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Effect of Inorganic Fertilizers on the Initial Growth Performance of *Anthocephalus chinensis* (Lam.) Rich. Ex. Walp. Seedlings in the Nursery

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Abstract: The study describes the effect of 2 (two) commonly used inorganic fertilizers (Urea and TSP) on *Anthocephalus chinensis* (Lam.) Rich ex. walp. seedlings in the nursery of the Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh with a view to standardize an optimum dose of inorganic fertilizers for raising quality seedlings. There were combinations of 16 treatments including a control one (NoPo). Seedlings were supplied 0, 75,175, 300 kg ha^{-1} of N and P of each in solution form in all possible combinations. Seedlings were evaluated for 13 weeks (90 days) in the nursery. Seedling mortality along with different growth parameters was measured. Different growth variables were also calculated. Seedling growth was in general markedly better for fertilized one in comparison to the control one. Nitrogen addition was found significantly promoting the collar dia. increment and total dry matter production of seedlings. Seedling mortality was observed as the nitrogen dose increases. Significant variation was not observed for different growth variables due to nitrogen doses. However, there was no significant variation in any parameters for different levels of phosphorus applied. The study suggests that application of 175 kg N ha^{-1} may be beneficial and also addition of 175 kg P ha^{-1} may boost the diameter, total dry matter production and leaf area of *Anthocephalus chinensis* on this type of soil (forest top soil collected from Chittagong University Campus).

Key words: *Anthocephalus chinensis,* inorganic fertilizers, nitrogen, phosphorus, growth, seedling, nursery

INTRODUCTION

Forest nurseries are an essential part of forestry in Bangladesh as well as throughout the world. A remarkable number of plants have been planted each year into privately and nationally owned forest since the emergence of plantation forestry practice. Soil is the principle supplier of plant nutrients but it vary considerably in their inherent capacities of supply nutrients which gradually decline over time due to intensive cropping, very little or no use of organic materials or improper soil or crop management practices[1]. As a result new seedlings suffer from inadequate supply of nutrients that is reflected in poor planting stock yield and inferior quality seedlings. Many plantations established to date are of poor quality due to use of unimproved seeds, use of traditional planting materials lack of site matching of species and poor management. Because of the failure of same plantations and the destruction of others, it is estimated 17% of recorded plantations do not exist in Bangladesh[2]. The policy of a nursery manager is to raise good quality plants at a lowest cost. But growing good quality seedlings with a lowest cost is only possible through intensive research and development of all aspects of nursery production, especially on soil fertility and nutrition management. Maintaining of adequate fertility in nursery soils is important to assure production of high quality planting stock. Among the factors that affect crop production fertilizer is the single most important one that plays a crucial role in quality production increase, provided other factors are not too limiting.

Fertilizer recommendation for soils and crops is a dynamic process in view of the generation of the new knowledge, changes in soil nutrient status, changes in plants and planting patterns and associated management practices. Gathering the appropriate information on maintaining adequate soil nursery fertility into a single publication has been attempted many times previously[3-7] and undoubtedly will be necessary again as conditions change and newly information becomes available and species specific information are very much important for producing better seedlings. Failure to manage nursery soil adequately can result in depletion of site quality[8] and a reduction of seedling growth[9].

The strategy of using quick growing and high yielding exotics is responsible for decreasing the diversity of the tropical environment with consequent loss of suitable habitat for wildlife and potentially valuable plant

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resources. Hence, the dilemma for the foresters is how to increase the yield and quality of products for rapidly expanding wood based industries and for use by a rapidly expanding human population and simultaneously maintaining the environmental diversity. However, it is well understood that the loss of diversity may be minimized in a sustainable manner through increasing the number of species used in production forestry through domestication of indigenous timber species[10]. *Anthocephalus chinensis* (Lamk.) Rich. ex. walp. is one of the indigenous large handsome deciduous tree with more or less horizontal branches forming a round crown having blackish, gray, fissured bark[11] and attains a height of 17.67 m and diameter of 25.3 cm at breast height[12]. It is an industrial species, used in match factories for making matchsticks and matchboxes. Timber is also used for making ceiling boats, planking, dugout, canoes, plywood, bobbins, chief painted toys, picture and slate frames, shoe lasts and shoe heeds and tea boxes[13,14]. The wood also suitable for pulping, carving, turnery, toys, combs, cigarette holder, pencil wood, novelties and chief grade furniture[15-19]. Fruit is eaten and foliage is sometimes used as fodder for cattle. It has also some medicinal value[20]. The tree has or medicinal value also. Due to its multipurpose function and utility the species is favored in plantation programs.

Nursery establishment is the first and foremost obvious task in raising a successful plantation. Availability of planting stock (particularly the seedlings) in proper time at proper quantity and quality is very much essential. The matter comes from in fact due to heavy weed competition in tropical planting sites. To overcome such problem the study of fertilizer application in the nursery is of great importance. These views let to undertaking the present experiment to observe the effects of added inorganic fertilizers (N and P) on the seedlings, to understand nutrient interactions in the contribution to seedling growth, to find out quality seedlings by applying N and P in the common nursery media and to find out an optimum dose of inorganic fertilizers (N and P) for raising quality seedlings of *Anthocephalus chinensis*.

MATERIALS AND METHODS

The study was conducted in the nursery of Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh. The soil used in the nursery was moderately coarse to fine textured. For the experiment Urea, 46% of nitrogen and TSP, 48% of P_2O_5 were used as nutrients. The seeds were collected from the Seed Orchard Division of Bangladesh Forest Research Institute, Chittagong, Bangladesh. Seeds were sown in the trays and dept inside the polybags in airtight condition. The trays were soaked into water once daily to keep the media moist to support the germination. In air tight condition the inner side of the polybag was warmer than outside which favored the germination of seeds in time. Within three weeks almost all the viable seeds were germinated. When seedlings attain an average height of 3 cm they were transferred to poly bags. 9X6" polybags were used for the experiment. The potting media used were forest topsoil and cow dung in a ratio of 3:1. Topsoil were collected 6-8 weeks before filling the bags. The mixture was made more or less uniform before filling in the polybags, so that it was free from root splinters and other foreign materials. A 2^4 factorial design based on randomized complete block with four replicates and nine seedlings were used in each replicates. There were altogether 576 seedlings involving 16 treatment combinations.

The amount of nutrients added and the experimental design were, Treatment1: N_0P_0(0 gm urea/seedling; 0 gm TSP/seedling), Treatment 2: N_0P_1(0 gm urea/seedling; 0.17 gm TSP/seedling), Treatment 3: N_0P_2 (0 gm urea/seedling; 0.63 gm TSP/seedling), Treatment 4: N_0P_3 (0 gm urea/seedling; 1.07 gm TSP/seedling), Treatment 5: N_1P_0(0.0.16 gm urea/seedling; 0 gm TSP/seedling), Treatment 6: N_1P_1(0.0.16 gm urea/seedling; 0.1799 gm TSP/seedling), Treatment 7: N_1 P_2(0.0.16 gm urea/seedling; 0.6300 gm TSP/seedling), Treatment 8: N_1P_3(0.0.16 gm urea/seedling; 1.07 gm TSP/seedling), Treatment 9: N_2P_0(0.64 gm urea/seedling; 0 gm TSP/seedling), Treatment 10: N_2P_1(0.64 gm urea/seedling; 0.17 gm TSP/seedling), Treatment 11: N_2P_2(0.6416 gm urea/seedling; 0.63 gm TSP/seedling), Treatment 12: N_2P_3(0.64 gm urea/seedling; 1.07 gm TSP/seedling), Treatment 13: N_3P_0(1.10 gm urea/seedling; 0 gm TSP/seedling), Treatment 14: N_3P_1(1.10 gm urea/seedling; 0.17 gm TSP/seedling), Treatment 15: N_3 P_2(1.10 gm urea/seedling; 0.63 gm TSP/seedling) and Treatment 16: N_3P_3 (1.10 gm urea/seedling; 0. 1.07 gm TSP/seedling). Following the treatments in each level 0, 50, 175 and 300 kg ha^{-1} Urea and TSP were applied (Table 1). Watering was carried regularly by fine shower, which could not disturb the seedlings physically. Removal of weeds, grasses etc. were done as far as possible.

Information recorded: After the establishment of the experiment, information was recorded periodically. The measurement of height was taken from the ground level to the tip of the seedlings by using meter scales. Measurement of diameter at collar region was taken at the ground level using slide calipers. Leaf area was determined by grid plate method. After 13 weeks of fertilization seedlings were harvested and separated into

Table 1: Level of nutrients applied

Commercial fertilizer	Elements	Grams added per pot Level-1 (0 kg ha^{-1})	Level-2 (50 kg ha^{-1})	Level-3 (175 kg ha^{-1})	Level-4 (300 kg ha^{-1})
Urea 46% of N	N	0	0.1683	0.6416	1.1000
TSP 48% of P_2O_5	P	0	0.1799	0.6300	1.0797

Table 2: Analysis of variance of Kadam seedlings

Parameter	Source of variation: Main factors: Nitrogen (N)	Phosphorus (P)	Interaction N*P
Survival percentage	***	NS	NS
Height at different interval:			
0 week	NS	NS	NS
2 week	NS	NS	NS
6.5 week	NS	NS	NS
11 week	NS	NS	NS
13 week	NS	NS	NS
Relative height growth rate			
RGRh at 2 week	***	NS	NS
RGRh at 6.5 week	NS	NS	NS
RGRh at 11 week	NS	NS	NS
RGRh at 13 week	NS	NS	NS
Collar dia at different interval :			
2 week	***	NS	NS
6.5 week	***	NS	NS
11 week	***	NS	NS
13 week	***	NS	NS
Fresh leaf weight	***	NS	NS
Fresh root weight	***	NS	NS
Fresh stem weight	***	NS	NS
Oven dry wt. of root	***	NS	NS
Oven dry wt. of stem	***	NS	NS
Oven dry wt. of leaf	***	NS	NS
Leaf area	***	NS	NS
Total biomass	***	NS	NS
Stem weight ratio	NS	NS	NS
Root weight ratio	NS	NS	NS
Fresh weight ratio	NS	NS	NS
Leaf area ratio	NS	NS	NS
Leaf weight ratio	NS	NS	NS
Root shoot ratio	NS	NS	NS

***: Significant at 1% level, NS: Not Significant at 5% level

root, shoot and leaf components. Fresh and dry weights were taken for each seedling compound with electronic balance. Total biomass (Total dry weight) was taken by adding dry weight of root, stem and leaf. After harvesting fresh weight dry weight ratio (FWR), leaf area ratio (LAR), stem weight ratio (SWR), root weight ratio (RWR), leaf weight ratio (LWR) and root/shoot ratio (R/S) were derived by using formulae of Briggs *et al.*[21]. Relative height growth rate (RGRh) was estimated by using the formula of Hunt[22].

Analysis of variance was done for the factorial experiment. Individual responses were detected by following the factorial experiment example described by Zaman *et al.*[23]. Duncan multiple range tests (DMRT) were used to compare mean values of all the treatments and for the 4 levels of nutrient.

RESULTS

Seedling growth: Application of N significantly affected survival percentage, collar dia., fresh root weight, fresh shoot weight, fresh leaf weight, total leaf area, dry matter production (root, shoot, leaf) and total biomass of the seedlings Different levels of N and P applied are given in Table 1. The effect of P was generally not significant. Though there were some differences due to different fertilizer doses the interaction effects of both N and P were not significant on any parameter (Table 2). Comparison of treatment means showed that collar dia. and fresh and dry matter production markedly better for those seedlings applied with fertilizers than the control. The difference were significant for survival percentage, collar dia. fresh weight (root, stem, leaf) production as well as dry matter production, leaf area expansion, total biomass according to Duncans multiple ranges (Table 3-6). Followings are some important growth response patterns:

Survival: There were negative responses of N and P dozes on survival. Increase in fertilizer dose caused decrease in survival percentage. At nitrogen level 3 there were significantly lower survival percent (higher mortality rate) than other N doses, P has no significant effect on survival.

Height and relative height growth rate: The seedlings used in the fertilizer experiment were not significantly different in their initial height. After 2 weeks of fertilization the response of nitrogen was not found significant at 5% level. Height was found superior with N_1 dose, though there was no significant difference from other Nitrogen doses. The greater height at 2 weeks was recorded in N_1P_1 (20.33 cm) and two folds as much as the lowest in N_3P_3 (10.45 cm) (Table 3). However, after 6.5 weeks of fertilization the response of nitrogen was positive and phosphorus was negative. There was no significant difference between heights. The performance of N_2 and P_2 treatment was better than other treatments. Similarly, after 11 weeks of fertilization the nitrogen responses positively and phosphorus responses negatively to the height growth. After 13 weeks the effect of both N and P dose was found positive. The differences in height among the doses were not statistically significant. Superior response (105.12 cm) found with N_3P_2 where the lowest height

Table 3: Height (cm) Kadam seedlings at different intervals (Values in the columns forwarded by the same letter are not significantly different at 0.05 level according to DMRT)

HT.00 Week	HT.2 Week	HT.6.5 Week	HT.11 Week	HT.13 Week
3.62a	20.33a	55.21a	95.35a	105.12a
(N_2P_2)	(N_1P_1)	(N_2P_2)	(N_2P_2)	(N_3P_2)
3.50a	20.16a	54.28a	92.11a	103.04a
(N_2P_1)	(N_1P_2)	(N_2P_1)	(N_3P_2)	(N_2P_2)
3.49a	18.68a	54.27a	90.80a	102.92a
(N_3P_2)	(N_1P_3)	(N_3P_2)	(N_3P_0)	(N_3P_1)
3.49a	18.56a	53.96a	90.25a	99.71a
(N_3P_1)	(N_2P_2)	(N_2P_0)	(N_3P_1)	(N_2P_3)
3.38a	18.38a	5368a	89.36a	97.87a
(N_1P_1)	(N_2P_1)	(N_2P_3)	(N_2P_3)	(N_2P_0)
3.37a	17.60a	52.65a	87.58a	97.60a
(N_3P_0)	(N_1P_0)	(N_3P_1)	(N_2P_0)	(N_0P_1)
3.37a	17.43a	51.55a	87.33a	97.19a
(N_2P_0)	(N_2P_0)	(N_3P_0)	(N_2P_1)	(N_2P_1)
3.37a	15.62a	51.18a	84.75a	95.68a
(N_0P_1)	(N_2P_3)	(N_1P_2)	(N_3P_3)	(N_3P_3)
3.36a	13.54a	49.36a	80.32a	94.01a
(N_1P_2)	(N_0P_2)	(N_3P_3)	(N_0P_0)	(N_0P_2)
3.35a	13.13a	48.63a	80.13a	93.14a
(N_0P_2)	(N_3P_1)	(N_1P_3)	(N_1P_2)	(N_3P_0)
3.32a	12.94a	47.67a	78.19a	92.92a
(N_2P_3)	(N_0P_3)	(N_1P_1)	(N_0P_1)	(N_1P_1)
3.16a	12.61a	47.12a	77.83a	90.85a
(N_0P_0)	(N_3P_2)	(N_0P_0)	(N_1P_1)	(N_1P_2)
3.12a	12.27a	47.05a	76.68a	88.49a
(N_1P_3)	(N_0P_1)	(N_1P_0)	(N_1P_3)	(N_0P_3)
3.10a	11.09a	46.98a	76.14a	88.35a
(N_1P_0)	(N_3P_0)	(N_0P_1)	(N_0P_2)	(N_1P_3)
3.06a	10.54a	45.90a	74.10a	86.77a
(N_3P_3)	(N_0P_0)	(N_0P_2)	(N_0P_3)	(N_1P_0)
2.81a	10.45a	44.01a	73.89a	85.37a
(N_0P_3)	(N_3P_3)	(N_0P_3)	(N_1P_0)	(N_0P_0)

Table 4: Collar dia (mm) at different intervals, leaf area (cm^2), suvival percentage (Values in the columns forwarded by the same letter are not significantly different at 0.05 level according to DMRT)

C.D 2Wk.	C.D.6.5. Wk	C.D 11 Wk	C.D 13 Wk	Leaf area	Survival%
59.75a	106.00a	133.25a	149.75a	1949.70a	100.00a
(N_3P_2)	(N_3P_2)	(N_2P_1)	(N_3P_0)	(N_3P_2)	(N_0P_0)
58.50ab	105.75a	131.50a	147.75ab	1845.40ab	100.00a
(N_3P_0)	(N_2P_1)	(N_3P_2)	(N_2P_1)	(N_3P_1)	(N_0P_1)
58.50ab	105.75a	131.25a	146.25ab	1835.00ab	100.00a
(N_3P_1)	(N_3P_3)	(N_3P_3)	(N_3P_2)	(N_3P_3)	(N_0P_2)
56.75a-c	101.50ab	131.00a	145.75ab	1586.40a-c	100.00a
(N_3P_3)	(N_3P_1)	(N_3P_0)	(N_3P_3)	(N_3P_0)	(N_0P_3)
54.00a-d	99.50ab	131.00a	145.00ab	1455.40a-c	100.00a
(N_1P_3)	(N_3P_0)	(N_3P_1)	(N_3P_1)	(N_2P_3)	(N_1P_0)
53.75a-d	95.50a-c	122.50ab	138.50a-c	1311.20a-c	100.00a
(N_2P_0)	(N_2P_2)	(N_2P_3)	(N_2P_3)	(N_2P_0)	(N_1P_1)
52.25b-e	94.25a-d	121.25ab	133.50a-d	1309.30a-c	100.00a
(N_1P_2)	(N_2P_3)	(N_2P_2)	(N_2P_2)	(N_0P_0)	(N_2P_1)
51.75c-e	89.50b-e	113.00a-c	122.00b-d	1297.90a-c	97.25a
(N_2P_3)	(N_2P_0)	(N_2P_0)	(N_2P_0)	(N_2P_1)	(N_1P_2)
51.25c-f	84.25c-f	104.75bc	115.00cd	1215.10a-c	97.25a
(N_1P_1)	(N_1P_3)	(N_1P_3)	(N_1P_0)	(N_1P_3)	(N_1P_3)
50.75c-f	83.50c-f	104.25bc	114.25cd	1109.50a-c	97.25a
(N_2P_2)	(N_1P_0)	(N_1P_0)	(N_0P_1)	(N_2P_2)	(N_2P_0)
50.50c-f	82.50c-f	103.00bc	113.75cd	1086.30a-c	97.25a
(N_0P_0)	(N_1P_1)	(N_1P_2)	(N_1P_3)	(N_1P_0)	(N_2P_2)
50.00d-f	82.50c-f	102.00bc	112.75cd	1016.10a-c	91.75ab
(N_2P_1)	(N_1P_2)	(N_1P_1)	(N_0P_0)	(N_0P_1)	(N_2P_3)
49.00d-f	80.00d-f	101.25bc	110.50d	943.30a-c	69.50bc
(N_1P_0)	(N_0P_1)	(N_0P_1)	(N_1P_2)	(N_1P_1)	(N_3P_3)
47.75d-f	79.50d-f	101.00bc	110.25d	891.20bc	61.25bc
(N_0P_1)	(N_0P_2)	(N_0P_2)	(N_0P_2)	(N_0P_3)	(N_3P_1)
46.25ef	78.00ef	98.75c	110.00d	745.50c	61.25bc
(N_0P_2)	(N_0P_3)	(N_0P_0)	(N_1P_1)	(N_0P_2)	(N_3P_2)
45.00f	74.75f	98.75c	106.50d	743.60c	50.00c
(N_0P_3)	(N_0P_0)	(N_0P_3)	(N_0P_3)	(N_1P_2)	(N_3P_0)

(85.37 cm) found with N_0P_0 (Table 3). When individual dose is examined, responses of N_2 and P_2 were found superior in comparison to other doses though the difference was not statistically significant. Finally after 13 weeks (90 days) of fertilization both the height increment and relative height growth rate found insignificant (Table 3).

Diameter increment: The seedlings used in the fertilizer experiment were not significantly different in their initial diameter (At the time of transplanting). Nitrogen have significant effect on diameter increment and Table 4 shows that after 13 weeks of fertilization, there were significant difference at 1% level on diameter growth among the doses. Highest response (149.75 cm) was found with N_3P_0 where the lowest (106.50 cm) found with N_0P_3. Individually N_3 has best response where there is no significant difference among N level 3, 2 and 1. Phosphorus individually had positive effect but the difference was not significant.

Total leaf area (cm^2): Table 4 shows that there was significant difference (at 1% level) for leaf area among different treatments. The highest leaf area (1949.70 cm^2) was found with N_3P_2 where the lowest (743.60 cm^2) were found with N_1P_2. Individual dose N_3 Produced best where phosphorus had no significant effect but P_2 have given better leaf area production compared to other P doses.

Fresh weight of root stem and leaf: Table 5 shows that there were significant difference (at 1% level) among treatments of fresh weight of the different components of the seedlings. N_3P_3 produced the highest 29.05 gm fresh root weight where N_0P_2 produced the lowest one, only 11.33 gm.

N_3P_2 produced the highest 86.25 gm fresh stem wt. where N_1P_3 produced (35.27gm) the lowest (Table 5). The pattern of stem production of the seedlings in terms of fresh weight to N fertilizer was similar to that of fresh root weight showing significant increases increasing level of N.

Table 5 indicates the fresh wt. of leaf production, which showed significant difference at 1% level with increasing levels of N. P has no significant effect. For N and P the response pattern were different. Maximum leaf weight appeared to be achieved at level 3 for N and level 2 for P. Level N_3P_1 yielded the highest (35.38 gm) fresh leaf weight that was three fold compared to 13.87 gm in N_1P_2.

Table 5: Fresh and dry matter production (gm) of kadam seedlings (Values in the columns forwarded by the same letter are not significantly different at 0.05 level according to DMRT)

Fr. Rt.Wt	Fr.St.Wt	Fr.Lf.Wt	Dr. Wt.Rt	Odr.Sht	Odr. Lf	W (G)
29.05a	86.25a	35.38a	11.24a	25.71a	8.74a	45.32a
(N_3P_3)	(N_3P_2)	(N_3P_1)	(N_3P_2)	(N_3P_2)	(N_3P_3)	(N_3P_2)
36.78a	81.93a	34.31ab	9.65ab	23.32a	8.37a	41.70ab
(N_3P_2)	(N_3P_3)	(N_3P_3)	(N_3P_3)	(N_3P_3)	(N_3P_2)	(N_3P_3)
32.59ab	78.08ab	33.65a-c	7.95a-c	21.71ab	7.41ab	37.00a-c
(N_3P_1)	(N_3P_0)	(N_3P_2)	(N_3P_0)	(N_3P_1)	(N_3P_1)	(N_3P_1)
29.64a-c	76.55ab	31.24a-d	7.88a-c	20.80a-c	7.08a-c	35.83a-d
(N_3P_0)	(N_3P_1)	(N_3P_0)	(N_3P_1)6.66	(N_3P_0)	(N_3P_0)	(N_3P_0)
22.52b-d	66.67a-c	27.03a-d	b-d	19.87a-d	6.50a-d	33.03a-de
(N_2P_0)	(N_2P_3)	(N_2P_3)	(N_2P_3)	(N_2P_3)	(N_2P_3)	(N_2P_3)
22.44b-d	63.97a-c	25.71a-d	6.43b-d	17.45a-de	5.87a-d	29.74a-f
(N_2P_1)	(N_2P_1)	(N_2P_1)	(N_2P_1)	(N_2P_1)	(N_2P_1)	(N_2P_1)
22.30b-d	57.21a-c	21.71a-d	6.33b-d	16.40a-e1	5.44a-d	27.98b-f
(N_2P_3)	(N_2P_2)	(N_2P_0)	(N_2P_0)	(N_2P_2)	(N_2P_0)	(N_2P_0)
19.07b-d	53.42a-c	21.10a-d	6.31cd	16.21b-de	4.59b-d	27.30b-f
(N_2P_2)	(N_2P_0)	(N_0P_0)	(N_2P_2)	(N_2P_0)	(N_2P_2)	(N_2P_2)
18.56b-d	43.79bc	19.98a-d	4.69cd	11.74b-de	4.58b-d	20.65c-f
(N_1P_0)	(N_1P_1)	(N_0P_1)	(N_1P_3)	(N_1P_1)	(N_1P_1)	(N_1P_1)
18.00cd	41.22c	19.97a-d	4.52cd	10.82c-e	4.49b-d	20.00c-f
(N_1P_3)	(N_0P_1)	(N_1P_3)	(N_1P_0)	(N_1P_3)	(N_1P_3)	(N_1P_3)
15.07cd	40.88c	19.66a-d	4.33cd	10.67de	4.43b-d	19.59c-f
(N_1P_1)	(N_1P_0)	(N_2P_2)	(N_1P_1)	(N_0P_1)	(N_1P_0)	(N_1P_0)
15.06d	39.52c	18.91a-d	4.26cd	10.64de	4.36b-d	18.45d-f
(N_1P_2)	(N_1P_2)	(N_1P_0)	(N_0P_0)	(N_1P_0)	(N_0P_0)	(N_0P_0)
11.85d	38.94c	17.98b-d	3.55cd	10.17de	4.31b-d	18.34d-f
(N_0P_0)	(N_0P_0)	(N_1P_1)	(N_1P_2)	(N_1P_2)	(N_0P_1)	(N_0P_1)
11.68d	36.19c	17.79b-d	3.36cd	9.83de	4.90b-d	17.02ef
(N_0P_1)	(N_0P_2)	(N_0P_3)	(N_0P_1)	(N_0P_0)	(N_0P_3)	(N_1P_2)
11.46d	36.11c	16.19cd	3.19cd	9.45e	3.30cd	16.30ef
(N_0P_3)	(N_0P_3)	(N_0P_2)	(N_0P_2)	(N_0P_3)	(N_1P_2)	(N_0P_3)
11.33d	35.27c	13.87d	2.96d	8.45e	3.14d	14.77f
(N_0P_2)	(N_1P_3)	(N_1P_2)	(N_0P_3)	(N_0P_2)	(N_0P_2)	(N_0P_2)

FR. RT. WT= Fresh wt. of root, FR. ST. WT = Fresh wt. of stem, FR. LF. WT= Fresh wt. of leaf, DR. WT. RT= Dry wt. of root, ODR. SHT = Dry wt. of stem, ODR. LF= Dry wt. of Leaf, W (G) = Total Biomass

Dry weight of root stem and leaf: Table 5 indicates that in every parameter (fresh wt., dry wt., total biomass) the differences among the treatment means were significant at 1% level. The patterns of stem, root and leaf dry weight response to the four levels of nutrients were almost similar to those of fresh weight. Table 5 presents that N_3P_2 produced highest (11.24 gm) dry root weight and N_0P_3 yielded the lowest (2.96 gm). $N_3 P_2$ yielded highest (25.71 gm) dry stem weight and N_0P_2 yielded the lowest (8.45 gm). N_3P_2 yielded the highest (8.74 gm) dry weight of leaf and N_0P_0 yielded the lowest (3.14 gm). Dry matter production is highest (45.32 g) with N_3P_2 and lowest (14.77 gm) was found with N_0P_2 almost 3 times better than the lowest one.

Different growth variables: Different growth variables to different fertilizer combination are shown in Table 6. The effect of N and P was not found statistically significant. Highest fresh weight ratio (4.34) was found with N_0P_2 where the lowest (3.46) was found with N_3P_2. Highest leaf area ratio (72.34) was found with N_0P_0 where the lowest

Table 6: Different growth variables of Kadam seedlings (Values in the columns forwarded by the same letter are not significantly different at 0.05 level according to DMRT)

FWR	LAR	SWR	RWR	LWR	R/S
4.34a	72.34a	0.60a	0.24a	0.25a	0.32a
(N_0P_2)	(N_0P_0)	(N_1P_2)	(N_1P_0)	(N_0P_3)	(N_1P_0)
4.03a	62.91a	0.60a	0.24a	0.24a	0.32a
(N_1P_2)	(N_1P_3)	(N_2P_2)	(N_3P_2)	(N_0P_0)	(N_3P_2)
4.02a	56.88a	0.60a	0.23a	0.23a	0.31a
(N_0P_3)	(N_1P_0)	(N_2P_3)	(N_0P_0)	(N_0P_1)	(N_3P_3)
4.00a	56.16a	0.59a	0.23a	0.23a	0.30a
(N_1P_0)	(N_0P_3)	(N_2P_0)	(N_1P_3)	(N_1P_0)	(N_0P_0)
3.99a	55.69a	0.59a	0.23a	0.23a	0.30a
(N_0P_1)	(N_0P_1)	(N_2P_1)	(N_2P_2)	(N_1P_3)	(N_1P_3)
3.91a	50.10a	0.59a	0.23a	0.22a	0.30a
(N_0P_0)	(N_0P_2)	(N_3P_1)	(N_3P_0)	(N_1P_1)	(N_2P_2)
3.90a	48.87a	0.58a	0.23a	0.21a	0.30a
(N_3P_0)	(N_3P_1)	(N_0P_1)	(N_3P_3)	(N_0P_2)	(N_3P_0)
3.87a	47.03a	0.58a	0.22a	0.21a	0.29a
(N_3P_1)	(N_1P_1)	(N_3P_0)	(N_0P_2)	(N_3P_3)	(N_2P_0)
3.75a	45.64a	0.58a	0.22a	0.20a	0.28a
(N_2P_1)	(N_2P_0)	(N_3P_2)	(N_2P_0)	(N_2P_3)	(N_0P_2)
3.75a	45.32a	0.57a	0.22a	0.20a	0.28a
(N_3P_3)	(N_3P_0)	(N_0P_2)	(N_2P_1)	(N_3P_0)	(N_2P_1)
3.75a	44.08a	0.57a	0.21a	0.20a	0.27a
(N_1P_1)	(N_2P_3)	(N_0P_3)	(N_1P_1)	(N_3P_1)	(N_1P_1)
3.66a	43.99a	0.56a	0.21a	0.19a	0.27a
(N_1P_3)	(N_3P_3)	(N_1P_1)	(N_1P_2)	(N_1P_2)	(N_3P_1)
3.51a	43.74a	0.55a	0.21a	0.19a	0.26a
(N_2P_0)	(N_1P_2)	(N_3P_3)	(N_3P_1)	(N_2P_0)	(N_1P_2)
3.51a	43.23a	0.53a	0.20a	0.19a	0.25a
(N_2P_3)	(N_2P_1)	(N_0P_0)	(N_2P_3)	(N_2P_1)	(N_2P_3)
3.50a	40.89a	0.53a	0.18a	0.18a	0.23a
(N_2P_2)	(N_3P_2)	(N_1P_0)	(N_0P_1)	(N_3P_2)	(N_0P_1)
3.46a	40.38a	0.53a	0.18a	0.17a	0.22a
(N_3P_2)	(N_2P_2)	(N_1P_3)	(N_0P_3)	(N_2P_2)	(N_0P_3)

FWR = Fresh wt./Dry wt. ratio, LAR = Leaf area ratio, SWR = Stem wt. ratio, LWR = Leaf wt. ratio, R/S = Root/Shoot ratio

(40.38) was found with N_2P_2. Highest stem weight ratio (0.60) was found with N_1P_2 where the lowest (0.53) was found with N_1P_3. Highest root weight ratio (0.24) was found with N_1P_0 where the lowest (0.18) was found with N_0P_3. Highest leaf weight ratio (0.25) was found with N_0P_3 where the lowest (0.17) was found with N_2P_2. Highest (0.32) root/shoot ratio found with N_1P_0 where the lowest (0.22) found with N_0P_2. Increasing doses of N increase the root: shoot ratio where as P decrease the root/shoot ratio.

DISCUSSION

The physical or visually determinable attributes of a tree seedling are its morphological characteristics. The major morphological criteria used to describe seedling quality are shoot height, stem diameter, root mass and shoot/root ratio. These are the basis for grading seedlings at the nursery. The results of this fertilizer study confirm with the general expected response, where application of fertilizers yielded better growth and seedlings quality. This is also in agreement with earlier reports on other plantation species, e.g. *Dryobalanops aromatica* and *D. oblongifolia*[24], *Tectona grandis*[24], *Pinus caribaea*[25-27]. Positive effects of fertilization were also reported on white spruce[28]. Douglas-fir[29-31] and Loblolly pine[32], while negative effect for white- spruce[33] sitka spruce[34] and Lobolly pine[35,36] was also recorded.

In the present experiment it is observed that survival percentage significantly decreases as the nitrogen dozes increases. This agrees with the finding of Kadeba[37] and Hartley[38] where addition of excess fertilizer on *Pinus caribaea* depressed growth and increased mortality on Nigerian Savannah sites. Due to application of too high a dose of fertilizers young trees may severely damaged[39]. Similarly Kadeba[37] and Oju and Jackson[40] reported that urea caused 50% mortality of seedlings if applied wrongly. Though little is known about the effects of nursery fertilization on seedling performance in the field, studies have been found positive effects of fertilization on either height growth or survival. Seedling height at the time of out planting can greatly influence the growth rate in the field. The response of several major timber species to N fertilization have been evaluated, including white spruce[3]; lodgepole pine[41] and loblolly pine[32]. Positive responses of fertilization also reported by Awang and Katim[42]; Zwierink[43]; Onuwaje and Uzu[44]; Van den Driessche[31]; Karani[45]; Sudvitsyna[46]; Smith *et al.*[47]; Switzer and Nelson[32]; Jung and Richle[48] and Wilde *et al.*[49].

Results of the present study can be briefly summarized as that there is a toxic response to kadam seedlings with increasing dozes of N and P. Total height and relative height growth rate of the species is not significantly affected by the N and P applications. However collar diameters are increased by N application but P has no significant effect. Considering the case of fresh and dry weight of root, shoot and leaf for the seedlings of Kadam 300 kg N ha^{-1} and 175 kg p ha^{-1} had given the best responses. These findings are in support of the earlier findings in other species[21,50-54], where the same interesting differences were also found. In case of different growth variables such as total biomass for Kadam, 300 Kg N ha^{-1}+175 kg P ha^{-1} gave the best response. No significant differences in fresh weight ratio were found. No significant differences were found in stem weight ratio, leaf area ratio, leaf weight ratio, root weight ratio. Hence, no significant differences in these growth attributes and no drastic impact on photosynthetic activities of the plant were found. However reports on these growth variables are not available.

Significant difference is found in leaf area where 300 kg ha^{-1} had shown best (1801.6 cm^2) leaf area production, hence, more photosynthetic activities as well as other physiological activities. Many workers have reported the effect of root shoot ratio on the subsequent growth and survival[55-67]. It is often assumed that nitrogen fertilization increases shoot weight proportionately more than root weight. Thus the root: shoot ratio will decrease with increasing fertilization. This imbalance could adversely affect field performance. However, data of Douglasfir, Sitka spruce and lodgepole pine[31], loblolly pine[32] indicate fertilization gain little or at worst minimal negative impact on root shoot ratio. Seedlings usually have been reared with the view that growth and survival will be best when the shoot/root ratio is between 1 and 3[68,69]. Works by Walker and Johnson[70] with northern species of spruce (*Picea* sp.) and pine shows that much higher shoot root ratios may be better for container grown seedlings. In present study no significant difference found for shoot/root ratio as well as root/shoot ratio due to N and P fertilization. However, the present findings are closely similar to the result of Wells[71] and Rowan[72]. The significant effect of N fertilization may indicate that the Chittagong University campus soils used for nursery grown media are deficient in Nitrogen but there is no deficiency of phosphorus.

The use of fertilizers discriminately to promote early growth of forest plantations is already an accepted policy. In Peninsular Malaysia, Yong[73] recommended the application of 120 g of rock phosphate into each planting hole at the time of planting, boosted by another 120 g of rock phosphate and 60 g of triple super phosphate one year after planting. These in total equivalent to 300 kg P ha^{-1}. However, the application of N and P at the rate of 300 kg N ha^{-1} + 175 kg P ha^{-1} for kadam may be needed to Chittagong University campus soil to boost the initial diameter, leaf area and dry matter production. However, these levels may have to varied depending on different soil types as already been reported for *Gmelina arborea* and *Swietenia mahagoni*[74] and for *Casuarina equisitfolia*[75].

However the results obtained from pot trials cannot be extrapolated to the field due to differences in soil volume, presence of impeding horizons or moisture stress[42,76]. Instead these pot trials should serve as a guidance for field application or further field studies into the effects of these nutrients on the growth of *Anthocephalus chinensis.* Considering the findings of the experiment conclusions may be drawn as the total height and relative height growth rate of kadam seedlings are not significantly influenced by different doses used in these experiments. But the level N_2 and P_2 (175 kg ha^{-1}) have shown better results, the collar diameter growth of the seedlings are effected by the nitrogen dose but not effected by phosphorus dose. Here N_3 level and P_1 level (300 kg N ha^{-1} and 50 kg P ha^{-1}) shown best results, total fresh weight, dry weight and total biomass are increased due to Nitrogen addition but here also (in most of the cases) N_2 and P_2 doses had shown better performance and in case of leaf area N_3 and P_3 level (300 kg N ha^{-1} and 300 kg P ha^{-1}) had shown better performance.

From over all aspects, it is found that, Nitrogen fertilizers obviously have beneficial effect increase the diameter, total biomass, leaf area of kadam in the present potting media used for nursery raising. It is also found that in respects of the seedlings of the control treatment, all the seedlings of the other treatment differ in their performance of collar dia. growth, total biomass and leaf area but beyond (above) the level 2 very few positive responses have found.

Of coarse, fertilizers accelerate the growth of seedlings in the nursery. But in fact, fertilizers also may destroy whole the nursery by toxic effect. Here it is found that treatment N_2P_2 showed the best performance. On the other hand from the study it is clear that up to level 2 fertilizer doses should there be fixed to avoid the toxic effect of and to augment the best results. Another thing is that the use of nitrogen and phosphorus fertilizers should there be in carefully in this study as it has itself toxic effects seriously. Finally it may be recommended that in the nursery practice of *Anthocephalus chinensis* seedlings, the combination of fertilizers belonging the treatment N_2P_2 should be applied.

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