Phenology of different planting stocks of *Populus deltoides* Bartr ex Marsh under different irrigation frequencies

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ABSTRACT

The present study was conducted during 2011-2012 to examine phenological trends (leaf fall and leaf emergence) of different planting stocks of poplar in relation to two irrigation frequencies. Maximum leaf fall week 1 (38.89%) was observed in polythene bag under 30-day irrigation followed by bare root (wrenched plants) (33.33%) under 30-day irrigation. Minimum leaf fall week 1 (11.11%) was observed in root trainer under 15-day irrigation and maximum (26.67%) under 30-day irrigation which was lower than other planting stocks for both irrigation frequencies.

Keywords: Leaf fall; planting stocks; leaf emergence; irrigation frequency; monsoon planting

INTRODUCTION

Phenology is an integrated response to the environmental conditions accomplishing growth and has been defined as the study of cyclical biological events. In plants this can include flowering, leaf unfolding (or budburst), seed set and dispersal and leaf fall in relation to climatic conditions (Davi et al 2011). Phenological events in plants may be affected by various factors that can be classified as proximate or ultimate causes. Proximate causes principally include short-term environmental events that may trigger phenological patterns while ultimate causes include evolutionary forces that are responsible for these patterns. Environmental cues such as changes in water level stored by plants (Reich and Borchert 1984, Borchert1994), seasonal variations in rainfall (Frankie et al 1974), changes in temperature (Ashton et al 1988, Williams-Linera 1997), photoperiod (Leopold 1951, Tallak Nilsen and Muller 1981, van Schaik 1986, Rivera et al 2002), irradiance (Wright and van Schaik 1994) and sporadic climatic events (Sakai et al 1999) have been mentioned as proximate causes triggering phonological events in tropical plants. In forests with a marked dry season changes in water availability from shifts in precipitation regimes and soil moisture have been proposed as the essential proximate and ultimate causes affecting phonological patterns (Reich and Borchert 1984, Borchert 1994). Another study comparing two tropical dry forest sites with different annual rainfall in southern India concluded that phenological patterns depend upon precipitation (Murali and Sukumar 1994).

Populus deltoides is usually planted during January-February months in winter season when the plants are dormant. The plant is moisture sensitive and needs regular heavy irrigation. When planted in winter season its root system is not sufficiently developed to tolerate the hot dry summer which starts in April and continues till second half of June. As a result the plant fails to survive if not watered well during these months. If planted in monsoon season (July-September) the plant might get enough time to grow and develop adequate root system to withstand its first summer season during next calendar year. Monsoon planting would provide an alternative season to the growers who cannot plant poplar in winter season due to inadequate irrigation or

for other practical reasons. Monsoon planting would also obviate the need for planting poplar in standing wheat crop as maturing wheat and poplar have opposite requirements during late spring and summer; maturing wheat does not require irrigation but poplar requires irrigation during this period. Planting in monsoon season would require growing of planting stock in the nursery till monsoon.

The different planting stocks tested were containerised stock (ie plants raised in polythene bag and root trainer) and containerless stock ie bareroot plants and entire transplants (ETPs) as terminology given by Fidelibus and Bainbridge (1994). The plants (both monsoon and winter planted) were analysed in the field for phenological trends (leaf fall and leaf emergence) in relation to two irrigation frequencies.

Location and climate

All nursery and some field investigations were carried out at the campus of Forest Research Institute, Dehradun, Uttarkhand. The site is located at 30° 20′ 10.31′ N latitude and 75° 59′ 55.32′ E longitude. Dehradun is in the influence of sub-tropical climate and experiences about 20°C mean annual temperature and 2,073 mm rainfall annually. Major part of the rainfall is received from mid-June to mid-September and winter showers are mild.

METHODOLOGY

The experiment on the comparison of containerized (polythene bag and root trainer) and containerless (bare root and entire transplant) production methods was done in the field. The polythene bag, root trainer and bareroot stocks were out-planted during monsoon season (1 July 2011) in pits of 30 cm length x 30 cm width x 45 cm depth leaving the planting spots of entire transplants without pits or plants at that time. Entire transplants were planted during mid-January (16 January 2012) in pits of 90 cm length and 23 cm diameter. Planting was done in the campus of Forest Research Institute, Dehradun, Uttarakhand. Four types of planting stocks viz polythene bag, root trainer, bareroot, entire transplant and two irrigation frequency (I_{15}: fortnightly and I_{30}: monthly) with three replications were evaluated under the present study. The recorded data were statistically analysed using randomised complete block design. The spacing used was 3 x 3 m. The plants were maintained in the field for 48 months (52 months cutting age) (till July 2014).

The following observations were recorded:

Leaf fall: Leaf fall was observed for individual tree at weekly interval from 30 November to 21 December 2012. A tree was considered as leafless when less than five leaves per main branch were left on branches of 2 to 5 cm diameter. The number was expressed as percentage of surviving plants.

Leaf emergence: Leaf emergence was observed for individual tree at weekly interval from 25 February to 18 March 2013. A tree was considered to have reached leaf emergence stage when at least 80 per cent of the buds on lowest five branches per plant had opened. The number was expressed as percentage of surviving plants.

RESULTS and DISCUSSION

Leaf fall (Table 1)

Week 1: Although variation was non-significant the maximum (32.96%) leaf fall was in 30-day and minimum 23.22 per cent in 15-day irrigation suggesting that 15-day irrigation was having less leaf fall in week 1. Maximum leaf fall (32.94%) was in polythene bag followed by bareroot (wrenched plants) (24.61%) and minimum (18.89%) in root trainer suggesting that root trainer had less leaf fall in week 1.

Week 2: Irrigation frequency was found to have a significant effect on leaf fall in week 2. Maximum leaf fall (74.44%) was in 30-day and minimum 56.31 per cent in 15-day irrigation suggesting that 15-day irrigation was having less leaf fall in week 2. Although variation was non-significant, maximum (77.78%) leaf fall was observed in all plants followed by polythene bag and bare root (wrenched plants) having 68.26 and 59.92 per cent respectively. Minimum leaf fall of 55.56 per cent was in root trainer suggesting that leaf fall in root trainer was delayed as compared to other production methods.

Week 3: Effects of irrigation and production method were not studied during 3rd week as there was 100 per cent leaf fall.

Leaf emergence (Table 1)

Week 1: Although variation was non-significant, the maximum (45.44%) leaf emergence was in 15-day and minimum (42.26%) in 30-day irrigation suggesting that

Table 1. Effect of production method and irrigation frequency on leaf fall and leaf emergence

Treatment	Leaf fall (30 Nov-21 Dec 2012)			Leaf emergence (25 Feb-18 Mar 2012)		
	Week 1	Week 2	Week 3	Week 1	Week 2	Week 3
Irrigation frequency						
I_{30}	32.96 (24.64)	74.44 (65.94)	100.00 (89.96)	42.26 (40.26)	86.71 (74.63)	100.00 (89.96)
I_{15}	23.22 (27.11)	56.31 (50.00)	100.00 (89.96)	45.44 (42.16)	90.48 (79.32)	100.00 (89.96)
SE_d	NS	7.05	-	NS	NS	-
$LSD_{0.05}$	-	15.12	-	-	-	-
Production method						
Polythene bag	32.94 (34.46)	68.26 (58.52)	100.00 (89.96)	48.02 (43.81)	92.86 (80.88)	100.00 (89.96)
Root trainer	18.89 (20.91)	55.56 (50.86)	100.00 (89.96)	53.97 (47.29)	95.24 (84.58)	100.00 (89.96)
Bareroot	24.61 (29.12)	59.92 (53.42)	100.00 (89.96)	46.43 (42.87)	92.86 (80.88)	100.00 (89.96)
Entire transplant	29.18 (32.68)	77.78 (69.09)	100.00 (89.96)	26.99 (30.86)	73.41 (61.56)	100.00 (89.96)
SE_d	NS	NS	-	4.95	NS	-
$LSD_{0.05}$	-	-	-	10.62	-	-

Values within parentheses are arc sine transformed values

there was greater leaf emergence in case of 15-day irrigation. Production method was found to have a significant effect on leaf emergence. Maximum leaf emergence (53.97%) was observed in root trainer followed by polythene bag and bare root (wrenched plants) having 48.02 and 46.43 per cent respectively. Minimum (26.99%) was in all plants suggesting that leaf emergence started early in root trainers as compared to others.

Week 2: The maximum (90.48%) leaf emergence was observed in 15-day and minimum 86.71 per cent in 30-day irrigation suggesting that 15-day irrigation had greater leaf emergence in week 2. However the differences were found to be statistically non-significant. Although variation was non-significant maximum 95.24 per cent leaf emergence occurred in root trainer followed by polythene bag and bare root (wrenched plants) which were however statistically on a par having 92.86 per cent leaf emergence. Minimum 73.41 per cent occurred in entire transplants suggesting that all transplants took greater time for leaf emergence as compared to others.

Week 3: Effects of irrigation and production methods were not studied during 3rd week as there was 100 per cent leaf emergence.

Interaction between different production methods and irrigation frequency was found to have a significant effect on leaf fall week 1 (Table 2). Four types of production methods showed their peak leaf fall under different irrigation frequencies.

The interaction between different production methods and irrigation frequencies further revealed that in all irrigation frequencies root trainer showed less leaf fall in week 1 as follows: 11.11 per cent in 15-day and 26.67 per cent in 30-day irrigation followed by entire transplant, bareroot (wrenched plants) and polythene bag. Minimum leaf fall week 1 of 11.11 per cent was observed in root trainer under 15-day irrigation and maximum (26.67%) under 30-day irrigation which was lower than other planting stocks for both irrigation frequencies.

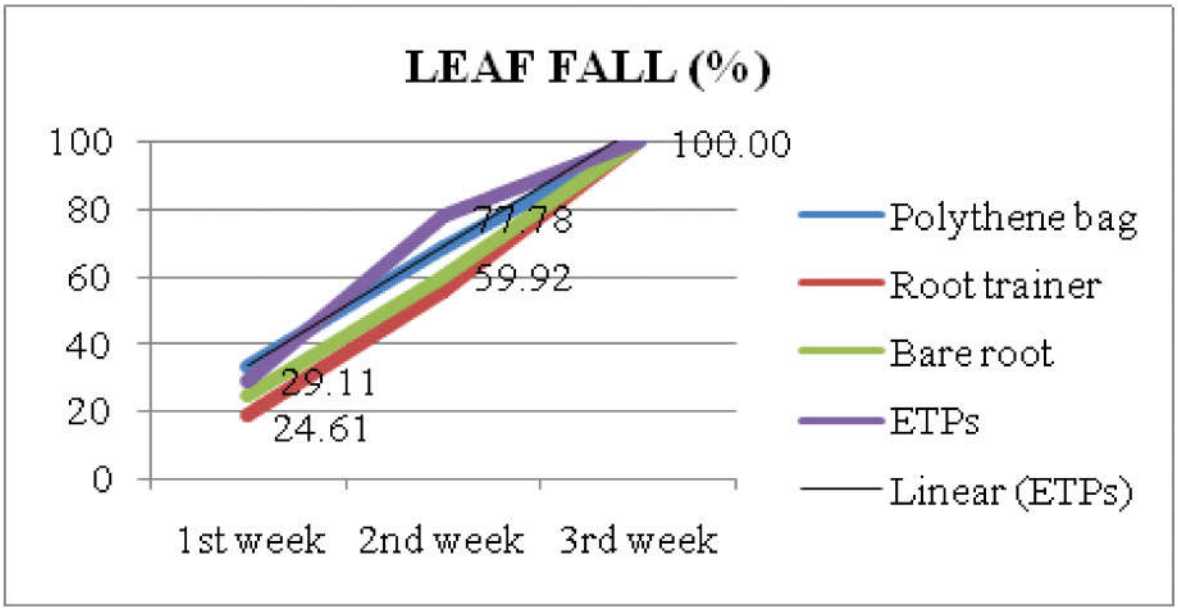
Maximum leaf fall in week 1 (38.89%) was observed in polythene bag followed by bareroot (wrenched plants) (33.33%) under 30-day irrigation. Minimum leaf fall in week 1 (11.11%) was observed in root trainer under 15-day irrigation.

During autumn season leaf fall occurred at a faster rate in all transplants and slowest in root trainer. Leaf emergence in the following spring occurred first in root trainer plants and last in entire transplants (Table 1, Fig 1). In all transplants, the tallest stock thus retained leaves for the shortest period of time while root trainer plant, the shortest stock retained leaves for the longest period of time. Anderson and Ryser (2015) have recorded a weak non-significant trend for taller trees to senesce earlier in *Acer rubrum.* Leaf chlorophyll content, tannin content, specific leaf area (SLA), dry

Table 2. Interaction effect of different production methods and irrigation frequency on leaf fall during week 1

Production method	Leaf fall (%) under irrigation frequency	
	I_{30}	I_{15}
Polythene bag	38.89 (38.02)	26.98 (30.90)
Root trainer	26.67 (25.77)	11.11 (16.06)
Bare root	33.33 (34.77)	15.88 (23.46)
Entire transplant	31.07 (33.86)	26.20 (30.78)

SE_d: 10.01, $LSD_{0.05}$: 21.46, Values within parentheses are arc sine transformed values



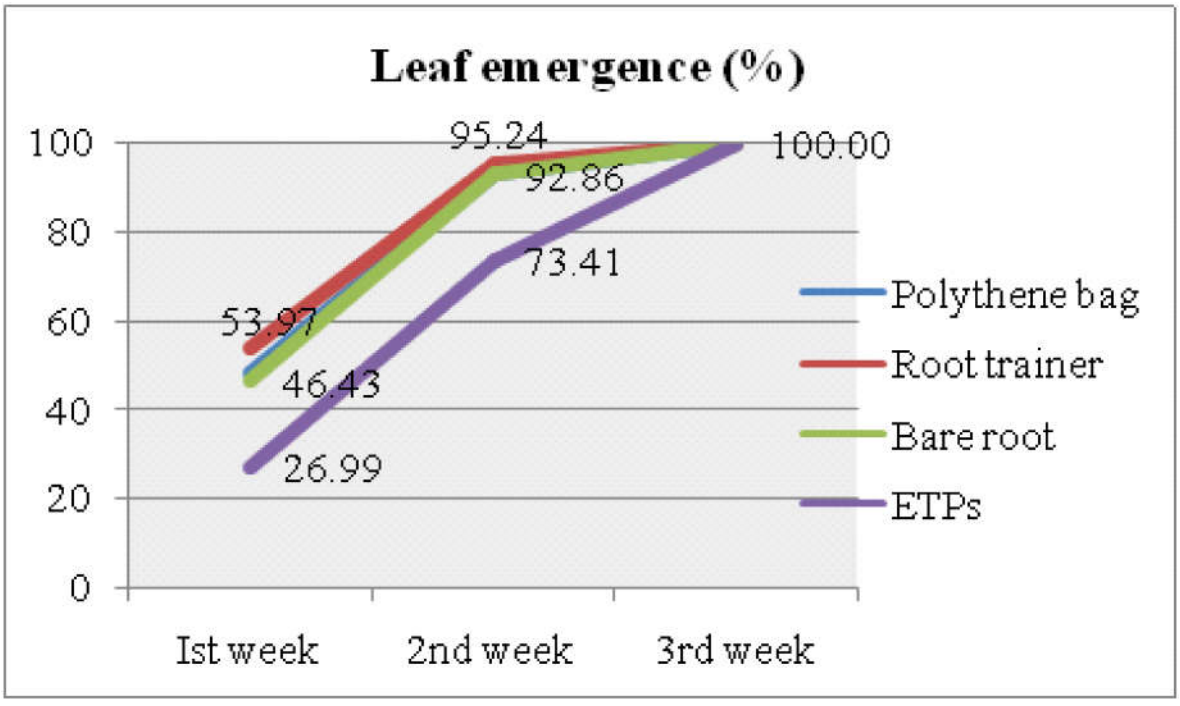


Fig 1. Leaf fall and leaf emergence in different stocks in plantation

matter content (DMC) and lamina thickness had relatively low correlation with leaf senescence. Seiwa (1999) in *Acer mono* established that leaf retention period decreased as tree height decreased.

Dhiman and Gandhi (2010) have innovated nursery production by first growing plants from mini-stem cuttings in tubes anytime after monsoon season to winters and planting the tube plantlets in nursery beds late next year till the beginning of the monsoon season. The terminal bud set and leaf fall in such saplings got delayed by approximately two weeks when compared with the traditionally-grown all transplants.

CONCLUSION

Monthly irrigation witnessed early leaf fall and late leaf emergence vis a vis fortnightly irrigation. Among all types of stocks all transplants experienced early leaf fall senescence and late leaf emergence while root trainer stock registered late leaf fall and early leaf emergence.

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