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INCREMENTAL GROWTH OF CONTAINERIZED KAIL PINE (*Pinus wallichiana* Jackson) SEEDLINGS AS AFFECTED BY THE VARYING LEVELS OF NITROGEN FERTIGATION

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ABSTRACT

This study was aimed to determine the effect of varying levels of nitrogen fertigation on growth of Kail pine *(Pinus wallichiana*) seedlings in nursery conditions. The germinated seedlings were fertilized at weekly interval with Ingestad pretreatment nutrient solution of N (1.98 mg week^{-1}) and P, K, Ca and Mg (in 100: 13: 65: 7: 8.5 ratio) @ 25 ml seedling^{-1} for one month as pretreatment. The pre-treated seedlings were divided into 12 lots and fertilized with either of the nitrogen doze @ 0 (with or without fertigation), 0.99, 1.98, 2.97, 3.96, 4.95, 5.94, 6.93, 7.92, 8.91 and 9.90 mg dissolved in 50 ml water alongwith fixed levels of P, K, Ca and Mg seedling^{-1} week^{-1} upto 28 weeks. Nitrogen significantly increased seedling height, biomass, relative growth rate and other quality parameters. Quality seedlings of Kail pine were produced at the nitrogen addition @ 7.92 mg seedling^{-1} week^{-1} for the first growing season at nursery. It increased seedling height by 113.7%, root collar diameter by 78% and dry biomass by 78.8% as compared to control. However, relative growth rate was highest at 5.95 mg of nitrogen addition rate.

Keywords: Biomass, growth, fertigation, nitrogen, pine

INTRODUCTION

Forests trees are the most bountiful renewable resources which provide goods and services which include timber, fuel wood, food products and fodder. Kail pine (*Pinus wallichiana)* Jackson is an important timber species found in moist and dry temperate forests of Western and Central Himalayas from Kashmir to Bhutan at the altitudinal zonation of 1700-3700 m masl. Kail pine is a tall evergreen tree with average height of 30-36 m and girth 2.5 to 3 m; Kail wood is moderately hard with specific gravity of 0.5 and weighs 513 kg m^{-3}. The calorific value of dried Kail wood is 4,995 kcal kg^{-1} (Troup, 1921).

The geographical area of Jammu and Kashmir state is 1,01,387 km^2, excluding the area under Pakistan and China, of which forests cover 20,230 km^2 (Anonymous, 2009). However, the forest cover in J&K state, as per satellite data interpretation, is only 16,309 km^2 with 2,958 km^2 under very dense forests, 6,507 km^2 under moderately dense, 6,844 km^2 under open forests and rest forest area engulfed by blanks and scrubs (Anonymous, 2009). In J&K forests Kail pine (*Pinus wallichiana* Jackson), deodar [*Cedrus deodara* (Roxb) G. Don], silver fir (*Abies pindrow*), spruce [*Picea smithiana* (Wall.) and Boiss] are dominant species. These species mostly rely on natural succession for regeneration and it may take hundreds of years to regenerate these degraded forests to climax stage. Further, the restocking of 6,844 km^2 of moderately dense forests of J&K state and reforesting 10,765 km^2 of degraded forest @ 1650 seedlings ha^{-1} shall require about 2,297 million conifer seedlings for restocking of demarcated

forest area under plantation forestry.

Shortening rotation time by applying nitrogen-based fertilizers is a common method for enhancing the nursery productivity because nitrogen is relatively an inexpensive input that greatly stimulates growth. The nitrogen plays prominent role in light harvesting and CO_2 fixation (Evans, 1989) with a pronounced effect on morphological parameters in nursery (Salvador *et al*., 2004; Oliet *et al*., 2005). Limited nitrogen supply impairs shoot growth proportionally more than the root growth (Ledig, 1983). Fertigation has flexibility, cost effectiveness and potential for improved seasonal fertilizer application efficiency over traditional fertilizer application methods (Jaynes *et al.,* 1992). The problem associated with natural regeneration of pines is a major concern and has invited the attention of forest scientists. A number of factors are considered responsible for the failure or patchy regeneration of this species. The only way to maintain the diverse nature of forests is plantation of quality seedlings of pine species. Keeping this in view, the present investigation was aimed to examine the relationship between mineral nutrition and seedling quality through evaluation of relative growth and also to determine minimum possible nitrogen concentration for optimum growth of Kail pine seedlings for the first year in nursery.

MATERIALS AND METHODS

The experiment was conducted at the Faculty of Agriculture, Wadura, Sopore (J&K). The site is located at 34°17′ N latitude and 74°33′ E longitude with altitude of 1524 m masl. The site falls in temperate zone. The winter starts from November and lasts until February, with severe cold and frost in January. The mean maximum temperature is 29.8°C and minimum temperature -1.92°C, with July and January as hottest and coldest months, respectively.

The Kail pine seeds were collected from Bandipora Forest Division, Kashmir, soaked in cold water for 24 h and treated with Captan (50% WP) @ 2.5 g kg^{-1} seed. The seeds were sown in polythene bags (10 x 15 cm) filled with sterilized river bed sand and kept in mist chamber for germination in the last week of February, 2009. Three seeds were sown in each polybag and weeding was carried out manually as and when required. Polybags were irrigated once in a week when fertilizer was not applied. Germinated seeds were thinned out to one baby plant $polybag^{-1}$ after 3 weeks of emergence. The germinated seedlings were then fertigated at weekly interval with Ingestad pretreatment nutrient solution (Ingestad and Lund, 1979) that included all major nutrients with weight proportions of N, P, K, Ca and Mg (in 100:13:65:7:8.5 ratio) @ 25 ml $seedling^{-1}$ for one month as pretreatment**.** Each application supplied 1.982 mg N, 0.258 mg P, 1.288 mg K, 0.139 mg Ca and 0.168 mg Mg $seedling^{-1}$. The pre-treated seedlings were shifted from mist chamber to nursery and treated weekly with nitrogen fertigation which was continued till the termination of experiment (upto seedling age of 28 weeks). The nitrogen fertigation treatments comprized of 12 levels of nitrogen viz., 0 [with and without fertigation], 0.99, 1.98, 2.97, 3.96, 4.95, 5.94, 6.93, 7.92 8.91 and 9.90 mg N $seedling^{-1}$. All the treatments, except without fertigation treatment, were given fixed levels of other nutrients viz., P, K, Ca and Mg $seedling^{-1}$ $week^{-1}$. Nutrient fertigation was applied weekly @ 50 ml $seedling^{-1}$ $week^{-1}$. The control treatment received only plain water. The experiment was conducted in a randomized block design with three replication per treatment and 6 seedlings representing each replication. Nine seedlings from each treatment were selected randomly and harvested at 4 weeks interval to measure seedling height, collar diameter and biomass. The collar diameter was measured slightly above the root collar by using digital caliper. The relative growth rate (RGR) was determined at the end of growth season as per the method of Hunt (1982).

$$RGR = \frac{\ln W_2 - \ln W_1}{t_2 - t_1}$$

Where, W_2 and W_1 are the mean plant biomass values at time t_2 and t_1, respectively. W_1 was taken prior to treatments (at 4^{th} week) and W_2 taken on 28^{th} week.

The data was subjected to statistical analysis as per Gomez and Gomez (1984). The variations between various factors and their interactions were tested at $P \leq 0.05$. The statistical analysis was carried out using the software SPSS version 15.

RESULTS AND DISCUSSION

Increase in nitrogen fertigation upto 7.92 mg N level significantly enhanced seedling height (8.76 cm) and RCD (1.75 mm) in Kail pine. However, seedling dry weight showed increase even upto 9.90 mg N application (Table 1, 2 and 3). There was no significant difference among last three higher doses applied in case of sapling height and RCD. Also, there was no significant difference in seedling height, RCD and seedling dry weight in nitrogen-free treatment and control. The effect of age on seedling height was conspicuous with longest seedlings (9.10 cm) observed at 28th week age which was 1.78 times more than the seedling height at 8th week age. With increase in age from 8 to 28th week, the height showed significant increase. Interaction between fertigation and age of Kail pine revealed maximum seedling height (11.50 cm) in 9.90 mg N treatment at 28th week age. As expected, with increase in the rate of N applied, the seedling size also increased. Similar increase in longleaf pine seedling size has

Table 1: Effect of nitrogen fertigation on seedling height of Kail pine *(Pinus wallichiana)*

Nitrogen levels	Seedling age (weeks)					
(mg seedling^{-1})	8	12	16	20	24	28
0.00 (No fertigation)	3.80	4.10	4.20	4.40	4.80	5.10
0.00 (No nitrogen)	3.90	4.30	4.40	4.70	5.00	5.40
0.99	4.10	5.00	5.60	6.40	7.30	7.90
1.98	4.40	5.20	5.90	6.70	7.60	8.20
2.97	4.60	5.50	6.30	7.10	7.90	8.57
3.96	4.80	5.87	6.70	7.50	8.40	8.93
4.95	5.10	6.10	7.10	7.90	8.90	9.50
5.94	5.70	6.80	7.80	8.90	9.80	10.60
6.93	5.93	7.10	8.20	9.20	10.20	10.90
7.92	6.20	7.40	7.97	9.40	10.40	11.20
8.91	6.30	7.70	8.50	9.50	10.50	11.40
9.90	6.40	7.80	8.70	9.70	10.43	11.50
Mean	5.10	6.07	6.78	7.62	8.44	9.10
$CD_{0.05}$	Treatment: 0.32;		Age: 0.23;		Treatment x age: 0.78	

Table 2: Effect of nitrogen fertigation on root collar diameter (mm) in Kail pine seedlings

Nitrogen levels	Seedling age (weeks)					
(mg seedling^{-1})	8	12	16	20	24	28
0.00 (No fertigation)	0.76	0.89	0.97	1.25	1.40	1.60
0.00 (No nitrogen)	0.82	0.93	1.03	1.28	1.45	1.66
0.99	0.85	0.96	1.08	1.32	1.59	1.87
1.98	0.88	1.00	1.12	1.41	1.65	1.89
2.97	0.92	1.05	1.16	1.44	1.69	1.94
3.96	0.98	1.09	1.24	1.50	1.75	2.03
4.95	1.06	1.16	1.34	1.58	1.85	2.15
5.94	1.18	1.30	1.48	1.71	1.99	2.32
6.93	1.22	1.35	1.54	1.76	2.05	2.38
7.92	1.25	1.39	1.57	1.79	2.10	2.41
8.91	1.26	1.41	1.58	1.80	2.13	2.42
9.90	1.28	1.42	1.60	1.82	2.15	2.44
Mean	1.04	1.16	1.31	1.56	1.82	2.09
$CD_{0.05}$	Treatment: 0.05;		Age: 0.04;		Treatment × Age : ns	

Table 3: Effect of nitrogen fertigation on total biomass (g) of Kail pine seedlings

Nitrogen levels (mg seedling^{-1})	Seedling age (weeks)					
	8	12	16	20	24	28
0.00 (No fertigation)	0.062	0.098	0.138	0.265	0.451	0.618
0.00 (No nitrogen)	0.068	0.108	0.170	0.318	0.516	0.752
0.99	0.073	0.113	0.185	0.364	0.604	0.840
1.98	0.078	0.118	0.191	0.402	0.635	0.872
2.97	0.082	0.124	0.204	0.415	0.664	0.896
3.96	0.087	0.138	0.218	0.463	0.700	0.927
4.95	0.091	0.141	0.248	0.481	0.738	0.970
5.94	0.098	0.180	0.328	0.520	0.812	1.050
6.93	0.102	0.188	0.360	0.542	0.846	1.105
7.92	0.107	0.195	0.384	0.564	0.868	1.142
8.91	0.110	0.199	0.391	0.579	0.884	1.156
9.90	0.113	0.204	0.398	0.594	0.898	1.166
Mean	0.089	0.151	0.268	0.459	0.718	0.960
$CD_{0.05}$	Treatment: 0.005 ;		Age: 0.004		Treatment × Age: 0.013	

been observed with increase in N rates from 0.5 to 4 mg N by Jackson *et al.* (2010). Larger seedlings tend to maintain size advantage over time compared to smaller seedlings (Rose and Ketchum, 2003). RCD is often considered the most important seedling attribute (South *et al*., 1993).

The effect of age on seedling height, RCD and dry weight was conspicuous with longest seedlings (9.10 cm), highest RCD (2.09 mm) and dry weight (0.96) observed at 28th week age which was 1.78, 3.2 and 11.0 times more than the seedling height, RCD and dry weight at 8th week age, respectively. The interaction between fertigation and age of Kail pine revealed maximum seedling height (11.5 cm), RCD (2.44 mm) and dry weight (1.166 g) at N level of 9.90 mg at 28th week age. Significant interaction effects between treatment and age was recorded in seedling height and dry weight, but in case of RCD no significant interaction effect was observed. South *et al.* (2005) reported that N addition @ 0.5 to 3.0 mg seedling^{-1} week^{-1} increased RCD in longleaf pine during nursery production as well as in the first year of out-planting. Significant increase in RCD of longleaf pine by nitrogen addition @ 2 to 5 mg seedling^{-1} week^{-1} has been reported by Dumrose *et al.* (2005). RCD is often considered the most important seedling quality attribute (South *et al*., 1993).

Seedling biomass continued to increase with increase in nitrogen application. Kail pine seedlings grew faster upto 7.92 mg N application indicating that other N additions were either too low or very high in the beginning to maintain near optimum growth rate. Miles (1974) observed that the addition of nitrogen alone considerably promoted seedling growth. Birge *et al.* (2006) using a broad range of nutrient supply from 0 to 3.35 g N plant^{-1} for 18 weeks observed increase in plant dry biomass by 113 – 260% in case of *Quercus rubra* and by 49 - 144% in case of *Q. alba* concluding that 1.68 g N seedling^{-1} season^{-1} is optimum for the two *Quercus* species at nursery stage.

Seedling biomass at 28 week age was 618 mg in control and in nitrogen treatments the values varied from 844 to 1166 mg with high biomass observed in high application doze. The cumulative amount of nitrogen added by treatments varied from 19.82 to

Table 4: Biomass and relative growth rate of Kail pine seedlings at 28 week age

Nitrogen levels (mg seedling^{-1})	Total N applied (mg)	Total dry weight (mg)	Relative growth rate (mg week^{-1})
0.00 (No fertigation)	7.93	618	0.110
0.00 (No Nitrogen)	7.93	752	0.118
0.99	19.82	840	0.123
1.98	39.64	872	0.125
2.97	59.46	896	0.126
3.96	79.28	927	0.127
4.95	99.10	970	0.129
5.94	118.92	1050	0.132
6.93	138.74	1105	0.134
7.92	158.56	1142	0.136
8.91	178.38	1156	0.136
9.90	198.20	1166	0.137

198.20 mg seedling^{-1} upto the harvest time i.e. at 28th week age. Relative growth rate in Kail pine showed an increasing trend and was high (0.137 mg week^{-1}) at 9.90 mg N level which decreased to 0.110 mg week^{-1}. Miles (1974) observed that addition of nitrogen alone considerably promoted growth of seedlings. Plants from high resource environments generally have high RGR and respond more strongly to added nitrogen in terms of photo-synthesis and growth (Schulze and Chapin, 1987) in contrast to the plants raised on dry and infertile soils which have low biomass and possess inherently low RGR potential (Grime, 1977; Chapin, 1980). Production by individual plant is a product of their size and relative growth rate. Burgess (1991) observed fastest growth in Douglas fir seedlings at 83.05 mg of nitrogen relative addition rate.

Conclusions: Kail pine **(***Pinus wallichiana)* seedlings responded to different fertigation treatments by improvement in seedling size. Growth of kail pine seedling was inherently slower in early growing period up to 12 weeks after germination. Hence, it is recommended that for raising quality seedlings of kail pine, starting with 7.92mg of nitrogen as pretreatment for one month and then adding treatments of 7.92mg (which adds158.56mg) of N week^{-1} seedling^{-1} should be given for first growing season to obtain maximum growth.

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