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Research Article

Study the effect of INM on seedling growth and quality parameters of *Bambusa vulgaris* (S) seedlings at different stages

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ABSTRACT : An investigation was undertaken with *Bambusa vulgaris* (S.) as the test tree species to standardize ideal Integrated Nutrient Management (INM) techniques for improving the growth of tissue cultured seedlings, so as to obtain the best quality seedling within a shortest nursery period. A nursery experiment was conducted by raising tissue culture *B. vulgaris* seedlings in polybags of size 25 cm x 15 cm filled with non-calcareous, red sandy loam soil (Typic Ustropept), sand and FYM with two levels of urea (500 and 1000 mg seedling^{-1}), two levels of single super phosphate (1000 and 1500 mg seedling^{-1}), two levels of muriate of potash (250 and 500 mg seedling^{-1}) and micronutrient mixture (5 g) along with *Azospirillum* (5 g) seedling^{-1}, phosphobacteria (5 g) seedling^{-1} and VAM (10 g) seedling^{-1}. The results revealed that the shoot and root length, collar diameter and number of shoots were increased by INM treatments. Application of urea, single super phosphate and muriate of potash (500: 1000: 250 mg) along with VAM (10 g), *Azospirillum* (5 g), phosphobacteria (5 g) and micronutrient mixture (5 g) seedling^{-1} (T_9) proved to be the ideal dose to improve above said parameters. The same treatment continued to be the best in enhancing the dry matter production, chlorophyll a and total chlorophyll.

KEY WORDS : Integrated Nutrient Management, VAM, Rhizome, Culm, Nursery

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INTRODUCTION

The species *Bambusa vulgaris var. vulgaris* S. (Bambusae) is selected for investigation because of its important role in the daily life of people; for house construction, paper and pulp industries, agricultural tools and implements, as food material and weaponry etc. It is also known as green bamboo or thornless bamboo which is the main feature of this bamboo which facilitated feasibility of work. *B. vulgaris* extend in colony starting from tropical mixed deciduous forest to the well known beautiful wet evergreen forests in the different forest types in India (Kondas, 1981). It is distributed in North East India and natural forest in Central India. It occurs in natural forests in areas upto 2100 m elevation and thrives best at temperatures between 18 to 35°C. It is light a demanding species and can tolerate minor frost. It is a preferred species for erosion control. *Bambusa vulgaris var. vulgaris* Schrad is a moderate sized bamboo with bright green, glossy erect culm which can grow up to 8-20 m, usually covered with brown hairs; inter nodes up to 15 cm long. The strength, straightness, lightness combined with extraordinary hardness and the short period in which the bamboo attains maturity, is best suited for a

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variety of purpose.

Many species of bamboo flower once every 50-100 years, and then all the plants from the same parentage flower simultaneously. In many species, this is a terminal event though this is not true in all species. Most of the bamboo falls between two physiological states of constant flowering (e.g. *Bambusa atra*) and constant sterility (e.g. *Bambusa vulgaris*). Therefore plantations of *Bambusa vulgaris var. vulgaris* (S.) from seeds are not possible because it never flower throughout its life. No seed set is reported in the common bamboo, *Bambusa vulgaris*, so far (Koshy and Jee, 2001).

Vegetative propagation like rhizome and culm cutting are successfully practiced for propagation of this species. The seedlings raised from culm cuttings can be successfully multiplied by shoot proliferation. Cuttings are usually made by planting one or more internodes the lowest bearing root-buds capable of growing. The more usual method of propagation is made by partly cutting and laying a culm in the ground, so that it may take root at the nodes. When the shoots have appeared and are strong-growing, the internodes are cut and the layers planted separately. Mass production of bamboo planting materials through *in-vitro* proliferation and micropropagation and somatic embryogenesis has shown great promises in production of planting materials to raise plantation of some bamboo species within specific time frame (Banik, 1994; Rao, 1994).

In bamboo nursery seedlings are raised in a potting mixture consisting of soil, sand and compost manure without assessment of nutritional value of the species. Nursery planting medium with sufficient nutrients induces resistance in the seedling and enable the seedling to be adaptable in adverse situation on out planting (Neeta Srivastava and Behl, 2002). So raising of good quality seedling of *B. vulgaris* through proper nutrition is an essential pre-requisite for large scale plantation.This study intends to throw light to the aspects of integrated nutrient management in bamboo nursery with special respect to *B. vulgaris.* As such no systematic study on the integrated use of organic, inorganic and biofertilizers on growth and quality indices of *B. vulgaris* seedlings have been taken up. Standardization of integrated nutrient management of *B. vulgaris* tissue cultured seedlings for quality stock production in the shortest period is needed to meet various demands in the coming future.

EXPERIMENTAL METHODS

The present investigation was conducted at Forest College and Research Institute, Mettupalayam, Dist-Coimbatore (Tamilnadu) with objective to study effect INM on seedling growth and quality parameters of *B. vulgaris* seedling at different stages. The study area is situated at at 11°19'N latitude and 77°56'E longitudes and an altitude of 300 m above mean sea level. The annual precipitation is about 830 mm. The mean maximum and minimum temperature are 32.2° C and 23.2° C, respectively. The soil used was non-calcareous, red sandy loam (*Typic Ustropept*), low in nitrogen, medium in phosphorus and potassium. Healthy tissue cultured plants (plantlets) of *B. vulgaris*, four months after hardening were obtained from Growmore Biotech, Hosur, Tamil Nadu and used for the present study. The main object of using tissue cultured plants was to maintain uniformity in the seedling to get the best result for the INM treatments by curtailing variability in vegetative propagated seedling from culm cuttings. Dried and well decomposed Farm Yard Manure (FYM) was used as organic manure. Urea, single super phosphate and muriate of potash were used as inorganic sources of nitrogen, phosphorus and potassium, respectively. The microbial inoculants *viz*., *Azospirillum*, Vesicular Arbuscular Mycorrhizae (VAM) and phosphobacteria were used as biofertilizers.

The polythene bags of size 25 x 15 cm (200 gauges) were filled with soil mixture of Soil: Sand: FYM @ 2:1:1. The bags were arranged in a completely randomised design with three replications @ 30 polythene bags treatment^{-1} replication^{-1}. Watering was done regularly using rose can and shifting is done once in 20 days. Initially seedlings were kept in 50 per cent shaded greenhouse to protect the seedlings from the sun shine and after two months they were taken out and kept in open condition. The calculated quantities of bio fertilizer were added basally to the respective polybag as per the treatment schedule. The inorganic fertilizers were added as aqueous solution to each poly bag. The treatment details of the experiment are furnished in Table A. The biometric observations were recorded at 30, 60, 90 and 120 days after planting (DAP) @ five seedlings treatment^{-1} replication^{-1} and the mean was reported. After recording all the biometric observations the seedlings were separated into shoot and root and dried in hot air oven. The dry weight was then taken individually for shoot and root and expressed in g seedling^{-1}.To study the effect of treatments, on biochemical index at different stages of growth, the plant samples were analyzed for chlorophyll content. The chlorophyll was estimated adopting the method of Yoshida *et al.* (1971) and expressed as mg per gram^{-1} of fresh weight.

The experimental and analytical data were subjected to statistical analysis for the possible relationship between the different parameters and analysis of variance employing completely randomized design as described by Snedecor and Cochran (1967). The data of every parameters analyzed stage wise separately in single factor analysis, using AGRES software. Then, the values of critical difference (CD) at 0.05 level and standard error deviation (SEd) is given in Table A.

Table A : Treatment details

Sr. No.	Treatments	Particulars
1.	T_1	Control (Soil: Sand: FYM @ 2:1:1)
2.	T_2	Urea, SSP and MOP @ 500:1000:250 mg
3.	T_3	Urea, SSP and MOP @ 1000:1500:500 mg
4.	T_4	10 g VAM + 5 g *Azospirillum* + 5 g Phosphobacteria
5.	T_5	Urea, SSP and MOP @ 500:1000:250 mg + 5 g Micronutrient
6.	T_6	Urea, SSP and MOP @ 1000:1500:500 mg + 5 g Micronutrient
7.	T_7	Urea, SSP and MOP @ 500:1000:250 mg + 10 g VAM + 5 g *Azospirillum* + 5 g Phosphobacteria
8.	T_8	Urea, SSP and MOP @ 1000 : 1500 :500 mg + 10 g VAM + 5 g *Azospirillum* + 5 g Phosphobacteria
9.	T_9	Urea, SSP and MOP @ 500 : 1000 :250 mg + 10 g VAM + 5 g *Azospirillum* + 5 g Phosphobacteria + 5 g Micronutrient
10.	T_{10}	Urea, SSP and MOP @ 1000 : 1500 :500 mg + 10 g VAM + 5 g *Azospirillum* + 5 g Phosphobacteria + 5 g Micronutrient
11.	T_{11}	10 g VAM + 5 g *Azospirillum* + 5 g Phosphobacteria + 5 g Micronutrient

EXPERIMENTAL RESULTS AND ANALYSIS

The various INM treatments significantly influenced the growth attributes *viz.*, shoot length, root length, mean collar diameter; number of shoots; dry matter production; growth indices *viz.*, volume index and quality index and biochemical indices of *Bambusa vulgaris var. vulgaris* tissue cultured seedlings at all stages of evaluation and are represented in Table 1, 2,3,4,5,6,7 and 8**,** respectively. Soil incorporation of Urea , SSP and MOP (500: 1000: 250 mg) along with *Azospirillum* 5 g, VAM 10 g, phosphobacteria (5 g) and micronutrient mixture (5 g) (T_9) seedling^{-1} significantly enhanced the various growth parameters like shoot length, root length, mean collar diameter and number of shoots. The highest shoot length (94.72 cm), root length (41.16 cm), mean collar diameter (2.66 mm) and number of shoots (5.75) in number were recorded under the T_9 treatment at the 120 DAP.

The data revealed that Urea , SSP and MOP (500: 1000: 250 mg) along with *Azospirillum* (5 g), VAM (10 g), phosphobacteria (5 g) and micronutrient mixture (5 g) (T_9) is optimum dose for attaining the maximum total dry matter production as a consequence of increased shoot and root dry matter at all the stages of crop growth. The treatment T_9 registered the highest total dry matter production of 11.359 g seedling^{-1} whereas the control could able to produce only 3.891 g seedling^{-1} at the end of period.

The above findings combines with the fact that the addition of organic, inorganic fertilizers and biofertilizers in combination, favored growth of seedlings with higher rate of biometrics due to continuous supply of nutrient by the quick release of inorganic fertilizers at initial stages and the slow release of organic and biofertilizers at the later stage. Such response to vegetative growth has been reported by Brar and

Table 1 : Effect of INM treatments on shoot length (cm) of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	18.34	24.94	29.18	32.51
T_2	25.51	33.82	40.36	46.87
T_3	17.71	24.78	29.33	37.78
T_4	20.37	26.74	34.97	43.54
T_5	30.78	42.94	53.03	55.86
T_6	25.28	37.32	45.73	50.32
T_7	21.39	33.31	43.26	48.22
T_8	21.17	27.10	32.99	38.67
T_9	35.56	53.06	79.59	94.72
T_{10}	25.18	44.61	58.71	72.22
T_{11}	21.92	28.61	39.33	44.51
S.E.$\pm$	0.70	0.71	0.66	1.24
C.D. (P=0.05)	1.35	1.48	1.36	2.58

Table 2 : Effect of INM treatments on root length (cm) of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	16.22	20.36	22.40	24.49
T_2	17.59	21.71	27.72	32.27
T_3	16.09	19.69	21.74	25.48
T_4	15.31	21.14	24.24	30.14
T_5	15.64	21.49	27.21	33.08
T_6	14.62	19.01	22.49	26.34
T_7	14.19	20.67	22.74	26.20
T_8	17.28	20.41	26.26	29.84
T_9	22.14	26.28	36.93	41.16
T_{10}	16.17	22.33	27.21	35.06
T_{11}	16.59	20.97	26.29	27.27
S.E.$\pm$	0.61	0.99	0.89	1.07
C.D. (P=0.05)	1.27	2.05	1.85	2.22

Katoch (1980) in *Populus deltoides.* The present results were also in line with that of Saravanan *et al*. (2000) who has reported that the VAM application highly influences the seedling height and root length of Acacia species in the nursery. This finding was in corroborate with that of Singh (2001) who reported that inorganic fertilizer (NPK) application significantly increased the collar diameter, height and shoot biomass by *Populus deltoides* seedlings in nursery. Increase in total dry matter production of seedling might be due to the synergistic role of *Azospirillum*, phosphobacteria and VAM fungi alone and in combination with Urea, SSP, MOP, micronutrients and FYM which could supply the required nutrition to bamboo to put forth higher dry matter production. This result also coincides with the results reported by Kumar (2007), that the application of phosphobacteria along with NPK enhanced the drymatter yield of *Ailanthus excelsa* seedlings. Similar increase in dry matter production due to VAM inoculation was documented in *Leucaena leucocephala* (Michelsen and Rosendahl, 1990) and in *Acacia* species (Narayana Bhat, 1991).

Considering the quality parameters like volume index and quality index, application of Urea, SSP and MOP (500: 1000: 250 mg) along with *Azospirillum* (5 g), VAM (10 g), phosphobacteria (5 g) and micronutrient mixture (5 g) seedling^{-1} (T_9) proved to be more effective. The seedlings are considered to be of a good quality when seedling quality index is better. The better nourishment to seedling through inorganic, organic and biofertilizers could obtain high quality parameter

Table 3 : Effect of INM treatments on mean collar diameter (mm) of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	0.72	1.13	1.36	1.66
T_2	0.90	1.20	1.61	2.03
T_3	0.76	1.13	1.42	1.76
T_4	0.92	1.28	1.64	2.14
T_5	0.94	1.31	1.70	2.17
T_6	0.81	1.17	1.46	1.92
T_7	0.96	1.26	1.62	2.06
T_8	0.74	1.12	1.42	1.72
T_9	1.13	1.51	2.09	2.66
T_{10}	1.04	1.32	1.78	2.09
T_{11}	0.88	1.22	1.53	1.98
S.E.±	0.04	0.06	0.06	0.06
C.D. (P=0.05)	0.09	0.12	0.12	0.13

Table 4 : Effect of INM treatments on number of shoots of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	1.50	1.97	2.32	3.01
T_2	1.69	2.09	2.92	3.24
T_3	1.90	2.23	3.09	3.67
T_4	1.80	2.12	3.02	3.56
T_5	2.04	2.58	3.19	3.90
T_6	2.09	2.69	3.30	4.02
T_7	2.15	2.76	3.49	4.20
T_8	2.31	2.91	3.68	4.44
T_9	2.91	3.68	4.72	5.75
T_{10}	2.39	2.98	3.78	4.48
T_{11}	1.94	2.32	3.25	3.98
S.E.±	0.19	0.26	0.33	0.47
C.D. (P=0.05)	0.41	0.69	0.98	1.18

Table 5 : Effect of INM treatments on Total dry matter (g) of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	1.424	2.329	3.031	3.891
T_2	2.309	3.347	4.162	5.102
T_3	1.705	2.427	3.215	4.192
T_4	1.882	2.816	3.715	4.745
T_5	3.195	4.457	5.693	6.837
T_6	2.692	3.811	5.129	6.141
T_7	2.528	3.710	5.016	5.982
T_8	1.715	2.445	3.219	4.323
T_9	4.943	6.997	9.380	11.359
T_{10}	4.245	5.609	7.571	9.490
T_{11}	1.813	2.810	3.641	4.591
S.E.±	0.074	0.097	0.133	0.152
CD (P=0.05)	0.153	0.201	0.277	0.317

Table 6 : Effect of INM treatments on volume index of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	12.835	28.085	39.761	54.060
T_2	22.602	40.613	65.135	95.148
T_3	13.066	27.959	41.642	66.398
T_4	18.188	34.165	57.375	93.213
T_5	28.216	56.166	89.979	121.380
T_6	19.926	43.857	66.954	96.619
T_7	19.802	42.107	69.936	99.616
T_8	15.613	30.397	46.865	66.696
T_9	39.422	80.297	166.539	252.280
T_{10}	26.263	58.752	104.386	150.879
T_{11}	18.871	34.794	60.187	88.260
S.E.	0.944	2.623	3.358	4.372
C.D. (P=0.05)	1.959	5.441	6.965	9.067

Table 7 : Effect of INM treatments on quality index of *Bambusa vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	0.053	0.098	0.131	0.182
T_2	0.075	0.108	0.150	0.201
T_3	0.067	0.100	0.140	0.177
T_4	0.077	0.120	0.154	0.211
T_5	0.087	0.122	0.162	0.237
T_6	0.076	0.103	0.142	0.204
T_7	0.096	0.120	0.159	0.219
T_8	0.056	0.092	0.126	0.176
T_9	0.145	0.186	0.232	0.299
T_{10}	0.157	0.154	0.213	0.255
T_{11}	0.065	0.106	0.126	0.182
S.E.$\pm$	0.005	0.006	0.006	0.008
C.D. (P=0.05)	0.010	0.012	0.014	0.018

Table 8 : Effect of INM treatments on total chlorophyll (mg g^{-1}) content of *B. vulgaris* seedlings

Treatments	Periods of nursery			
	30 DAP	60 DAP	90 DAP	120 DAP
T_1	0.765	1.137	1.598	1.847
T_2	1.659	2.338	2.867	3.331
T_3	0.862	1.299	1.716	1.864
T_4	1.565	2.163	2.838	3.250
T_5	1.830	2.553	3.121	3.559
T_6	1.654	2.412	3.025	3.407
T_7	1.707	2.480	3.267	3.624
T_8	0.996	1.562	1.947	2.480
T_9	1.980	2.663	3.266	3.663
T_{10}	1.402	1.953	2.533	2.943
T_{11}	1.386	1.929	2.391	2.840
S.E.$\pm$	0.150	0.125	0.170	0.164
C.D. (P=0.05)	0.312	0.259	0.353	0.341

in bamboo seedling. Similar finding have been well documented earlier by various scientists (Radomiljac and McComb, 1998; Surendran *et al*., 1999 and Nagaveni and Vijayalakshmi, 2002). The biofertilizers also had enhanced response in quality parameters due to the influence of *Azospirillum*, phosphobacteria and VAM. This combination could have increased the availability of nutrients at the root region and produce high quality aspects of seedling. The impact of INM were also reported earlier by Adalarasan (2002) who stated that application 13.5 kg of N, 54 kg of P_2O and 27 kg of K_2O along with FYM and Frankia proved to be ideal dose for improving the growth and quality of *Casuarina equisetifolia* and helped to reduce the nursery period.

The increased chlorophyll content was recorded under superior performance of T_9 over control might be ascribed to the fact that crop has enjoyed a better balanced nutrition especially N and K from inorganic source and P from both inorganic and biofertilizers sources and hence enhanced chlorophyll content. The combined application of phosphobacteria and *Azospirillum* has enhanced the availability of 'P' in soil. Nitrogen fixation by *Azospirillum* enhanced nitrogen availability and VAM enhanced root absorptive area network. This could have led to better chlorophyll content. These INM findings were in line with Vivek Acharya (2003) who stated that INM application could improve chlorophyll content of *Bambusa bamboos.*

From the above observation, it can be concluded that for raising successful plantations, the production of better nursery stock forms an important prerequisite. The optimum type and amount of fertilizers vary with the species due to a wide difference in nutrient requirement of various species and the heterogenous soil fertility. Hence, the judicial integration of fertilizers, manures and biofertilizers has a vital role in the current intensified forest nursery programme. Keeping this in mind the present investigation was conducted and it standardize INM dose with the application of Urea, SSP and MOP (500: 1000: 250 mg) along with *Azospirillum* (5 g), VAM (10 g), phosphobacteria (5 g) and micronutrient mixture (5 g) seedling^{-1} (T_9) for *Bambusa vulgaris var. vulgaris* seedlings.

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