	46(31.400)	25(0.000)	25 (21.600)	25(25.000)	37(17.600)	32(20.400)
(%)	85-90	38(21.600)	29(19.000)	33(21.800)	29(28.800)	17(19.000)	29(20.200)
Average hormone		42(24.500)	27(12.200)	29(19.900)	27(24.200)	27(19.800)	30(20.000)
Rooting surface	95-100	0.33(0.241)	0.15(0.033)	0.53 (0.808)	28(0.245)	0.31(0.082)	0.32(0.356)
area (cm)	85-90	0.25(0.187)	0.19(0.160)	0.19(0.092)	0.42(0.308)	0.08(0.095)	0.23(0.193)
Average hormone		0.29 (0.197)	0.17(0.106)	0.36(0.546)	0.35(0.260)	0.19(0.145)	0.27(0.286)
Root number	95-100	1.33 (1.092)	0.92(0.072)	1.29(1.808)	0.79(0.753)	1.62(0.359)	1.19(0.913)
(unit/cutting)	85-90	0.75(0.125)	1.04(1.371)	0.62(0.165)	1.04(1.063)	0.54(0.732)	0.80(0.748)
Average hormone		1.04(0.765)	0.98(0.871)	0.96(1.206)	0.92(0.835)	1.08(0.783)	0.99(0.844)
The longest	95-100	2.03(1.515)	1.01(0.229)	1.98(1.566)	1.22(1.225)	1.28(0.676)	1.50(1.074)
root (cm)	85-90	1.09(0.461)	1.80(0.746)	0.72(0.043)	0.71(1.107)	0.52(0.789)	0.84(0.664)
Average hormone		1.56(1.125)	1.09(0.502)	1.35(1.207)	0.96(1.081)	0.80(0.778)	1.17(0.939)
The shortest	95-100	0.42(0.130)	0.48(0.344)	0.79(0.665)	0.20(0.189)	0.75(1.117)	0.53(0.563)
root (cm)	85-90	0.88(0.593)	0.36(0.219)	0.47(0.316)	0.09(0.086)	0.11(0.101)	0.38(0.407)
Average hormone		0.65(0.459)	0.42(0.266)	0.63(0.498)	0.13(0.153)	0.43(0.792)	0.45(0.489)
Root branching	95-100	0.50(0.330)	0.29(0.190)	0.88(1.192)	0.21(0.260)	0.51(0.443)	0.48(0.564)
(unit/ cutting)	85-90	0.63(0.642)	0.63(0.866)	0.19(0.082)	0.13(0.216)	0.13(0.216)	0.34(0.490)
Average hormone		0.57(0.462)	0.46(0.589)	0.53(0.843)	0.17(0.218)	0.32(0.375)	0.41(0.524)
Root diameter	95-100	0.60(0.494)	0.37(0.088)	0.33(0.295)	0.39(0.338)	0.61(0.414)	0.46(0.323)
(mm)	85-90	0.54(0.262)	0.37(0.367)	0.47(0.291)	0.40(0.426)	0.23(0.26)	0.40(0.298)
Average hormone		0.57(0.355)	0.37(0.238)	0.40(0.273)	0.40(0.344)	0.42(0.374)	0.43(0.307)
Cutting	95-100	3.63(0.143)	3.43(0.099)	3.37(0.407)	3.50(0.186)	3.64(0.319)	3.52(0.243)
diameter (cm)	85-90	3.84(0.331)	3.63(0.070)	3.68(0.246)	3.27(0.167)	3.62(0.202)	3.61(0.267)
Average hormone		3.73(0.256)	3.53(0.131)	3.53(0.344)	3.39(0.202)	3.63(0.239)	3.56(0.255)

* Data are the means of three replications ± standard error. Values within column followed by the same letter are not significantly different at P= 0.05 (Ducan's multiple range test)

95-100 per cent humidity level.

Similarly, Debnath and Mathi (1990) studied the effect of growth regulator on rooting of soft wood cuttings of guava under mist and concluded that IBA was most effective@2500 ppm under rainy season.

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