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Growth performance and biomass production of Moso bamboo (*Phyllostachys pubescence)* under the influence of N-fertigation

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Abstract
This study investigated the growth and biomass production of Moso bamboo (*Phyllostachys pubescence)* under the influence of N-fertigation in the temperate condition of Kashmir. The rhizomes of *Phyllostachys pubescence* before sprouting of new buds were extracted and immediately transplanted in the poly bags. The established seedlings were fertigated with the different nitrogen levels *viz*., 0, 3, 6, 9, 12, 15, 18 and 21mg dissolved in 50ml of water along fixed levels of P, K, Ca and Mg seedling^{-1} week^{-1} up to 28 weeks. Different levels of nitrogen and age significantly increased growth, biomass and other quality parameters of Moso bamboo seedlings. The nitrogen addition rate of 18mg seedling^{-1} week^{-1} was found best treatment for raising quality seedlings of *Phyllostachys pubescence*. At this addition seedling height increased by 35.53%, root collar diameter by 55.14%, fresh biomass by 83.34% and dry biomass by 191.30% as compared to control. Similarly, shoot root ratio of 3.15 and seedling quality index 13.09 was recorded at 18mg seedling^{-1} week^{-1} at 28 weeks age. Hence, nitrogen addition rate of 18mg seedling^{-1} week^{-1} is the paramount for achieving maximum growth and biomass production of Moso bamboo (*Phyllostachys pubescence)* under the temperate condition of the Kashmir

Keywords: *Phyllostachys pubescence,* Moso bamboo, fertigation, Kashmir

Introduction
Bamboo is a major Non-Timber Forest Product (NTFP) exploited by the rural people for household food and fodder security besides herbal medicine formulation (ITTO, 2009) [1]. Bamboo is an exceptionally fast growing plant which allows harvesting for house construction and other multiple products within 4-7 years playing a vital role in income generation (Tamang, 2013) [2]. Bamboos have a wide range of ecological amplitude and are distributed throughout the tropical, sub-tropical and cold temperate regions except in Europe, from sea level to 4000m (Soderstrom and Calderon, 1979) [3]. The bamboos have about 70 genera divided into about 1,500 species all over the world (Khalil *et al*., 2012) [4]. According to Naithani (2008) [5] a total of 20 genera and 115 species of bamboos are present in India. They are particularly abundant in the Western Ghats and the "Sister States" of north-east India (Rai and Chauhan, 1998) [6]. China has the highest bamboo diversity (626 species), followed by India (102) and Japan (84) (Bystriakova *et al*., 2003) [7]. The bamboo has versatile uses qualifying to be an alternative to timber known as "poor man's timber". About 50% of the annual production of bamboo in our country is used by various industries like pulp, paper, rayon, mat boards, besides agricultural implements. It is also used for making baskets, bridges, coffins, beds, toys and weapons (Reddy, 2006) [8]. Besides particle board material and substitute for rattan the pickled or stewed bamboo shoots are regarded as delicacies in many parts of the country. The major user of bamboo in India is paper industry, which consumes sizeable proportion (20%) of the total annual bamboo production. Bamboos are good soil binders owing to their peculiar clump formation and fibrous root system and therefore, play an important role in soil and water conservation. Furthermore, bamboo tolerates poor soils, which makes it useful for planting on degraded soils (Hunter, 2003) [9].
The Moso bamboo (*P. pubescence*) is the most important bamboo species in China, its aerial shoots are long-lived, persisting aboveground for more than ten years (Zhou *et al*., 2014) [10]. The species originates from China and has been naturalized in some other neighboring countries, such as Korea and Vietnam. Economically, Moso bamboo is the most important bamboo species in the world. In India Moso bamboo is a prioritized species under National Bamboo Mission and has been included in bamboo for PAN India plantation program under which it has been planted in sub temperate zones of Arunachal Pradesh and Himachal Pradesh. The applications include bamboo flooring that is produced in China and exported to the United States and Europe. It is also widely cultivated for production of shoots, which is considered a

delicacy throughout Asia. Moso bamboo is a key species for rural and industrial development, particularly in south-eastern parts of China. The application of N-fertigation influences the growth and biomass production of Moso bamboo, hence, recommendations of N-fertigation vary widely. The fertilizer often provide actual N requirement and thus more frequent doses accompanied with tissue analysis to determine concentration needed for optimum growth (Mills and Jones, 1996) [11]. Nonetheless, the N-Fertilization is the most important management technique for obtaining greater biomass production (Widjaja, 1991) [12]. The perusal of literature reveals that no consolidated account on N-fertigation is available on Moso bamboo (*Phyllostachys pubescence*) or any other temperate bamboo species. Keeping in view the utilization of bamboo and its valuable socio-economic and environmental benefits the present investigation was undertaken with the objective to produce quality plant material of *Phyllostachys pubescence* under various nitrogen addition regimes.

Materials and methods

The present investigation was conducted in the nursery of Faculty of Forestry, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Benhama, Ganderbal, during the year 2015-2016. The experimental site is located at 34º17′ N latitude and 74º46′ E longitude at 1617m altitude above the mean sea level. The site experiences the temperate conditions where winter starts from November to February with severe cold and frost in the month of January. The mean maximum temperature is 29.8º C and minimum temperature -1.92º C with July and January as hottest and coldest months, respectively. The average precipitation of the study site is 690mm mostly in the form of snow during winter months.

The rhizomes of *Phyllostachys pubescence* before sprouting of new buds were extracted from the nursery of Agricultural Production Department, Government of Jammu and Kashmir, Budgam in the last week of February 2015 and were immediately transplanted in the poly bags of size (10cm × 15cm) filled with soil. The well-established clumlets were treated weekly with nitrogen fertigation and continued till end of growing season. The seedlings were applied with 0, 3, 6, 9, 12, 15, 18 and 21mg of nitrogen per seedling and fixed levels of P (0.39mg), K (1.95mg), Ca (0.21mg) and Mg (0.25mg) seedling^{-1} week^{1}. The N-fertigation was applied weekly @ 50ml seedling^{-1} (Table 1). Suitable control was also maintained and applied with plain water. Each treatment was replicated three times with 50 polybags in each replication.

Table 1: Treatment details of the experiment

Treatment code	Description
T_0	Control (no fertigation)
T_1	N (0) mg + P (0.39) mg + K (1.95) mg + Ca (0.21) mg + Mg (0.25) mg
T_2	N (3) mg + P (0.39) mg + K(1.95) mg + Ca(0.21) mg + Mg (0.25) mg
T_3	N (6) mg + P(0.39) mg + K (1.95) mg + Ca (0.21) mg + Mg (0.25) mg
T_4	N (9) mg + P(0.39) mg + K (1.95) mg + Ca (0.21) mg + Mg(0.25) mg
T_5	N (12) mg + P(0.39) mg + K(1.95) mg + Ca(0.21) mg + Mg(0.25) mg
T_6	N (15) mg + P(0.39) mg + K(1.95) mg + Ca(0.21) mg + Mg(0.25) mg
T_7	N (18) mg + P(0.39) mg + K(1.95) mg + Ca(0.21) mg + Mg(0.25) mg
T_8	N (21) mg + P(0.39) mg + K(1.95) mg + Ca(0.21) mg + Mg(0.25) mg

Note: The values in parenthesis are different values of nutrients applied

All cultural operations were viz., weeding, irrigation, *etc.* were carried as and when required. Nine seedlings from each treatment were selected randomly and harvested to record the observations.

Results

Height

The N-fertigation significantly ($p \leq 0.05$) affected the seedling height in *Phyllostachys pubescence* as it increased with increasing levels of N-fertigation (Table 2). The maximum mean seedling height (74.03cm) was recorded in T_7; however, seedling height was at par with T_8 (73.47) (Fig. 1). Mean height of seedlings increased consciously from T_1 to T_7 and was about 1.36 times than control. The effect of age on average height of seedlings was prominent with maximum average seedling height of 102.88cm at 28 week age. It was 4.15 times longer than height of seedlings at 4 week of age. With increasing age from 4 to 28 week, the height increased significantly at every date of observation ($p \leq 0.05$). Interaction between N-fertigation and age with respect to seeding height (Fig. 2) of *Phyllostachys pubescence* showed wide range of results. Maximum seedling height (116.28cm) was observed under the influence of treatment T_7 at 28 of week that was almost 6.06 times higher than control at 4 week of age. The seedling height increased progressively with age and under the influence of increasing concentration of nitrogen from T_0 to T_7 at all age segments.

Table 2: Effect of N-fertigation and age on height (cm) of *Phyllostachys pubescence* seedlings

N-fertigation levels (mg seedling^{-1})	Age (weeks)							Mean
	4	8	12	16	20	24	28	
$T_{0 = (0.00)}$	19.17	27.96	36.91	54.30	72.64	82.70	88.67	54.62
$T_{1 = (0.00)}$	19.90	29.39	39.39	56.73	76.07	86.23	93.33	57.29
$T_{2 = (3.00)}$	20.65	30.67	40.67	58.20	77.60	88.61	95.80	58.89
$T_{3 = (6.00)}$	22.70	32.80	43.17	60.91	80.37	92.07	99.27	61.61
$T_{4 = (9.00)}$	24.60	34.93	45.41	63.26	82.75	94.47	102.50	63.99
$T_{5 = (12.00)}$	25.59	36.05	47.00	64.87	84.35	96.35	104.53	65.53
$T_{6 = (15.00)}$	28.71	39.67	50.42	68.53	88.10	100.60	109.61	69.38
$T_{7 = (18.00)}$	31.00	42.80	54.60	73.60	93.65	106.30	116.28	74.03
$T_{8 = (21.00)}$	30.63	42.33	53.93	72.90	92.67	105.93	115.93	73.47
Mean	24.77	35.16	45.72	63.70	83.13	94.81	102.88	

C.D ($p \leq 0.05$) Fertigation : 0.63
Age (weeks) : 0.55
Fertigation × Age : 1.66

Collar diameter

The average collar diameter increased consistently with increasing levels of nitrogen ($p \leq 0.05$) with the maximum average seedling collar diameter of 12.21mm in T_7 as compared to minimum (7.86mm) in T_0 (Table 3). Collar diameter at the higher concentrations of nitrogen (T_7 and T_8) did not vary significantly. As the age increased seedling collar diameter increased significantly ($p \leq 0.05$). Maximum average collar diameter (16.75mm) was recorded in seedlings when they were 28 week old and was 2.41 times higher than the seedlings when they were 4 weeks old. The interactions between N-fertigation age and has significant effect ($p \leq 0.05$) on collar diameter (Fig. 3). Maximum collar diameter of 21.23mm was recorded in T_7 at 28 week, which was almost 2.78 times higher than collar diameter in the control (T_0) at 4 weeks of age.

Fig 1: Bamboo seedlings

Fig 2: Height measurement

Fig 3: Diameter measurement

Fig 4: Weight measurement

Table 3: Effect of N-fertigation and age on collar diameter (mm) of *Phyllostachys pubescence* seedlings

N-fertigation levels (mg seedling^{-1})	Age (weeks)							Mean
	4	8	12	16	20	24	28	
T_0 = (0.00)	6.03	7.10	5.43	6.30	8.07	10.00	12.07	7.87
T_1 = (0.00)	6.30	7.37	6.03	7.07	8.97	11.00	13.13	8.55
T_2 = (3.00)	6.63	7.67	5.73	7.40	9.40	11.90	13.97	8.96
T_3 = (6.00)	6.90	8.80	5.53	7.50	10.20	13.23	15.33	9.64
T_4 = (9.00)	6.97	9.00	5.13	8.00	11.00	15.10	16.30	10.21
T_5 = (12.00)	7.00	9.50	4.67	8.45	12.49	16.47	17.93	10.93
T_6 = (15.00)	7.27	9.73	4.30	8.80	13.80	18.57	19.80	11.75
T_7 = (18.00)	7.83	9.87	4.07	8.97	14.30	19.17	21.23	12.21
T_8 = (21.00)	7.70	9.77	4.00	8.83	13.87	19.00	21.00	12.02
Mean	6.96	8.76	4.99	7.92	11.34	14.94	16.75	

C.D ($p \leq 0.05$)
Fertigation : 0.20
Age (weeks) : 0.17
Fertigation × Age : 0.51

Total fresh weight

The data (Table 4) revealed that increase in concentration of N-fertigation increased fresh weight significantly ($p \leq 0.05$) having maximum average fresh biomass of 67.05 g in T_7 which was more than 1.8 times greater than control (T_0). The treatment (T_8 and T_7, T_0 and T_1,) did not show any significant difference. The influence of age on seedling fresh weight was also significant ($p \leq 0.05$). Fresh biomass increased conspicuously ranging between 22.83g at 4 weeks to 78.13g at 28 week, however, the mean fresh weight was at par between 24 to 28 weeks of age. Interaction between fertigation and age for seeding fresh weight also differed significantly ($p \leq 0.05$). The maximum value (109.93g) was recorded in T_7 at 28 weeks age which was 5.30 times greater than control at 4 week of age. However, treatments T_0 to T_2 and T_7 to T_8 were at par at 28 weeks of age.

Table 4: Effect of N-fertigation and age on total seedling fresh weight (g) of *Phyllostachys pubescence* seedlings

N-fertigation levels (mg seedling^{-1})	Age (weeks)							Mean
	4	8	12	16	20	24	28	
$T_{0 = (0.00)}$	20.73	23.69	27.71	35.36	45.48	50.80	52.23	36.57
$T_{1 = (0.00)}$	21.00	24.00	28.29	36.25	47.70	51.50	53.00	37.39
$T_{2 = (3.00)}$	21.83	25.23	30.18	41.16	54.43	59.90	54.11	40.98
$T_{3 = (6.00)}$	21.80	26.30	31.43	44.93	61.29	67.25	65.27	45.47
$T_{4 = (9.00)}$	22.67	27.40	33.34	49.73	67.50	78.75	75.10	50.64
$T_{5 = (12.00)}$	23.61	28.65	35.40	54.27	71.53	84.63	86.67	54.97
$T_{6 = (15.00)}$	23.66	29.64	37.71	58.67	78.27	94.17	97.00	59.87
$T_{7 = (18.00)}$	25.20	33.67	43.30	65.67	87.17	104.40	109.93	67.05
$T_{8 = (21.00)}$	25.00	33.50	43.43	65.17	87.00	104.30	109.83	66.89
Mean	22.83	28.01	34.53	50.13	66.71	77.30	78.13	

C.D ($p \leq 0.05$)
Fertigation : 1.00
Age (weeks) : 0.99
Fertigation × Age : 2.66

Total seedling dry weight

The Table 5 revealed that increased concentration of N-fertigation increased the seedling dry weight significantly ($p \leq 0.05$) with maximum average dry weight of 59.25g in T_7 followed by 58.97g in T_8, however, does not differ statistically. Dry weight (Fig. 4) increased by 191% as compared to control. All treatments resulted in concomitant increase in seedling dry weight with the increase in N-fertigation. Influence of age on seedling dry weight also showed significant difference. Maximum mean seedling dry weight of 71.50g was recorded at 28 week age which was 5.63 more than dry weight at 4 weeks of age ($p \leq 0.05$). Seedling dry weight increased significantly as age of seedlings advances from 4 to 28 weeks. The interaction between fertilizer treatment and age with respect to seeding dry weight was significant ($p \leq 0.05$). Dry weight of seedlings varied from 9.27g in control at 4 week age to 107.32g at 28 week of age under the T_7 nitrogen addition rate depicting 11.58 times increase.

Table 5: Effect of N-fertigation age on total on total seedling dry weight (g) of *Phyllostachys pubescence* seedlings

N-fertigation levels (mg seedling^{-1})	Age (weeks)							Mean
	4	8	12	16	20	24	28	
$T_{0 = (0.00)}$	9.27	11.53	14.66	19.95	22.73	29.40	34.84	20.34
$T_{1 = (0.00)}$	9.55	11.93	15.37	20.50	25.79	32.09	37.76	21.86
$T_{2 = (3.00)}$	10.50	13.84	18.44	25.82	34.10	41.86	47.80	27.48
$T_{3 = (6.00)}$	11.63	15.21	20.54	29.90	41.78	53.15	60.68	32.27
$T_{4 = (9.00)}$	12.60	17.09	23.40	35.93	51.34	64.83	72.77	39.71
$T_{6 = (15.00)}$	14.67	20.81	29.80	46.91	65.73	84.27	94.44	50.95
$T_{5 = (12.00)}$	13.47	18.65	25.87	41.25	57.30	72.40	81.03	44.28
$T_{7 = (18.00)}$	16.33	24.57	36.60	56.87	77.17	95.88	107.32	59.25
$T_{8 = (21.00)}$	16.27	24.22	36.48	56.07	77.25	95.59	106.89	58.97
Mean	12.70	17.54	24.57	37.02	50.35	63.27	71.50	

C.D ($p \leq 0.05$)
Fertigation : 0.47
Age (weeks) : 0.41
Fertigation × Age : 1.24

Shoot root ratio

Data pertaining to shoot root ratio in response to nitrogen treatments indicated that the highest shoot root ratio of 2.30 was recorded in T_7 which is significantly higher ($p \leq 0.05$) than control (1.09) T_0 (Table 6). The treatments T_7 and T_8, T_0 and T_1 did not vary significantly. As the age of seedling increases from 4 to 28 weeks, the shoot root ratio increased ($p \leq 0.05$) significantly. Shoot root ratio at 28 week is about 4.61 times more as compared to control at 4 weeks. Interaction between nitrogen concentration and age was found significant ($p \leq 0.05$) and shows wide range of results the maximum shoot root ratio of (3.33) was obtained in T_7 at 24 week which was 9.8 times more than the shoot root ratio at 4 weeks in T_0.

Table 6: Effect of N-fertigation and age on shoot root ratio of *Phyllostachys pubescence* seedlings

N-fertigation levels (mg seedling^{-1})	Age (weeks)							Mean
	4	8	12	16	20	24	28	
$T_{0 = (0.00)}$	0.34	0.58	0.80	1.22	1.33	1.77	1.60	1.09
$T_{1 = (0.00)}$	0.35	0.57	0.80	1.24	1.27	1.90	1.54	1.10
$T_{2 = (3.00)}$	0.42	0.67	0.98	1.50	1.91	2.10	1.93	1.36
$T_{3 = (6.00)}$	0.48	0.72	1.09	1.69	2.29	2.66	2.45	1.62
$T_{4 = (9.00)}$	0.52	0.84	1.21	1.95	2.68	3.06	2.84	1.87
$T_{5 = (12.00)}$	0.57	0.90	1.31	2.18	2.83	3.14	2.86	1.97
$T_{6 = (15.00)}$	0.64	0.98	1.39	2.18	2.93	3.25	2.88	2.04
$T_{7 = (18.00)}$	0.77	1.19	1.77	2.69	3.20	3.33	3.15	2.30
$T_{8 = (21.00)}$	0.77	1.17	1.90	2.55	3.24	3.25	3.18	2.29
Mean	0.54	0.85	1.25	1.91	2.41	2.72	2.49	

C.D ($p \leq 0.05$)
Fertigation : 0.05
Age (weeks) : 0.04
Fertigation × Age : 0.14

Seedling quality index

The N-fertigation significantly (p≤0.05) affected seedling quality index in *Phyllostachys pubescence* which increased progressively with increased levels of nitrogen (Table 7). Maximum mean seedling quality index (6.95) was recorded in T_7. However there was no significant difference between T_7 and T_8. Minimum seedling quality index (2.68) was recorded in control T_0 control. The effect of age on seedling quality index was conspicuous (p≤0.05). Maximum seedling quality index (8.43) was recorded at 28 week of age which was 3.10 times higher as compared to 2.72 at 4 week of age. Interaction between nitrogen concentration and age was found significant (p≤0.05) and shows wide range of results. The maximum seedling quality index (13.09) obtained in T_7.

Table 7: Effect of N-fertigation and age on seedling quality index of *Phyllostachys pubescence* seedlings

Nitrogen fertigation levels (mg seedling^{-1})	Age (weeks)							Mean
	4	8	12	16	20	24	28	
$T_{0\ =\ (0.00)}$	2.26	2.47	2.42	2.31	2.40	3.35	3.66	2.68
$T_{1\ =\ (0.00)}$	2.46	2.69	2.36	2.48	2.83	3.65	4.30	2.97
$T_{2\ =\ (3.00)}$	2.59	2.96	2.64	3.01	3.96	4.67	5.44	3.61
$T_{3\ =\ (6.00)}$	2.71	3.42	2.71	3.42	4.33	5.64	7.11	4.19
$T_{4\ =\ (9.00)}$	2.73	3.49	2.86	4.02	4.92	7.16	8.55	4.82
$T_{5\ =\ (12.00)}$	2.78	3.98	2.79	4.58	6.30	8.22	9.44	5.44
$T_{6\ =\ (15.00)}$	2.81	4.09	3.82	5.12	7.40	9.94	11.22	6.34
$T_{7\ =\ (18.00)}$	3.08	4.45	3.09	5,44	8.28	11.25	13.09	6.95
$T_{8\ =\ (21.00)}$	3.04	4.34	2.88	5.31	8.34	11.15	13.05	6.87
Mean	2.72	3.54	2.84	3.97	5.42	7.21	8.43	

C.D (p≤0.05)

Fertigation	:	0.14
Age (weeks)	:	0.13
Fertigation × Age	:	0.38

Discussion

The N-fertigation significantly influenced growth and biomass of *Phyllostachys pubescence* seedlings. This was expected because the cumulative amount of nitrogen added by treatments varied considerably up to the time, when the seedlings where 28 week old. It varied from 84 to 588mg seedling^{-1}. The seedlings were modified by more than 1.36 times in average height, 1.55 times in mean collar diameter, 1.83 times in green biomass and response of seedlings up to 28 week age to cumulative addition of nitrogen beyond 588mg seedling^{-1} was non-significant. Up to this addition rate seedlings were 116.28cm long with collar diameter of 21.23mm and accumulating a fresh biomass of 109.93g. The *Phyllostachys pubescence* seedlings grew faster up to 18mg of nitrogen indicating that other addition rates either too low or very high in the beginning to maintain near optimum growth rate. Burgess (1991) [13] also observed fastest growth in Duglas fir seedlings at 83.05mg of nitrogen relative addition rate. Miles (1974) [14] observed that addition of nitrogen alone considerably promoted growth of seedlings. Larger seedlings tend to maintain size advantage over time compared to smaller seedlings (Rose and Ketchum, 2003) [15]. Increased collar diameter is believed to enhance out planting performance of seedlings. South *et al.* (2005) [16] also reported that N addition rate of 0.5 to 3mg seedling^{-1} week^{-1} increased root collar diameter in Long leaf pine during nursery production as well as in the first year of out planting. Birge *et al.* (2006) [17] using a broad range of nutrient supply from 0.00-3.35g N per plant for 18 weeks observed increase in plant dry mass by 113-260 per cent for *Quercus rubra* and by 49-144 per cent in *Quercus alba* concluding that 1.68 g N per seedling per season is optimum for the two species at nursery stage.

The average shoot root ratio of *Phyllostachys pubescence* seedlings up to 28 week age increased by 111 percent at cumulative addition of 504mg N seedling^{-1} as compared to the control. Eamus and Jarvis (1989) [18] observed that under conditions of low nutrient availability, trees increase the proportion of root biomass, but under high nutrient availability, root proportion may decrease, remain unaltered or increase. The average shoot to root ratio is not statistically distinguishable beyond T_7. Similarly at 28 week age the variation in shoot root ratio even under high nitrogen regime is non-significant. There appears to be fine balance in coupling of biomass allocation to roots in response to changes in N availability. A seedling shoot root balance of approximately 70:30 percent in high N will apparently ensures adequate supply of water and nutrients from roots and maintains adequate photosynthetic capacity in shoots (Gratani *et al.*, 2008; Tomer *et al.*, 2010) [19-20]. The fertigation increased the seedling quality index (SQI) of *phyllostachys pubesence* seedlings by inducing growth. These seedlings reached near acceptable size; however, the progressive increase in the SQI was due to the total amount of N added by fertigation with different concentration. Up to the age of 28 weeks the average SQI increased by 2.59 times (Table-6). SQI up to the age of 28 weeks showed conspicuous increase to 6.95 under the influence of 588mg N added till this stage. The highest (13.09) SQI was recorded in treatment (T_7) on the application of 18mg N seedling^{-1} week^{-1}. The quality index was calculated by evaluating possible combination of morphological parameters predicted for field performance of white spruce and white pine seedlings as proposed by Dickson *et al.* (1960a) [21] subsequently, Dickson *et al.* (1960b) [22] employed this index to predict quality on the basis of nutrient environment (soil fertility) in which the seedlings were grown.

Conclusion

The study led to conclude that to raise quality seedlings of *Phyllostachys pubescence* under Kashmir conditions 18mg of N week^{-1} seedling^{-1} should be applied during the first growing season to obtain maximum overall growth and biomass production. Thus, it is recommended to farmers as a suitable fertilizer dosage to increase the growth performance of *Phyllostachys pubescence.*

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