

**EFFECT OF DIFFERENT DOSES OF NITROGEN AND
PHOSPHORUS ON SELECTED GROWTH PARAMETERS
OF *Bouhinia variegata* Linn. DURING NURSERY STAGE**

THESIS

By

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Submitted in partial fulfilment of the requirements for the

Degree of

MASTER OF SCIENCE

in

FORESTRY



**Dr YASHWANT SINGH PARMAR UNIVERSITY OF HORTICULTURE AND FORESTRY
COLLEGE OF FORESTRY**

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Dedicated
to
the
lotus
feet
of
my
Brother
Late Pradhiman Koul

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C E R T I F I C A T E - I

, This is to certify that the thesis entitled "Effect of different doses of nitrogen and phosphorus on selected growth parameters of Bauhinia variegata Linn. during nursery stage", submitted in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in FORESTRY to Dr. Y.S. Parmar University of Horticulture & Forestry, Solan, is a record of bonafide research work carried out by Shri VIJAY KUMAR KOUL son of Shri Omkar Nath Koul, under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of research work has been fully acknowledged.

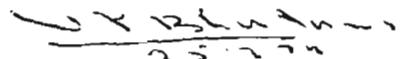
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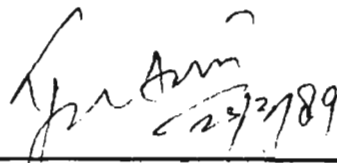

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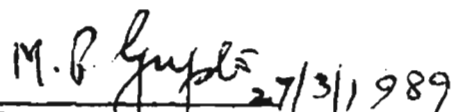
C E R T I F I C A T E - I I

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A C K N O W L E D G E M E N T

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Dated: January 19, 1989

Vijay Kumar Koul
VIJAY KUMAR KOUL

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CHAPTER I

INTRODUCTION

CHAPTER 1

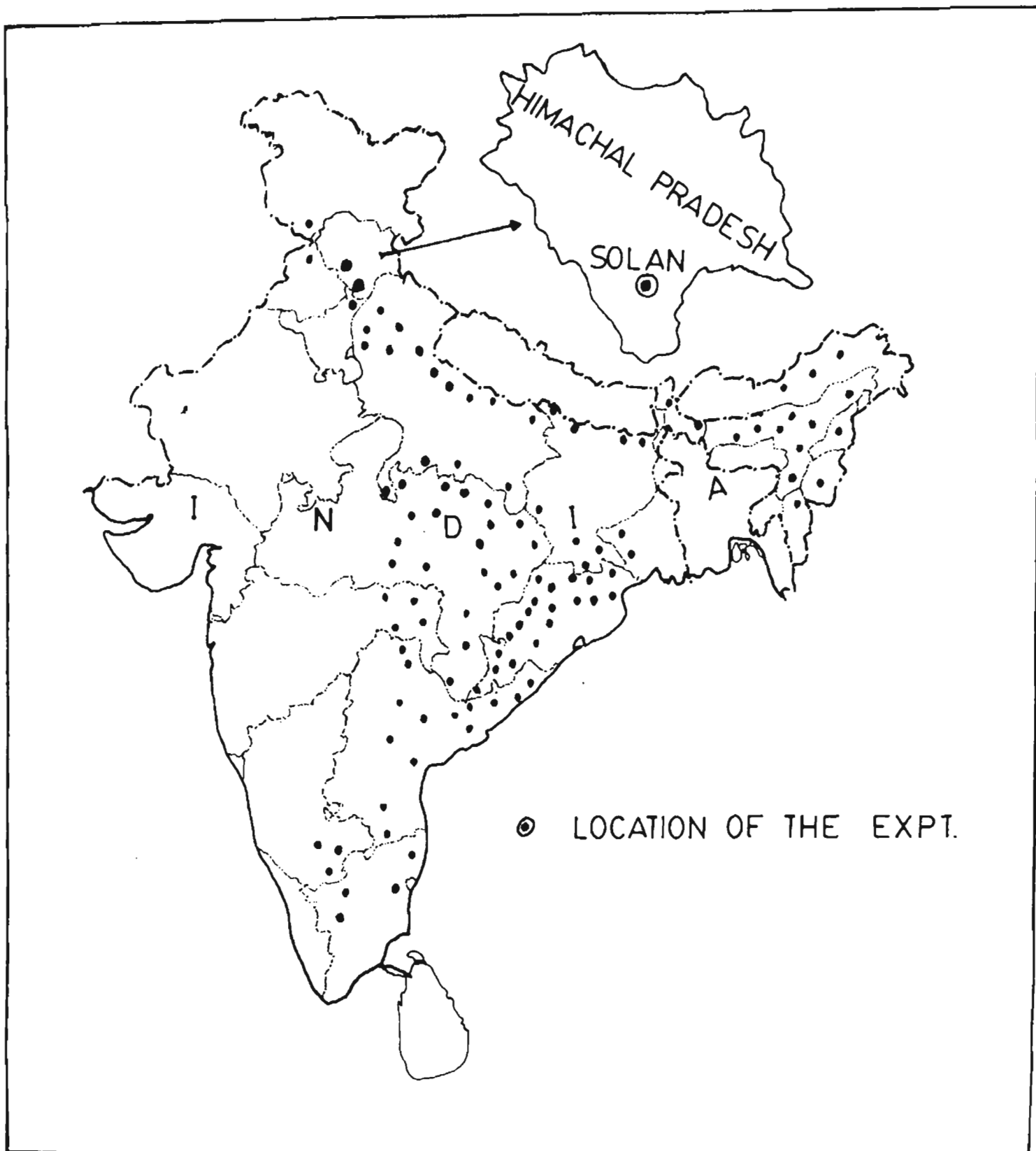
INTRODUCTION

Bauhinia variegata Linn. member of family Leguminosae (Caesalpinioideae) is a medium sized deciduous tree commonly found in sub Himalyan tract and the outer Himalya. It is also found in dry forests of East, Central and South India (Fig. I). In Himachal Pradesh it grows scattered almost throughout the sub tropical and Shivalik range upto elevation of about 1400m. Being multipurpose species mostly used for fodder, fuel, fibre and small timber. The species commands good reputation of easy propagation, wide adaptability, wind firm, frost and drought resistance, coppicing and has high aesthetic value too (Anon. 1983).

The wood is chiefly used for agricultural implements and bark for dyeing and fibre. Flowers and flower buds are consumed as vegetable and pickle. The leaves are good source of fodder for cattle. This is one of the common fodder trees of Himachal Pradesh. There is high liking for its leaves by villagers as fodder. Average leaf yield per adult tree is about 15 - 20 kg. per year (Negi et al., 1979).

Though Bauhinia variegata owing to its outstanding attributes is becoming increasingly popular in Himachal Pradesh, yet, the information regarding its nursery practices is scanty. In the current intensified programme for raising of forest nurseries, the use of fertilizers has vital role to play, provided they are used judiciously. The amount and type of fertilizer has to vary according to species due to wide differences in nutrient requirement and prevailing fertility levels of soil. Though the plants need all essential elements but some of them are of paramount importance. The two major elements i.e. nitrogen and phosphorus in general play important role in boosting the initial growth and development of plants. Nitrogen is an important constituent of proteins, protoplasm, enzymes and biological catalytic agents which speed up life processes in plants. Similarly phosphorus in early growth is important in germination of seeds, stimulation of root growth and laying down the primordia for reproductive parts of plant.

The combination of N and P increases biomass production (Prasad et al., 1984). Nitrogen and phosphorus fertilization give better results than separate application in Tilia cordata(Loffler,1971). Bauhinia variegata, however, has almost



Source :- Troup's The Silviculture of Indian Trees. Vol. IV

FIG.I. Map showing distribution of Bauhinia variegata.

remained unattempted with standardisation of optimum N and P levels under nursery conditions.

Keeping these facts in view present investigation has been undertaken with the following objectives

1. To study the effect of nitrogen on growth, biomass production, nutrient content and uptake.
2. To study the effect of phosphorus on growth, biomass production, nutrient content and uptake.
3. To elucidate the combined effect of nitrogen and phosphorus on growth, biomass production, nutrient content and uptake.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The literature on the effect of fertilizer application on Bauhinia variegata is very meager, however, whatever relevant literature is available here have been reported in the following pages. For the sake of convenience it has been presented under following heads.

1. Effect of nitrogen on growth, biomass production, nutrient content and uptake in plants.
2. Effect of phosphorus on growth, biomass production, nutrient content and uptake in plants.
3. Effect of NxP interaction on growth, biomass production, nutrient content and uptake in plants.
4. Misc. literature cited other than forest plants.

2.1. Effect of nitrogen on growth, biomass production, nutrient content and uptake in plants.

2.1.1. Growth

Giulimondi (1961) studied the effect of nitrogen fertilization on young poplars in nursery in Rome. The nursery beds were fertilized with ammonium sulphate @ 400 and 800 Kg ha⁻¹. He observed that diameter at breast height increased with increasing doses of N as compared to control.

Hussain et al., (1980) concluded that the application of nitrogen resulted in higher diameter in Black wattle (Acacia mearnsii).

Deol and Khosla (1983) made a study to evaluate the effect of different levels of nitrogen (30, 60, 90 kg ha⁻¹) in form of calcium ammonium nitrate on Populus ciliata. They found that dose of 60 kg N ha⁻¹ resulted in significant increase in height, collar diameter and internodal length over control but specific gravity was maximum with 30 kg N ha⁻¹ which decreased with higher levels.

Bhardwaj et al., (1986) made a study to evaluate the effect of different N levels (25, 50, 75, 125 and 150 Kg ha⁻¹) in the form of calcium ammonium nitrate (CAN) on Bauhinia variegata. They found that maximum height of 35.10 cm and diameter of 2.62 mm were obtained by applying 75 kg N ha⁻¹ which was found to be significant over control.

2.1.2 Biomass production

Rao (1985) in a study on biomass production of Acacia mollissima reported that N application @ 60 kg ha⁻¹ significantly increased green shoot weight and dry shoot weight.

In an attempt to find the response of fertilizers on Albizia procera, Hussain et al., (1986) reported maximum oven dry weight of sapplings when nitrogen was applied @ 20 kg ha⁻¹

Sivasupiramaniam et al., (1986) reported that an application of 25 kg N ha⁻¹ at planting increased shoot dry weight of Leucaena leucocephala as compared to control by 77, 88, 52 and 51 percent at 5, 15, 32 and 52 weeks respectively.

2.1.3 Nutrient content and uptake

Kaul et al., (1972) observed that N content in foliage (percent dry weight) of Tectona grandis was reduced and that of P and K increased in nitrogen deficient treatment over control. They also obtained similar results in their earlier studies on Eucalyptus grandids and Eucalpytus globulus.

Aluko and Adivayi (1983) reported that in Terminalia ivorensis increasing N fertilization increased N and K uptake while Ca, Mg decreased.

Application of nitrogen @ 20 kg ha⁻¹ induced higher

N uptake over control in Albizia procera seedlings (Hussain et al., 1986).

Reinsvold and Pope (1987) observed that application of nitrogen decreases foliar P content in Black locust (Robinia pseudacacia) seedlings.

2.2 Effect of phosphorus on growth, biomass production and nutrient content and uptake in plants.

2.2.1 Growth

Application of phosphorus resulted in better growth in Robinia pseudacacia seedlings (Miyazaki et al., 1954).

Brandl et al., (1977) conducted an experiment to elucidate the effect of phosphorus on Eucalyptus citriodora seedlings and reported that seedlings growth was higher with application of $1.17 \text{ g P plant}^{-1}$.

Kharitonov (1978) made a study on the ratio of aerial and underground parts of Fagus sylvatica, Quercus robur and Tilia cordata grown in pots with different levels of phosphorus and found that there was not a significant

effect on shoot/root ratio.

Horgan and Wareing (1980) reported low level of P resulted in rapid decrease of levels of cytokinins but the effect of K deficiency on cytokinins was less marked in Betula pendula and Acer pseudoplatanus.

Dutt and Pathania (1984) reported that at 18 months all the growth parameters were at their maximum at 48 kg ha⁻¹ single super phosphate (SSP) application on Sesbania sesban. Height increased by 4.0 percent and dbh by 27.6 percent. The increase in these parameters was highly significant over control.

Duguma and Okali (1987), observed that application of phosphorus improved height and growth in Leucaena leucocephala on acid soils.

2.2.2 Biomass production

Mccracken (1970) observed that phosphorus application resulted in higher survival and increased dry matter production in Alnus viridis.

Garza et al., (1987) concluded that phosphorus

application resulted in higher total biomass, top dry weight, root dry weight and nodules dry weight in Leucaena leucocephala over control in medium fertile and in infertile low pH 5.2 soils.

2.2.3 Nutrient content and uptake

Prasad et al., (1984) noticed that phosphate fertilizers increased P content in leaves but resulted in decreased nitrogen and potassium content in Eucalyptus grandis. Similar trend was also observed by Reinsvold and Pope (1987) during their study on Robinia pseudacacia seedlings.

Sharma (1988) reported that application of 45 kg P ha⁻¹ increased N, P and K concentration in Robinia pseudacacia leaves, but maximum uptake of these nutrients was observed when 30 kg P ha⁻¹ was applied.

2.3 Effect of N X P interaction on growth, biomass production nutrient content and uptake.

2.3.1 Growth

Dakev (1964) found that combined application of ammonium nitrate and superphosphate improved the size of

nursery stock compared with control in nursery production of Beech (Fagus sylvatica).

Pires and Silva (1964) concluded an experiment to elucidate the effect of nitrogen and phosphorus on Eucalyptus saligna seedlings. They reported significant response when nitrogen and phosphorus were applied 0.0572 g N and 0.0574 g P_2O_5 per seedling respectively.

Loffler (1971) concluded that NP fertilization had a favourable effect on height but lesser effect on diameter growth in seedlings of Tilia cordata rather than application of N and P separately.

Babev (1978) concluded that better height growth could be obtained with 120 kg N and 60 kg P ha^{-1} application to the young plant of Canadian poplars.

Chen et al., (1984) reported that N and P were the most important nutrients for Acacia mearnsii growth, which is affected when there is lack of either or both the elements.

While studying the effect of fertilizers on direct seeded Acacia albida, Stewart and Gwaze (1988) observed that 32 kg ha^{-1} nitrogen and 24 kg ha^{-1} phosphorus application

increased height significantly after 20 and 30 weeks of sowing.

2.3.2 Biomass production

Dutt and Pathania (1986) made a study on the combined nitrogen and phosphorus in the form of di-ammonium phosphate (DAP) in Leucaena leucocephala and concluded that application of DAP at 1 g/seedling increased total dry weight, dry weight stem and dry weight root per seedling over control. Similarly in an attempt to find out response of phosphorus and nitrogen application on early growth of Adenanthera pavonina, Albizia falcataria and Schleinitzia insularum, Moloney et al., (1986) observed that applying phosphorus increased significantly dry matter yield of all these species in presence of applied nitrogen.

2.3.3 Nutrient content and uptake

Stanberry and Clore (1950) reported increased N content in N and NP treated plant leaves. Similarly P content was increased in P and NP treatments. The content of N from NP treatments was found to be significant and also the P content from P treatment was significant, but it was non

significant from NP treatment when compared with control in Bing cherries (Prunus avium).

Prasad et al., (1984) observed that interaction of N X P in form of urea and superphosphate lowered N and K content in the leaves. P content was not significantly affected, however uptake of N, P and K increased with combined doses of urea and superphosphate in Eucalyptus grandis.

Rao (1985) studied N X P interaction effecting Acacia mollissima and observed significant increase in N content while P and K content decreased in shoot with the combined application of 60 kg N and 40 kg P ha⁻¹.

2.4. Misc. literature cited, other than forest plants.

While screening of 44 soyabean varieties in plant nutrient solution, Howell and Bernard (1961) identified 4 cultivars sensitive to high phosphorus concentration.

The close correlation between nitrogen supply and formation of Cytokinins in root and their export to shoot has been clearly demonstrated by Wagner and Michael (1971); Salma and Wareing (1979) in plants of sunflower. Nitrogen supply affects abscisic acid (ABA), however the effect is reverse of

that of cytokinins (Goldbach et al., 1975).

Krauss and Marshner (1982) reported that nitrogen has the most prominent effect on gibberellins. In potato plants interruption in supply of nitrogen induces a sharp drop in GA levels of shoot associated with sharp increase in ABA levels.

CHAPTER

III

MATERIALS

AND

METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigation on " Effect of different doses of nitrogen and phosphorus on selected growth parameters of Bauhinia variegata Linn. during nursery stage " was carried out at forest nursery of Department of Forestry, Dr. Y. S. Parmar University of Horticulture & Forestry solan, during 1987. Details about the experimental site, materials used and methodology employed during the course of investigation are described in this chapter.

3.1 Experimental site

3.1.1 Location

Experimental site is located at an altitude of 1100m above mean sea level and lies between 30° - $50'$ N latitude and 70° - $11''$ longitude.

3.1.2 Climate

Climatically area is intermediate zone between subtropical and subtemperate. May and June are the hottest months, whereas December and January are the coldest and experience severe frost. The area receives an average 1150 mm annual rain fall and most of the precipitation occurs during monsoons from June to August. The meteorological data for the experimental site recorded for the year 1987 are

Table 1. Meteorological data for the experimental site during 1987.

Month	Temperature (°C) Maximum	Minimum	Relative humidity (%)	sun shine hours	Rainfall (mm)
January	15.4	04.8	62.9	6.8	61
February	19.9	07.9	69.5	6.9	40
March	22.8	11.3	63.7	7.6	17
April	27.7	14.5	66.4	9.6	27
May	26.2	14.1	74.9	8.2	307
June	32.1	18.0	79.2	10.4	77
July	31.1	20.1	81.1	9.3	109
August	28.7	19.0	85.6	7.2	164
September	29.9	18.4	79.6	9.4	100
October	27.8	14.1	57.0	8.5	81
November	23.1	04.5	54.1	8.4	-
December	20.5	01.5	54.9	6.8	8

Annual

1991

Source : Meteorological observatory, Deptt. of Forest
Biology & Tree Improvement, UHF, Solan.

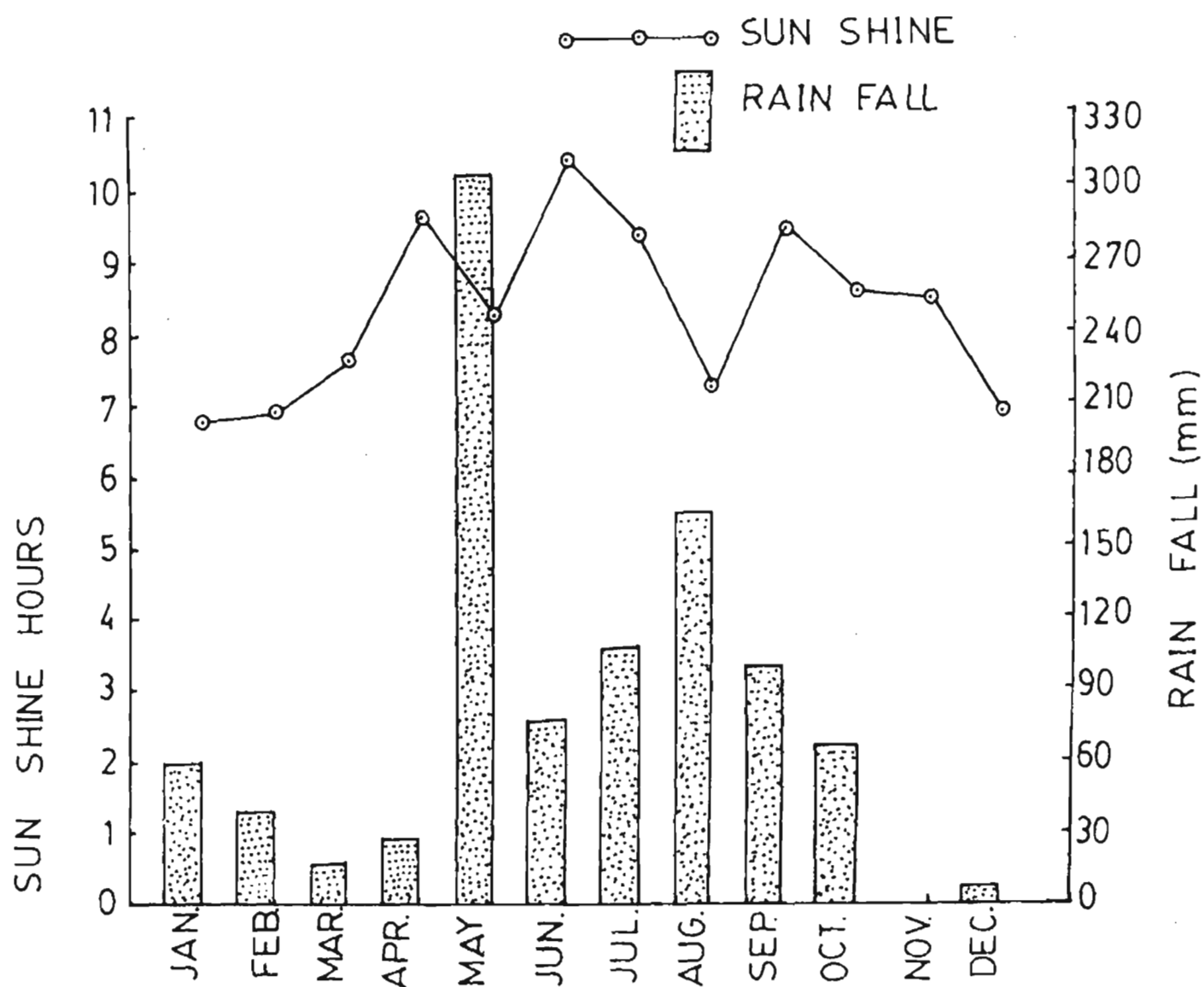
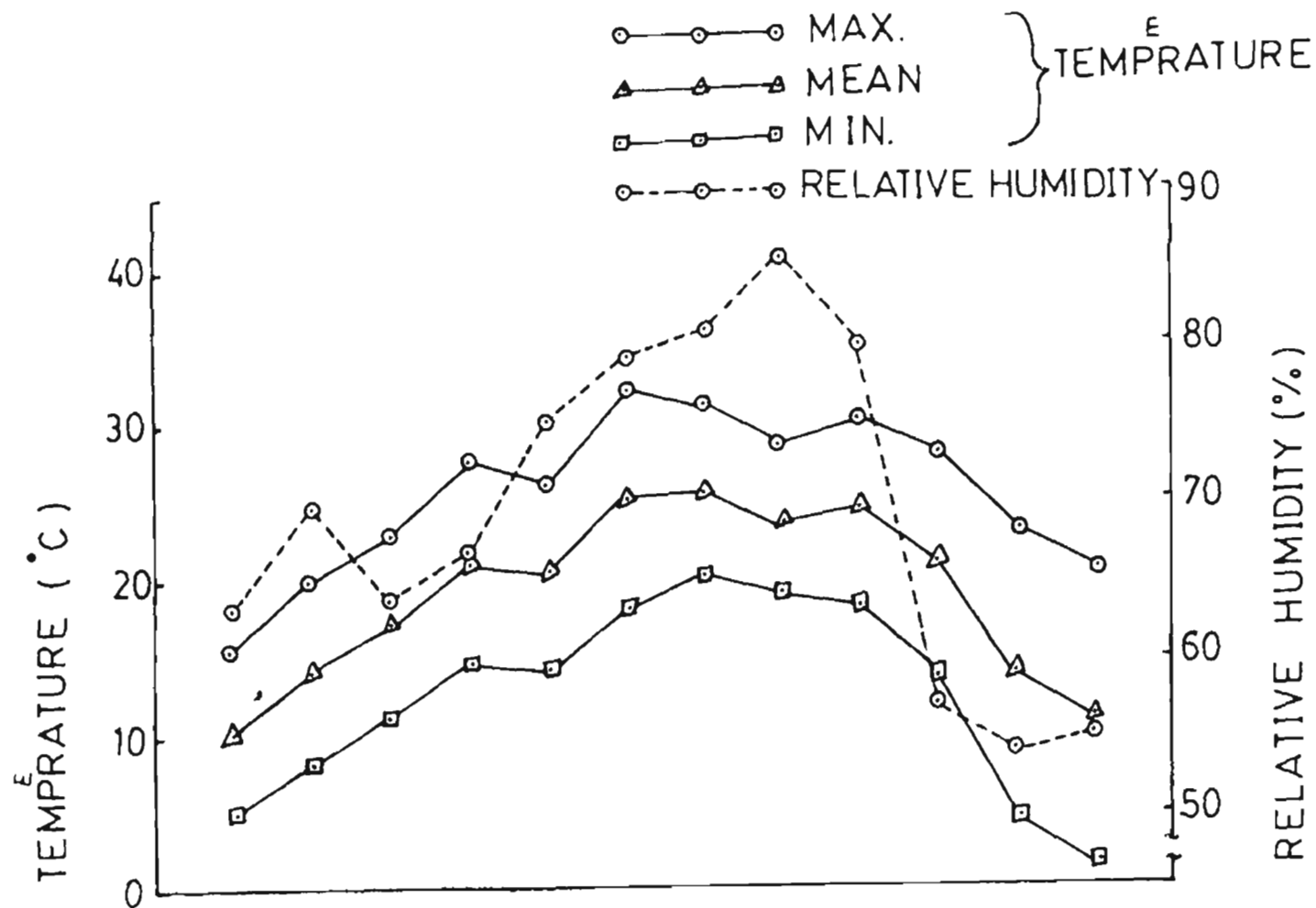


FIG. 1. MEAN MONTHLY WEATHER DATA YEAR 1987.

presented in Table 1 and Fig. 1.

3.1.3 Soil analysis

Three representative composite soil samples of entire soil heap before filling in polythene bags were taken and analysed in order to evaluate its fertility status (Table 2).

3.2 Experimental methodology

3.2.1 Layout and Design

The experiment was laid out in a factorial randomised block design with three replications. There were in all 12 treatment combinations. Under each treatment 30 polythene bags of size 22 X 12 cm were filled with 1 kg of well mixed air dried soil.

3.2.2 Treatments

The treatments comprised of all possible combination of 4 levels of nitrogen and 3 levels of phosphorus. The details are given as under :-

Nitrogen levels

N_0 = no nitrogen (control)

N_{30} = 30 kg N ha^{-1} = 15 mg N per bag

$N_{60} = 60 \text{ kg N ha}^{-1} = 30 \text{ mg N per bag}$

$N_{90} = 90 \text{ kg N ha}^{-1} = 45 \text{ mg N per bag}$

Phosphorus levels

P_0 = no phosphorus (control)

$P_{40} = 40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} = 20 \text{ mg P}_2\text{O}_5 \text{ per bag}$

$P_{80} = 80 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1} = 40 \text{ mg P}_2\text{O}_5 \text{ per bag}$

3.2.3 Fertilizer application

Phosphorus was applied in the form of single superphosphate (16% P_2O_5) as basal dose. Nitrogen in the form of urea (46% N) in two split doses, half with basal dose and another half as top dressed on May 16, 1987.

A basal dose of potash in form of murate of potash (60% K_2O) was applied @ 50 kg ha^{-1} .

3.2.4 Seed treatment and sowing

Seeds were sown on March 15, 1987 @ one seed in each polythene bag after giving pre-sowing, over night treatment in cold water.

3.3 Cultural operations

All the cultural operations were done timely and

Table 2. Chemical analysis of soil

sr.no	Parametres	Test values	Method employed
1.	pH	7.2	1:2 soil water suspension using glass electrode (Jackson, 1967)
2.	Organic Carbon (%)	0.99	Walkley and Black rapid titration method (Piper, 1966)
3.	Available nitrogen (kg ha ⁻¹)	498.62	Alkaline permaganate (Subbiah and Asija, 1956)
4.	Available phosphorus (kg ha ⁻¹)	40.32	Olsen et al., (1954)
5.	Available potassium (kg ha ⁻¹)	375.2	Morwin and Peech (1951)

vi. Number of internodes

Average number of internodes was determined by counting the number of internodes per plant.

viii Specific gravity

Observations on specific gravity were confined to main stem. Specific gravity was determined by maximum moisture method (Smith, 1954). Two centimeter samples of wood were taken at collar level. The green weight of the samples at maximum moisture level was noted. The samples were taken then oven dried at $102^{\circ} \pm 1^{\circ}$ C temperature till these attained a constant weight. Dry weight of samples were noted and specific gravity was worked out according to formula.

$$\text{Specific gravity of sample} = \frac{\frac{M_m - M_o}{M_o}}{\frac{1}{G_s}}$$

where M_m = Weight of fresh sample having maximum moisture content.

M_o = Oven dried weight of sample.

G_s = A constant where value is 1.53

ix Shoot/root ratio

Shoot/root ratio was determined by dividing the shoot length with corresponding root length.

For P and K estimation the digestion was done in di-acid (AR grade nitric acid and perchloric acid in 4:1 ratio V/V). The digest was dissolved in distilled water and filtered into 100 ml volumetric flask to ~~make~~ final volume of 100 ml.

3.5.2 Nitrogen content

Nitrogen was estimated by Micro-Kjeldhal method (Jackson 1967). The nitrogen content was expressed in percent.

3.5.3 Phosphorus content

Phosphorus was determined by vando-molybdate method (Jackson 1967), which was expressed in terms of percent phosphorus content.

3.5.4 Potassium content

Quantitative estimation of potassium in the extract was done by flame photometer (Jackson 1967) and expressed in percent.

3.6 Nutrient uptake

Nutrient uptake of different biomass yielding components (leaf and root and shoot) was worked out according to formula.

Table 2-A Schedule of Cultural Operations

No.	Operation	Date	Brief detail
1.	Soil preparation	15-03-87	Soil was sieved and filled into polythene bags.
2.	Date of sowing	15-03-87	Direct sowing.
3.	Fertilizer application	15-03-87 16-05-87	Basal dose of N, P and K applied. Remaining nitrogen dose top dressed
4.	Weeding	At the interval of 10-15 days	Hand weeding.
5.	Irrigation/ Watering	3-5 days interval except July & August	By water can. with attached sprinkler
6.	Uprooting of plants	23-08-87	The plants were removed as described in section 3.4.

Nutrient uptake (mg plant⁻¹)

$$= \frac{\text{Nutrient content\%} \times \text{Dry matter} \times 1000}{100}$$

Sum of the nutrient uptake of different components (leaf + root and shoot) gave total plant nutrient uptake.

3.7 Soil studies

3.7.1 Available N,P and K in soil after experiment.

A representative soil sample from each treatment after completion of experiment was taken and analysed for available N, P and K as per methods described in table 2.

3.8 Statistical analysis

The data thus recorded for different parameters was subjected to appropriate statistical analysis as per procedure given by Cochran and Cox (1970).

CHAPTER IV

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

In accordance with the plan of the work reported in previous chapter. The results emerging out of the present investigations are presented in this chapter and have been dealt under following heads.

4.1 Effect of nitrogen on growth, biomass production, nutrient content and uptake.

4.2 Effect of phosphorus on growth, biomass production, nutrient content and uptake.

4.3 Effect of N X P interaction on growth, biomass production, nutrient content and uptake.

4.1 Effect of nitrogen on growth, biomass production nutrient content and uptake.

The pertaining data to this head have been presented in Table 3-7 and Fig. 2-7.

4.1.1 Growth

It can be noticed from Table 3 and Fig. 2-3 that N application did influence growth characters, viz, plant height, collar diameter, number of leaves, root length, number of internodes and internodal length significantly.

Plant height increased significantly with the

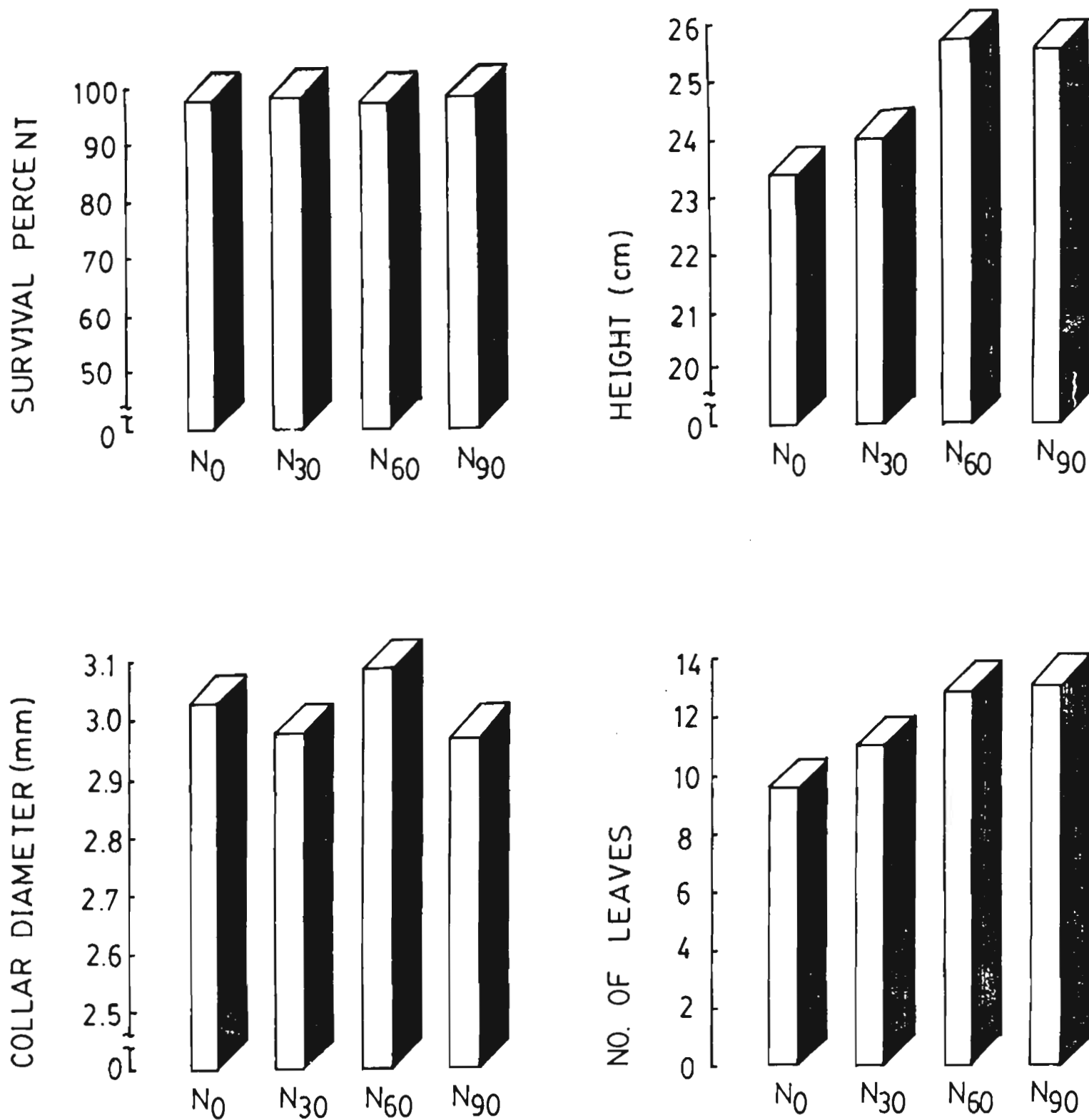


FIG.2. Effect of N levels on seedling growth.

Table 3. Effect of nitrogen levels on growth of Bauhinia variegata

Parameter	N levels (kg ha ⁻¹)				S.Ed/S.Em ±	C.D at 5%
	N ₀	N ₃₀	N ₆₀	N ₉₀		
Survival percentage	98.14	99.25	98.88	99.25	0.731	N.S.
Plant height (cm)	23.40	24.05	25.72	25.49	0.625	1.30
Collar diameter (mm)	3.03	2.98	3.09	2.97	0.043	0.09
Number of leaves plant ⁻¹	9.62	11.08	12.84	13.03	0.693	1.44
Root length (cm)	23.61	24.71	25.64	25.10	0.409	0.85
Number of internodes plant ⁻¹	8.27	8.47	8.67	8.71	0.104	0.22
Internodal length (cm)	2.83	2.84	2.97	2.92	0.046	0.09
Specific gravity	0.608	0.621	0.613	0.605	0.01	N.S.
Shoot/root ratio	0.99	0.98	1.00	1.01	0.02	N.S.

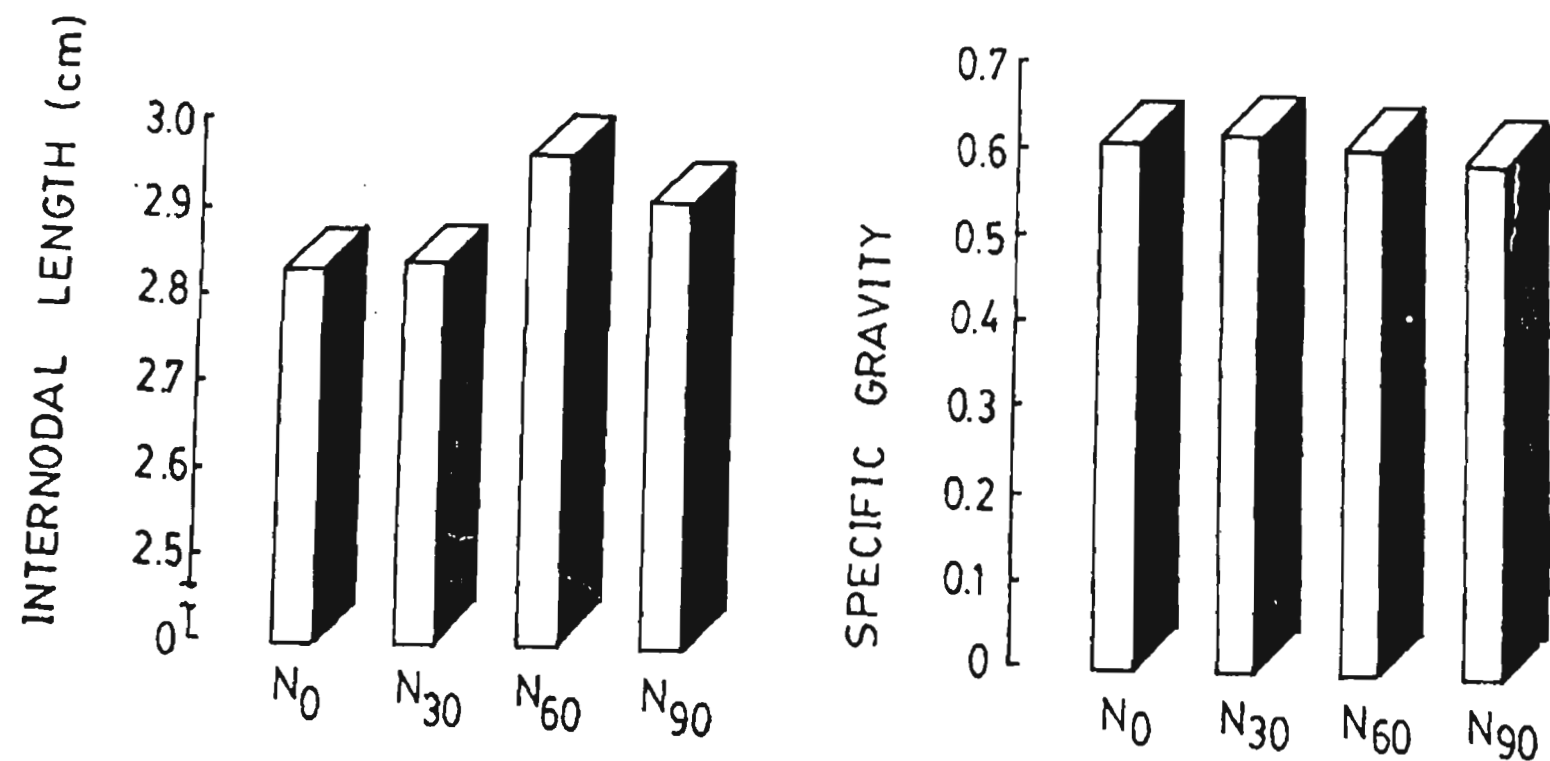
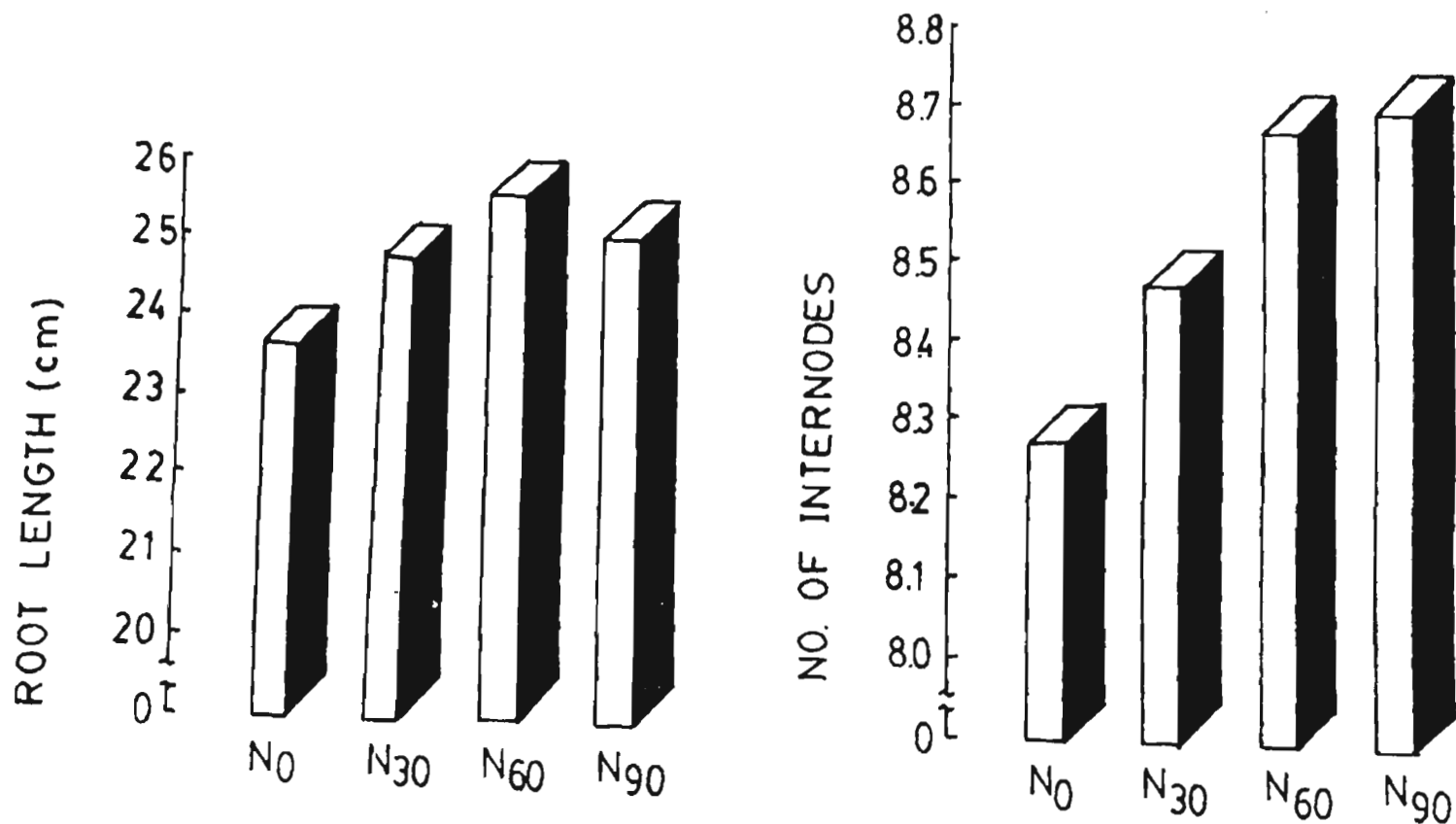


FIG.3. Effect of N levels on seedling growth.

Increasing levels of nitrogen up to N₆₀ followed by N₉₀ and N₃₀ (Table 3 and Fig. 2). Maximum plant height was recorded at N₆₀ level. The percent increase in height under N₃₀, N₆₀ and N₉₀ was achieved 2.78, 9.91 and 8.93 respectively over control.

Collar diameter attained maximum value at N₆₀, yet remained statistically alike control but superior to N₃₀ and N₉₀ (Table 3 and Fig. 2).

Number of leaves per plant were significantly increased by varying N levels (Table 3 and Fig. 2) Maximum leaves were obtained at N₉₀ which proved to be statistically identical to N₆₀ but superior to control.

Root length also showed progressive increase with increasing nitrogen levels upto N₆₀ (Table 3 and Fig. 3). N₆₀ was found to be significantly superior to control but at par with N₉₀. Percent increase in root length under N₆₀ and N₉₀ was recorded to be 8.6 and 6.3 percent respectively over control.

Application of nitrogen at N₆₀ and N₉₀ levels resulted in additional number of internodes and increased internodal length (Table 3 and Fig. 3). Former level of

Table 4. Effect of nitrogen levels on biomass production of Bauhinia variegata

Parameter	N levels (kg ha ⁻¹)				S.Ed/S.Em ±	C.D at 5%
	N ₀	N ₃₀	N ₆₀	N ₉₀		
Green weight (g plant ⁻¹)	5.87	6.14	6.28	5.83	0.170	0.35
Total biomass (g plant ⁻¹)	2.28	2.37	2.56	2.23	0.067	0.14
Leaf biomass (g plant ⁻¹)	0.48	0.49	0.52	0.46	0.018	0.04
Root and shoot biomass (g plant ⁻¹)	1.81	1.88	2.04	1.77	0.064	0.13

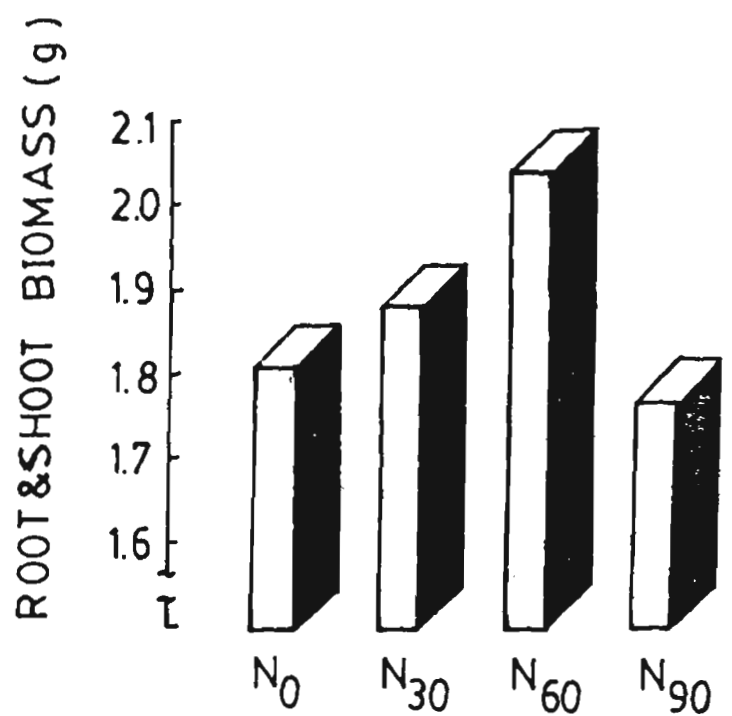
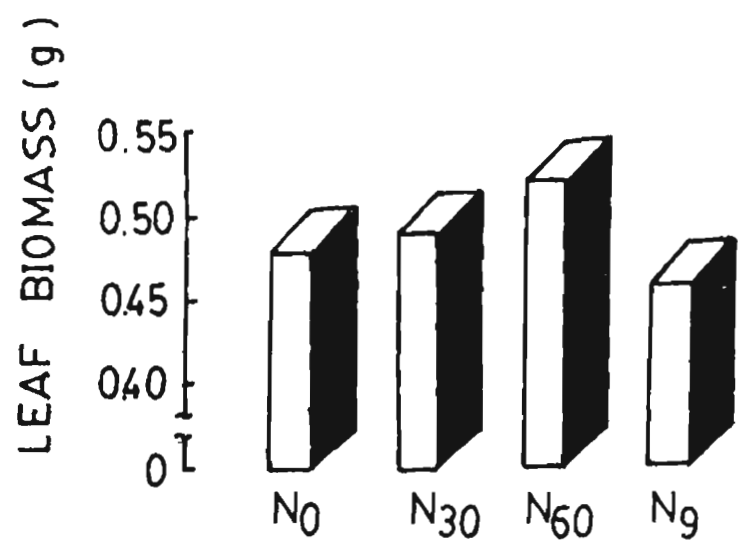
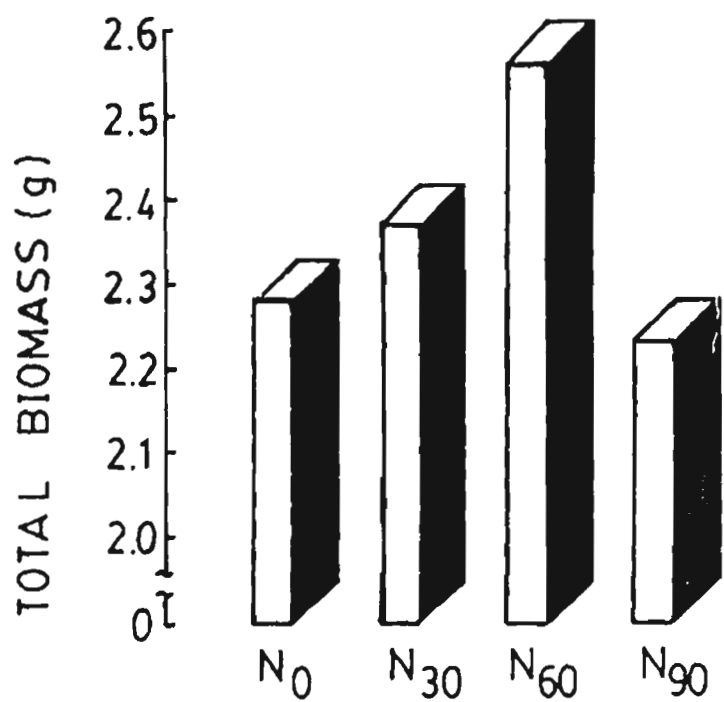
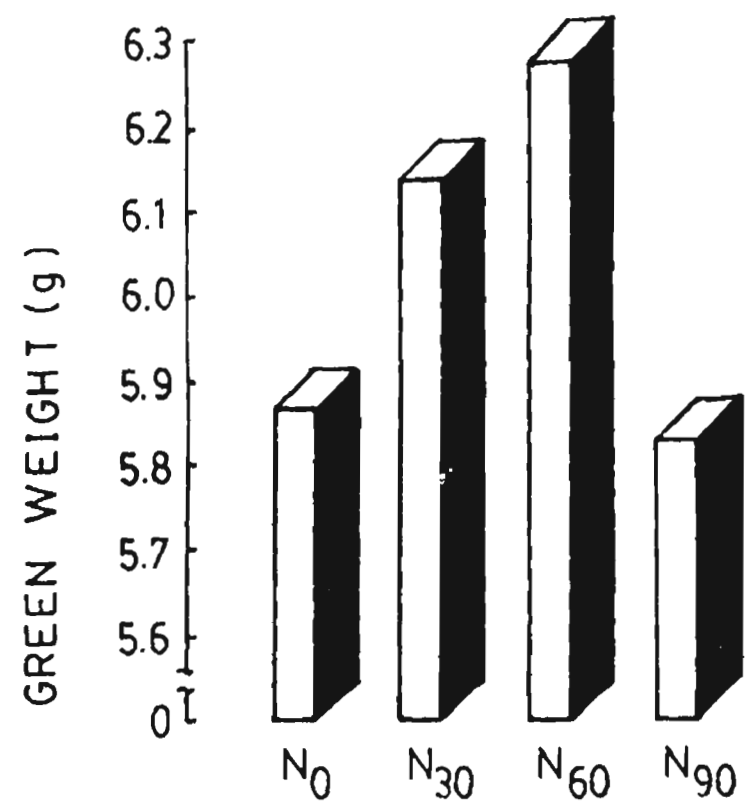


FIG.4. Effect of N levels on biomass production.

nitrogen was found significantly superior over control.

Survival percentage, specific gravity and shoot/root ratio (Table 3 and Fig. 2-3) were not significant with varying levels of nitrogen. However, slight increase in specific gravity and shoot/root ratio were obtained at N_{60} .

4.1.2 Biomass production

Nitrogen levels had significant effect on biomass production (Table 4 and Fig. 4). N_{60} was statistically superior over control but at par with N_{30} . The percent increase in green weight under N_{30} and N_{60} was recorded to be 4.6 and 6.98 percent respectively over control.

Total biomass (dry weight) registered highest value under N_{60} and proved to be significantly superior over all other levels (Table 4 and Fig. 4). The percent increase in total biomass was found to be 12.28 percent over control.

Leaf and root and shoot biomass had almost similar trend in response to various N levels (Table 4 and Fig. 4). With the increase in nitrogen level from N_0 to N_{60} , maximum biomass was obtained. N_{60} was found to be statistically superior over control only in root and shoot biomass.

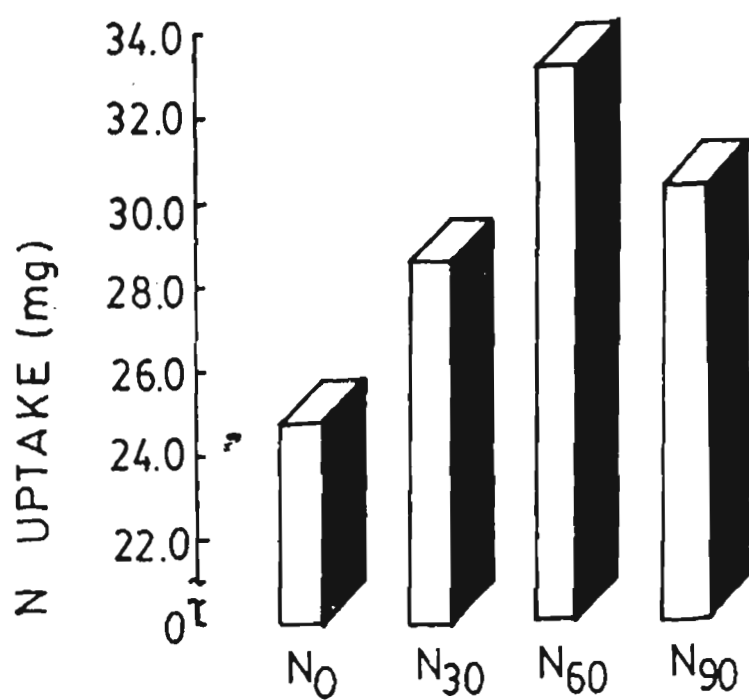
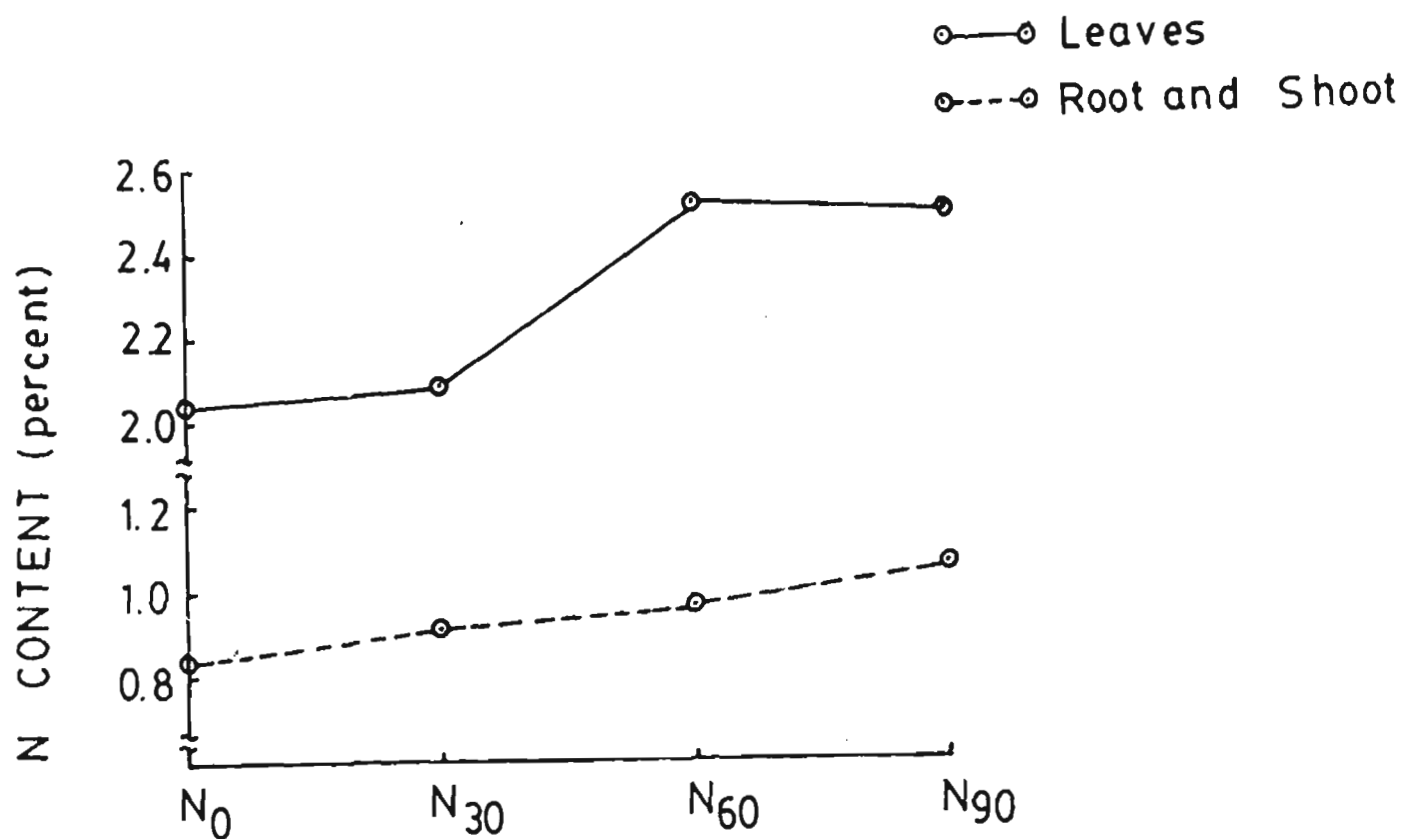


FIG. 5. Effect of N level on nutrient content and uptake.

Table 5 Effect of nitrogen levels on nutrient content of Bauhinia variegata leaves

Treatment/ Nutrient content	N (%)	P (%)	K (%)
N ₀	2.04	0.273	1.35
N ₃₀	2.30	0.274	1.32
N ₆₀	2.52	0.289	1.31
N ₉₀	2.50	0.269	1.27,
S.Ed / S.Em $\pm$	0.055	0.004	0.019
C.D at 5%	0.11	0.008	N.S

Table 6 Effect of nitrogen levels on nutrient content of Bauhinia variegata root & shoot.

Treatment/ Nutrient content	N (%)	P (%)	K (%)
N ₀	0.84	0.221	1.02
N ₃₀	0.92	0.226	0.97
N ₆₀	0.97	0.226	0.90
N ₉₀	1.06	0.200	0.88
S.Ed / S.Em $\pm$	0.043	0.003	0.020
C.D at 5%	0.09	0.006	0.04

Table 7 Effect of nitrogen levels on nutrient uptake of Bauhinia variegata.

Treatment/ Nutrient uptake (mg plant ⁻¹)	N	P	K
N ₀	24.83	5.29	24.87
N ₃₀	28.65	5.59	24.70
N ₆₀	33.15	6.15	25.15
N ₉₀	30.33	4.75	21.40
S.Ed / S.Em $\pm$	1.194	0.173	0.632
C.D at 5%	2.48	0.36	1.31

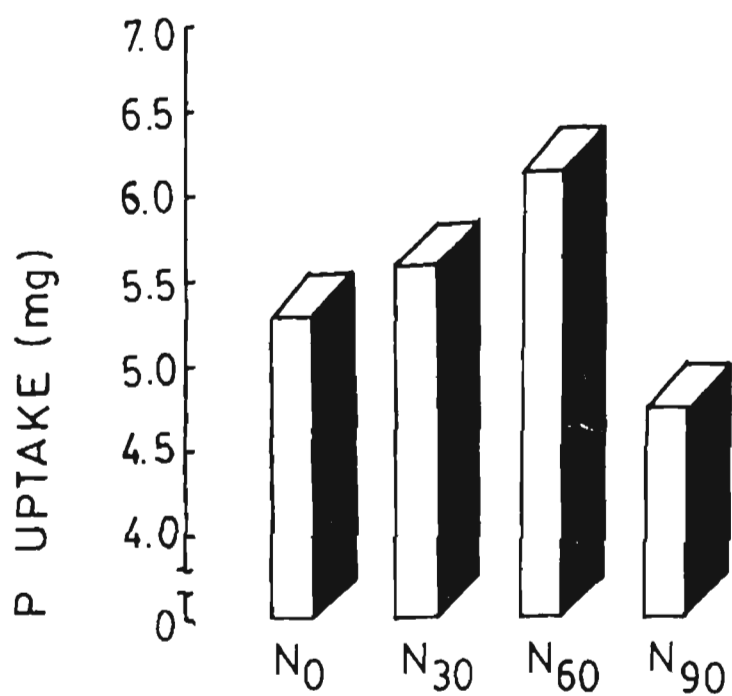
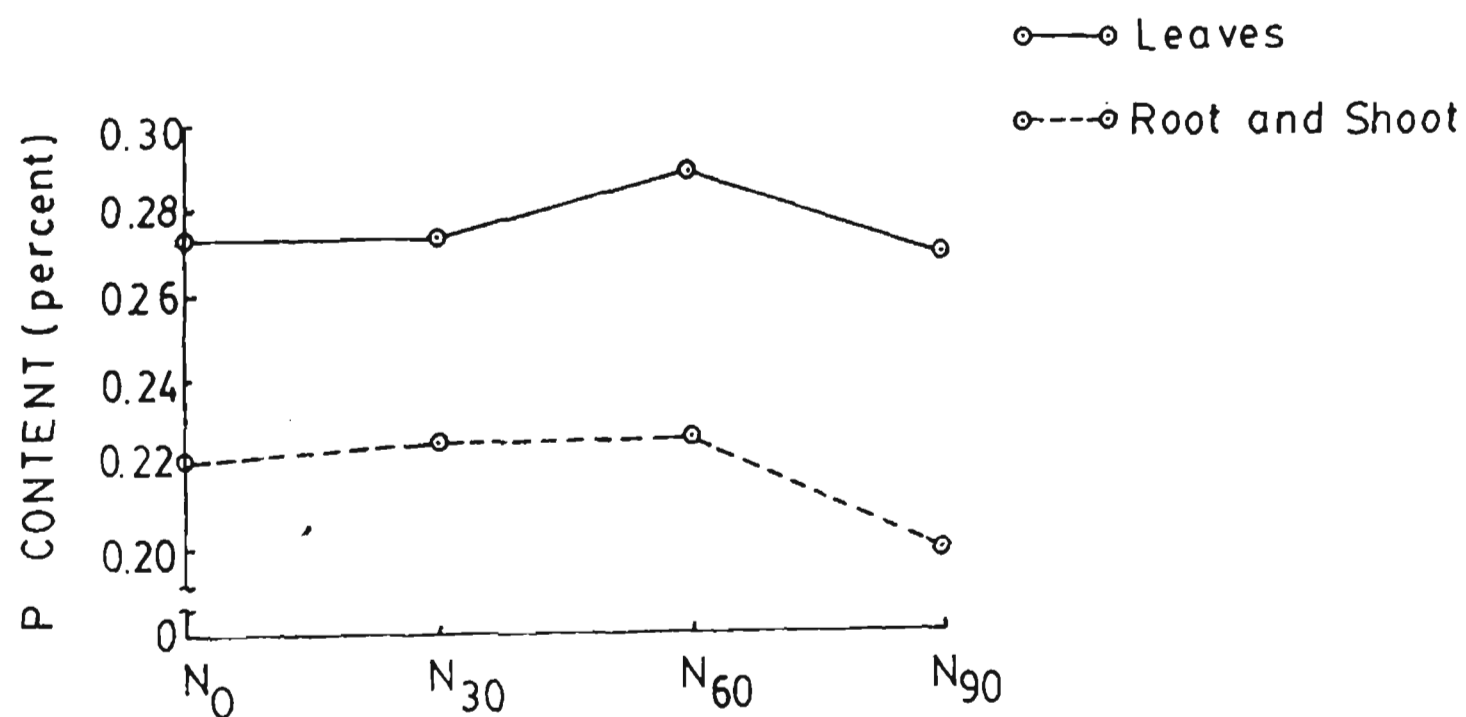


FIG. 6. Effect of N levels on nutrient content and uptake.

4.1.3 Nutrient content

It is evident from data given in Table 5 and Fig. 5 that nitrogen content in leaves enhanced with increasing levels of nitrogen upto N_{60} followed by N_{90} and N_{30} . N_{60} proved statistically similar to N_{90} but superior to N_{30} and control.

The root and shoot contained lower nitrogen content as compared to leaf under all nitrogen levels (Table 6 and Fig. 5) N_{90} treatment registered maximum N content which proved to be significantly higher than all other levels except N_{60} .

P content in leaves as well as in root and shoot exceeded with increase in nitrogen level from N_0 to N_{60} (Table 5-6 and Fig. 6) and declined with further increase. N_{60} recorded significantly higher P content over all other levels in leaves while in root and shoot N_{60} , N_{30} and control were at par with each other.

K content in leaves did not differ significantly with varying levels of nitrogen (Table 5 and Fig. 7).

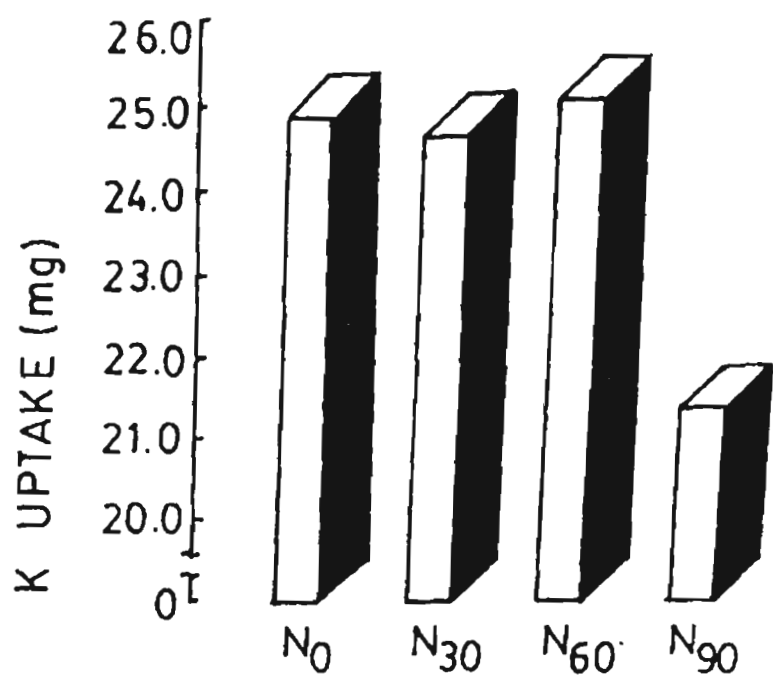
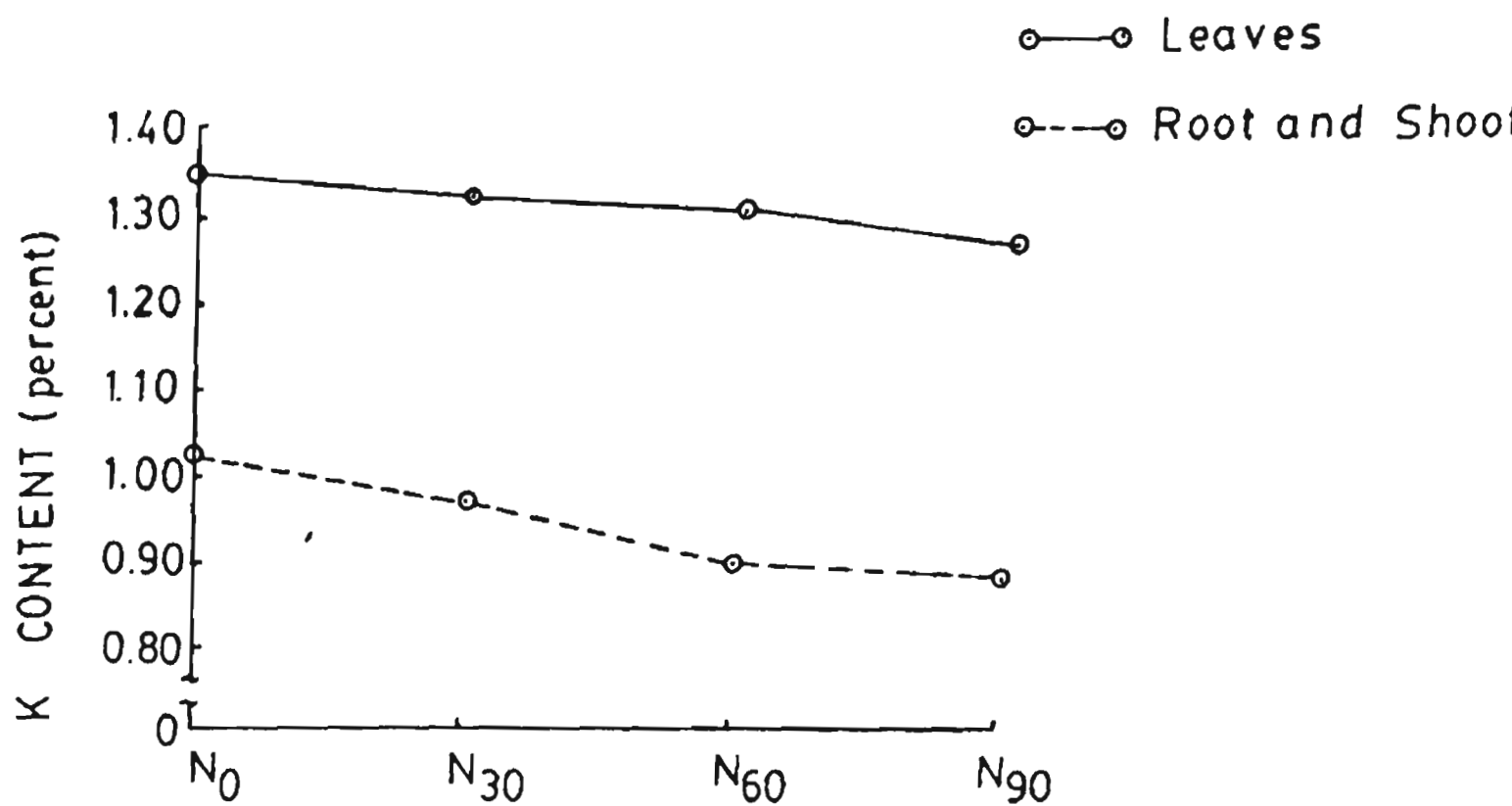


FIG.7. Effect of N levels on nutrient content and uptake.

Table 8. Effect of phosphorus levels on growth of Bauhinia variegata

Parameter	P levels (kg ha ⁻¹)			S.Ed/S.Em ±	C.D at 5%
	P ₀	P ₄₀	P ₈₀		
Survival percentage	98.60	98.88	99.16	0.633	N.S
Plant height (cm)	24.58	24.94	24.48	0.383	N.S
Collar diameter (mm)	2.89	3.17	2.98	0.037	0.08
Number of leaves plant ⁻¹	11.50	12.05	11.38	0.424	N.S
Root length (cm)	24.49	25.71	24.09	0.354	0.73
No of internodes plant ⁻¹	8.53	8.58	8.47	0.063	N.S
Internodal length (cm)	2.88	2.90	2.89	0.028	N.S
Specific gravity	0.615	0.613	0.607	0.009	N.S
Shoot/root ratio	1.00	0.97	1.01	0.017	N.S.

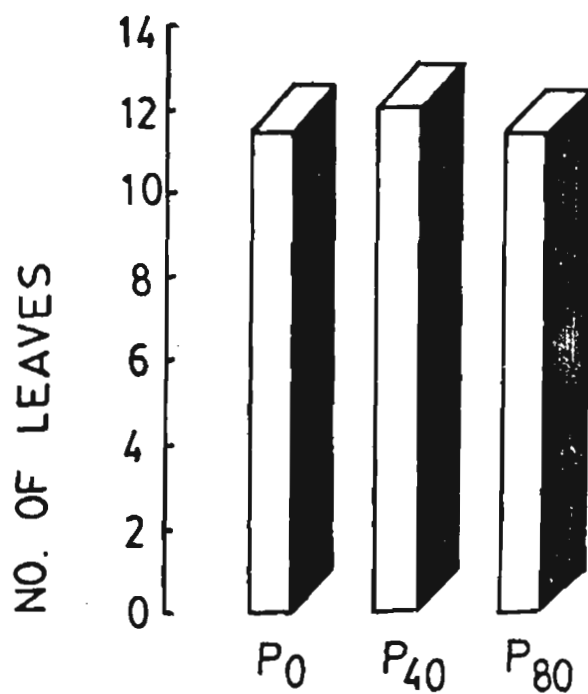
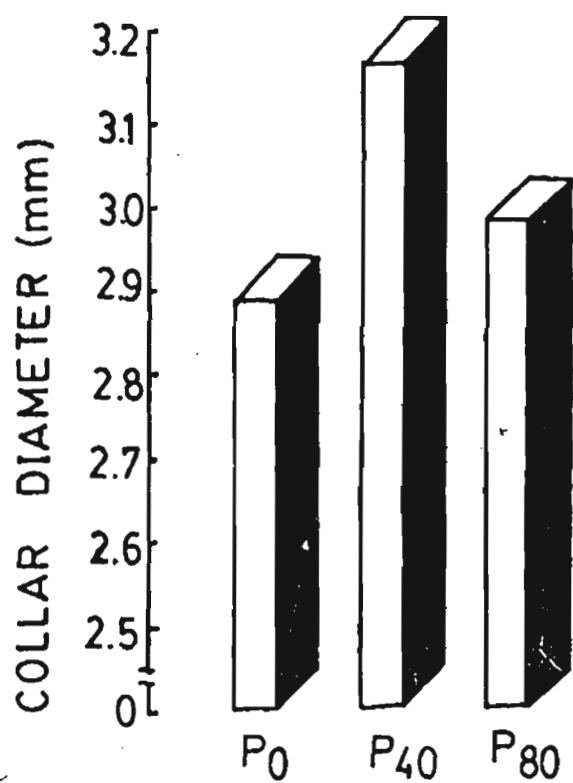
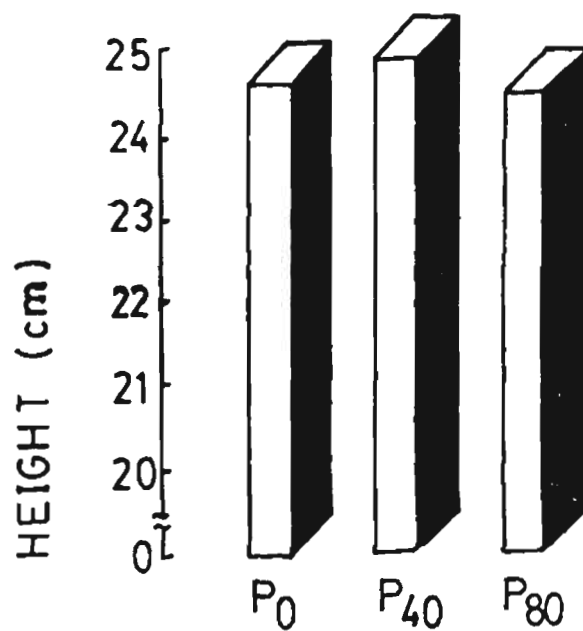
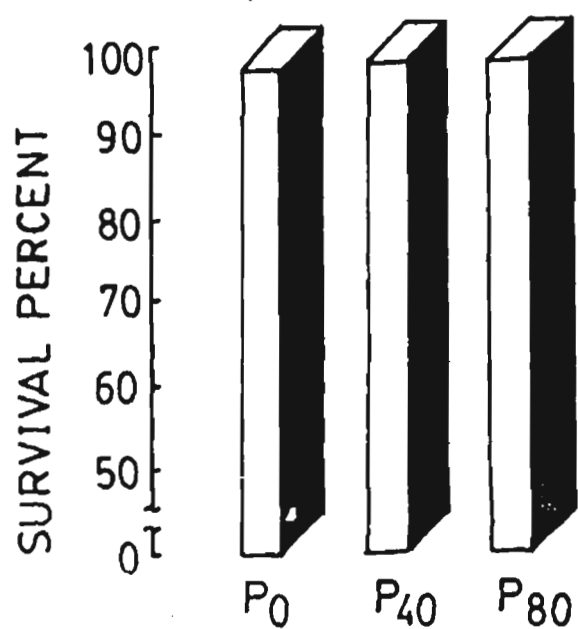


FIG. 8. Effect of P levels on seedling growth

K content in root and shoot indicated maximum value over control (Table 6 and Fig. 7).

4.1.4. Nutrient uptake

Nutrient uptake by the plant is product of total biomass and nutrient content of plant. The data reflecting the influence of various N levels on nutrient uptake in the plants have been presented in (Table 7 and Fig. 5-7).

Maximum N uptake was obtained at N_{60} followed by N_{90} , N_{30} and control (Table 7 and Fig. 5) respectively. N_{60} treatment was found to be significantly superior over all other levels. The increase in percentage of nitrogen uptake was recorded to be 33.51 and 22.15 under N_{60} and N_{90} levels respectively over the control.

N_{60} indicated maximum P uptake (Table 7 and Fig. 6) which proved to be statistically significant over control. The increase in terms of P uptake at N_{60} level was recorded to be 16.26 percent over control.

K uptake too was found maximum under N_{60} (Table 7 and Fig. 7) but it was, however, not having significant difference as compared to control.

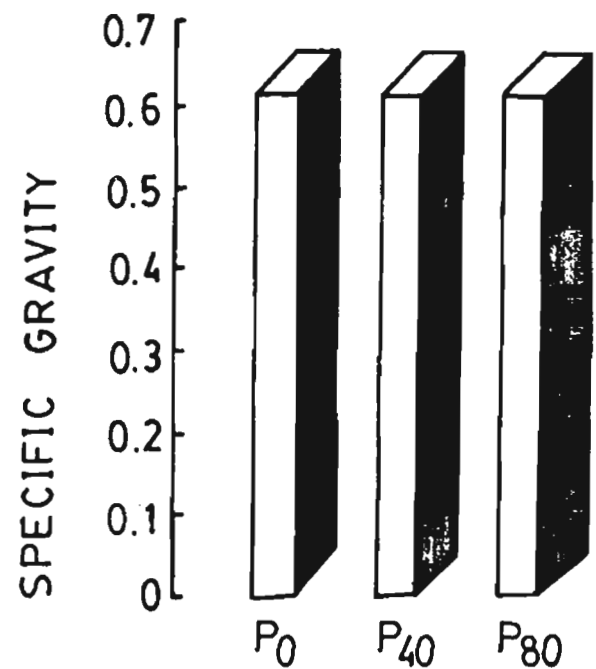
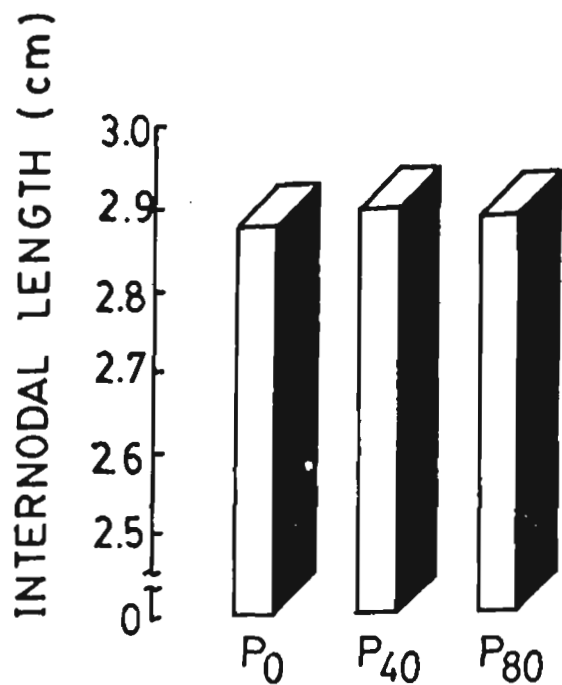
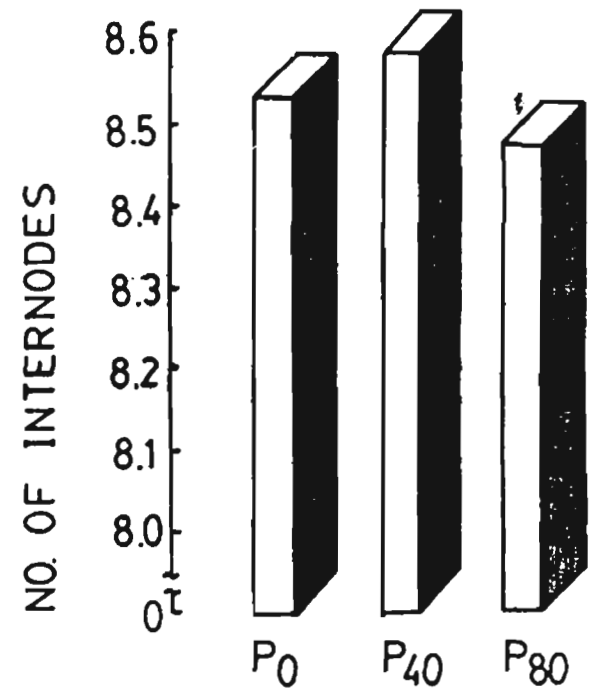
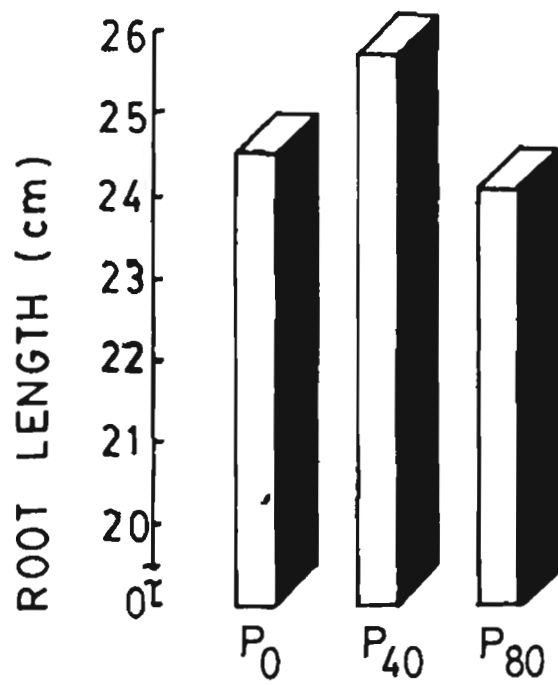


FIG. 9. Effect of P levels on seedling growth

4.2 Effect of phosphorus on growth, biomass production, nutrient content and uptake.

The data concerning to this head have been presented on Table 8-12 and Fig. 8-13.

4.2.1 Growth

A perusal of the data given in Table 8 and Fig. 8-9 confirmed that phosphorus application did influence growth characters like collar diameter and root length.

A significant increase in collar diameter and root length was recorded when $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ was applied (Table 8 and Fig. 8-9). The percent increase in collar diameter and root length was recorded to 9.69 and 4.98 over control.

Phosphorus application did not influence growth characters, viz, survival percentage, plant height, number of internodes, internodal length, specific gravity and shoot/root ratio significantly (Table 8 and Fig. 8-9). However maximum value was found when $40 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$ was applied.

4.2.2 Biomass

Total biomass and leaf biomass was enhanced with

Table 9. Effect of phosphorus levels on biomass production of Bauhinia variegata

Parameter	P levels (kg ha ⁻¹)			S.Ed/S.Em ±	C.D at 5%
	P ₀	P ₄₀	P ₈₀		
Green weight (g plant ⁻¹)	6.00	6.19	5.91	0.104	N.S
Total biomass (g plant ⁻¹)	2.35	2.46	2.27	0.058	0.12
Leaf biomass (g plant ⁻¹)	0.49	0.51	0.46	0.015	0.03
Root and shoot biomass (g plant ⁻¹)	1.87	1.95	1.81	0.039	N.S

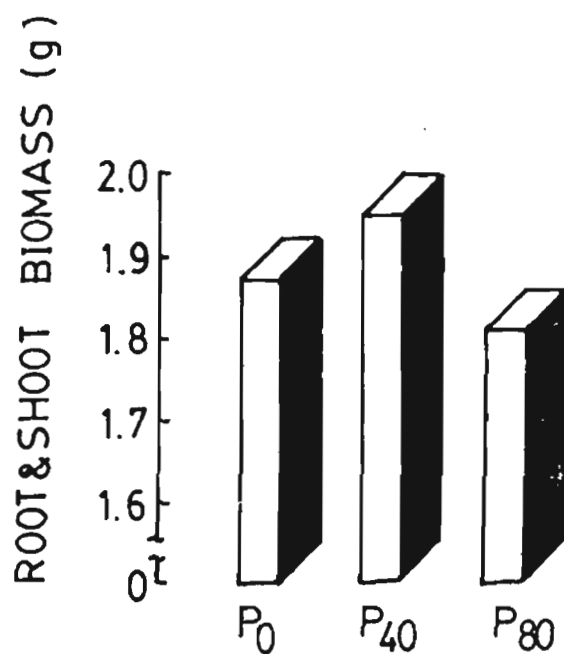
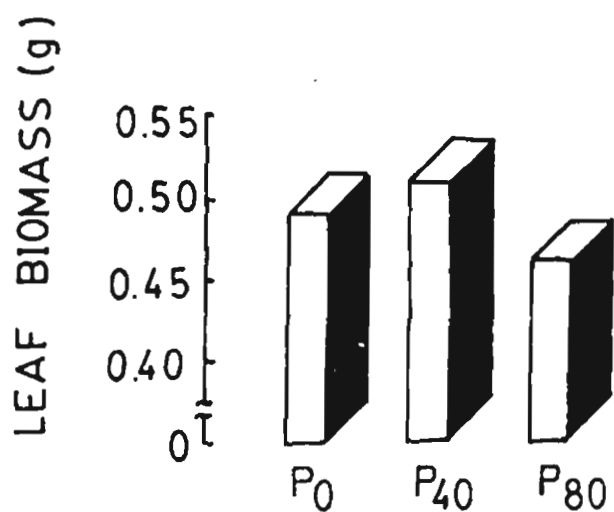
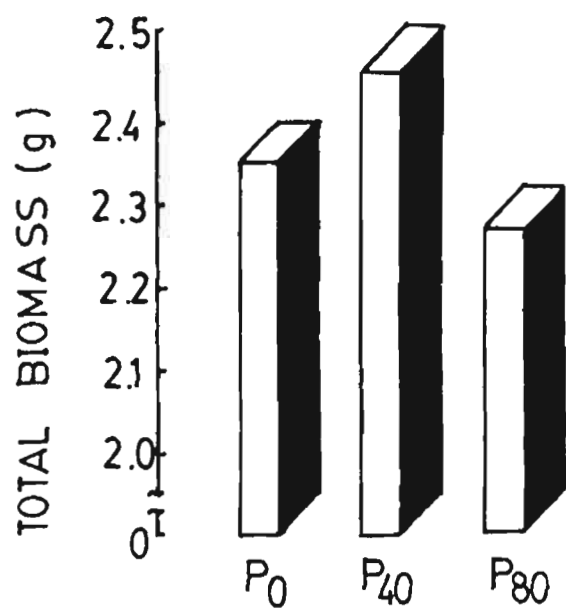
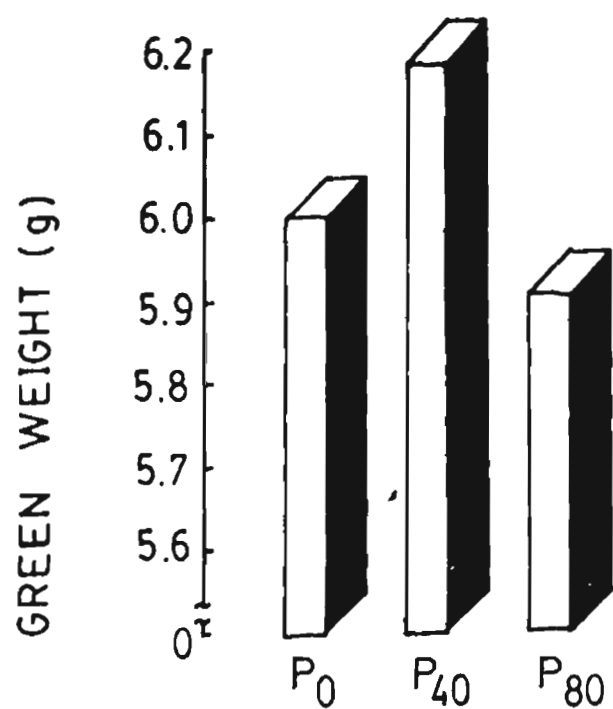


FIG.10. Effect of P levels on biomass production.

increase in phosphorus level upto P_{40} (Table 9 and Fig. 10), but behaved statistically at par to control. Further rise in phosphorus upto $80 \text{ kg P}_{25}\text{ha}^{-1}$ demonstrated a significant decline.

Application of phosphorus did not have any influence on green weight and root and shoot biomass (Table 9 and Fig. 10) as the results are not found significant for these characters.

4.2.3. Nutrient content

N content in leaves declined with the application of phosphorus (Table 10 and Fig. 11). It was found to be significantly lower at P_{80} level. However control and P_{40} behaved to be statistically at par with each other.

Similar results were recorded in root and shoot N content (Table 11 and Fig. 11).

P content was found significantly more in leaves at P_{40} (Table 10 and Fig 12). Thereafter decrease was noticed with further increase in phosphorus level, yet P_{40} and P_{80} witnessed to be statistically at par with each other.

Table 10 Effect of phosphorus levels on nutrient content of Bauhinia variegata leaves.

Treatment/ Nutrient content	N (%)	P (%)	K (%)
P ₀	2.41	0.266	1.32
P ₄₀	2.40	0.283	1.31
P ₈₀	2.20	0.279	1.31
S.Ed / S.Em $\pm$	0.048	0.003	0.016
C.D at 5%	0.10	0.006	N.S

Table 11 Effect of phosphorus levels on nutrient content of Bauhinia variegata root and shoot.

Treatment/ Nutrient content	N (%)	P (%)	K (%)
P ₀	1.01	0.210	0.96
P ₄₀	0.99	0.222	0.94
P ₈₀	0.84	0.223	0.92
S.Ed / S.Em $\pm$	0.037	0.003	0.012
C.D at 5%	0.08	0.006	N.S

Table 12 Effect of phosphorus levels on nutrient uptake of Bauhinia variegata.

Treatment/ Nutrient uptake (mg plant ⁻¹)	N	P	K
P ₀	30.69	5.22	24.31
P ₄₀	31.68	5.80	24.96
P ₈₀	25.34	5.32	22.82
S.Ed / S.Em $\pm$	1.034	0.150	0.547
C.D at 5%	2.14	0.31	1.13

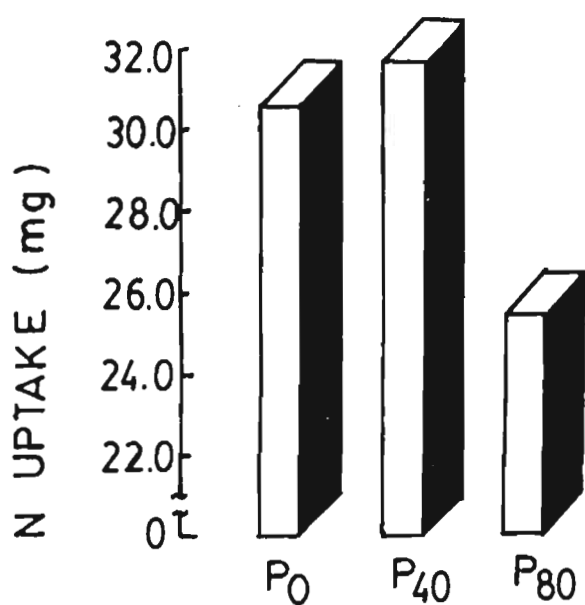
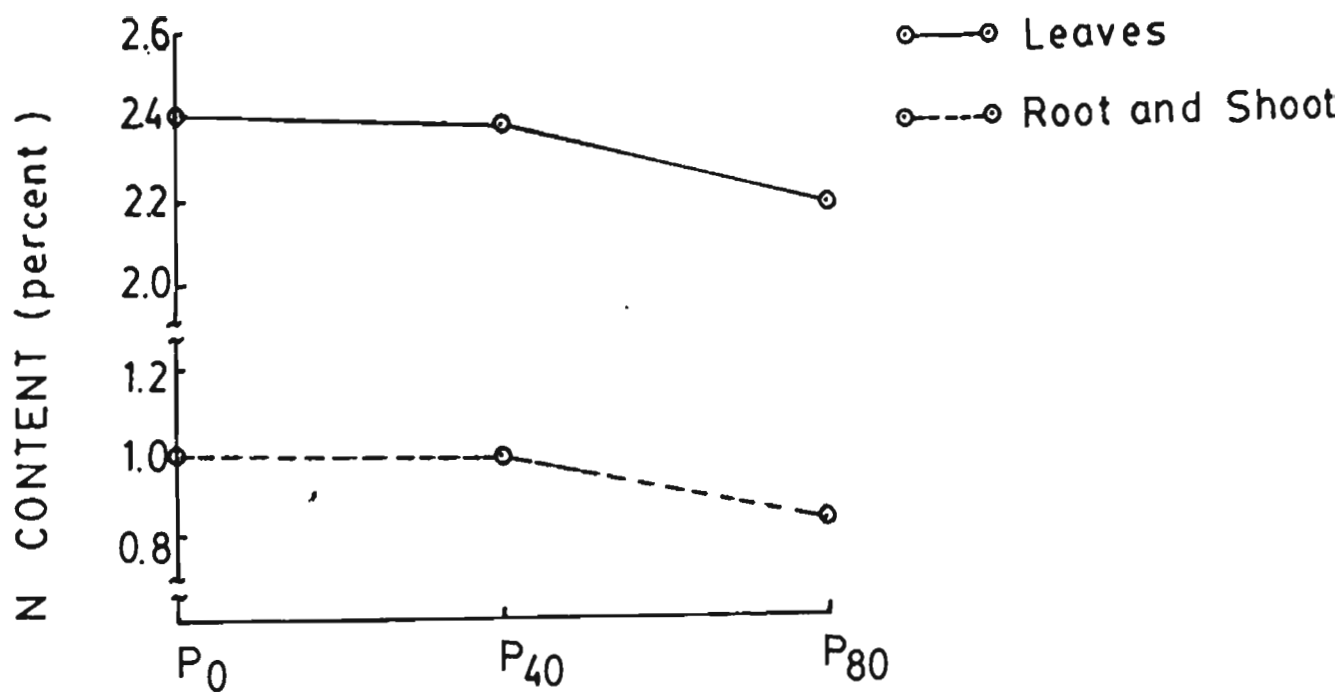


FIG.11. Effect of P levels on nutrient content and uptake.

Increasing trend of P in root and shoot was associated with increase in phosphorus application. (Table 11 and Fig. 12) Application of 40kg and 80kg P_2O_5 ha^{-1} registered significantly higher content than control, however, increase with the application of P_{40} and P_{80} was statistically at par with each other.

K content (Table 10-11 and Fig. 13) in both leaves as well as root and shoot was not influenced by the application of phosphorus.

4.2.4 Nutrient uptake

The maximum uptake of N, P and K nutrients was recorded with the application of 40kg P_2O_5 ha^{-1} (Table 12 and Fig. 11-13). The uptake of N, P and K decreased significantly when higher level of phosphorus was applied.

4.3 Effect of NxP interaction on growth, biomass production, nutrient content and uptake.

The data pertaining to the effect of N X P interaction on growth, biomass yield attributes, nutrient content and uptake have been given in Table 13-23 and Fig. 14-22.

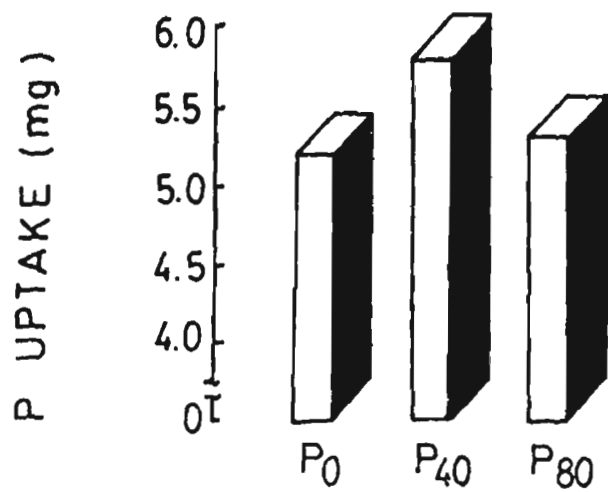
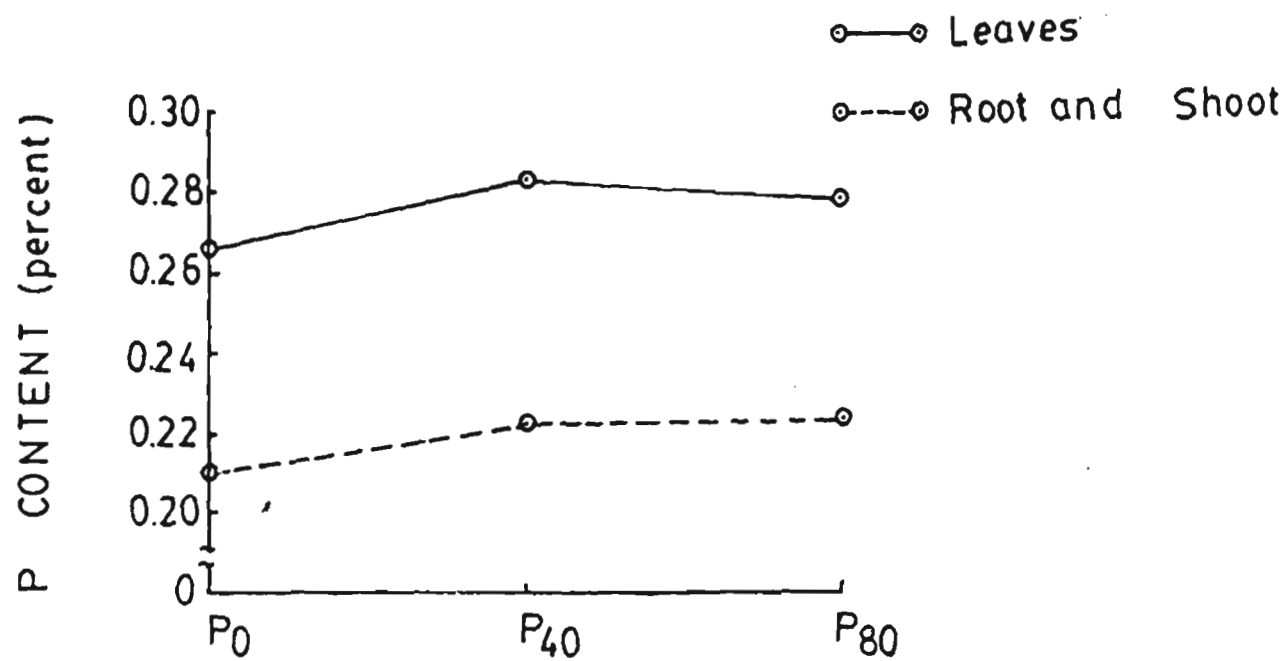


FIG.12. Effect of P levels on nutrient content and uptake.

Table 13. Effect of N X P interaction on growth of Bauhinia variegata

parameter	P levels (kg ha ⁻¹)	N levels (kg ha ⁻¹)				S.Ed/S.Em ±	C.D at 5%
		N ₀	N ₃₀	N ₆₀	N ₉₀		
Survival percentage	P ₀	97.77	100.00	97.77	98.88	1.27	N.S
	P ₄₀	97.77	98.88	98.88	100.00		
	P ₈₀	98.88	98.88	100.00	98.88		
Plant height (cm)	P ₀	22.20	24.76	24.90	26.46	1.082	2.24
	P ₄₀	23.80	22.93	27.96	25.06		
	P ₈₀	24.20	24.46	24.30	24.96		
Collar diameter (mm)	P ₀	2.75	2.97	2.98	2.86	0.074	0.15
	P ₄₀	3.24	3.14	3.26	3.06		
	P ₈₀	3.10	2.82	3.02	2.99		
Number of leaves plant ⁻¹	P ₀	8.46	11.26	12.00	14.30	0.849	N.S
	P ₄₀	10.33	10.93	14.00	12.93		
	P ₈₀	10.06	11.06	12.53	11.86		
Root length (cm)	P ₀	23.13	24.06	25.33	25.43	0.500	N.S
	P ₄₀	24.73	25.83	26.80	25.50		
	P ₈₀	22.96	24.23	24.80	24.36		
Number of internodes plant ⁻¹	P ₀	8.07	8.60	8.53	8.93	0.180	0.37
	P ₄₀	8.33	8.33	9.07	8.60		
	P ₈₀	8.40	8.47	8.40	8.60		
Internodal length (cm)	P ₀	2.75	2.88	2.92	2.96	0.056	N.S
	P ₄₀	2.86	2.75	3.08	2.91		
	P ₈₀	2.88	2.89	2.90	2.90		
Specific gravity	P ₀	0.597	0.634	0.618	0.610	0.017	N.S
	P ₄₀	0.612	0.622	0.616	0.603		
	P ₈₀	0.614	0.607	0.604	0.603		
Shoot/root ratio	P ₀	0.96	1.03	0.98	1.04	0.034	N.S
	P ₄₀	0.96	0.89	1.05	0.98		
	P ₈₀	1.05	1.01	0.98	1.02		

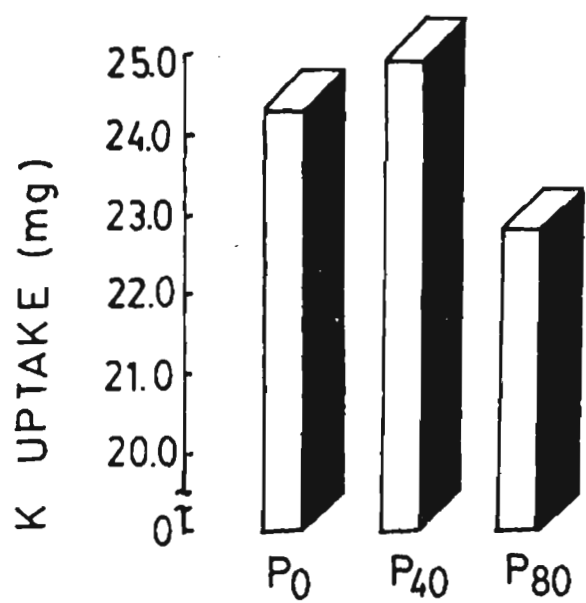
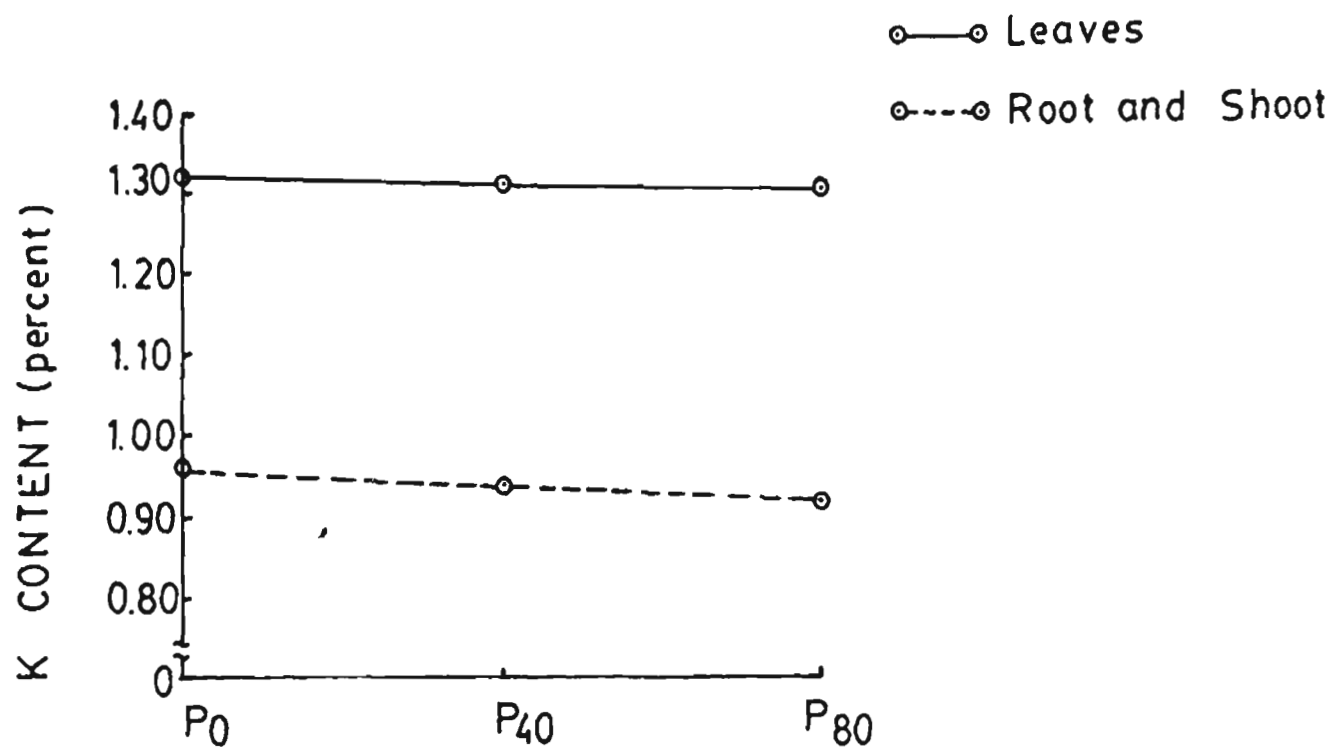


FIG.13. Effect of P levels on nutrient content and uptake.

4.3.1 Growth

NxP interaction resulted in a significant effect on growth parameters, viz, plant height, collar diameter and number of internodes. However, interaction effects for survival percentage number of leaves per plant, root length, internodal length, specific gravity and shoot/root ratio were not found to be significant (Table 13 and Fig. 14-17).

NxP interaction lacked to exhibit any consistent pattern with respect to plant height (Table 13 and Fig. 14). However plant height demonstrated maximum value under $N_{60}P_{40}$ treatment which was observed to be significant over all other interaction effects except $N_{90}P_0$ which was at par with it. The percent increase with the application of $N_{60}P_{40}$ was recorded to be 25.95 over N_0P_0 .

Collar diameter was too influenced significantly by NxP fertilization (Table 13 and Fig. 15). Increase of phosphorus levels from P_0 to P_{40} resulted in significant enhancement of collar diameter in presence of nitrogen at all levels with maximum value at $N_{60}P_{40}$ combination. Percent increase in collar diameter under $N_{60}P_{40}$ was recorded to 18.54 over control.

Table 14. Effect of N X P interaction on biomass production of Bauhinia variegata

parameter	P levels (kg ha ⁻¹)	N levels (kg ha ⁻¹)				S.Ed/S.Em ±	C.D at 5%
		N ₀	N ₃₀	N ₆₀	N ₉₀		
Green weight (g plant ⁻¹)	P ₀	5.71	6.24	6.27	5.77	0.208	N.S
	P ₄₀	5.95	6.27	6.63	5.90		
	P ₈₀	5.96	5.92	5.94	5.82		
Total biomass (g plant ⁻¹)	P ₀	2.13	2.39	2.45	2.45	0.117	0.24
	P ₄₀	2.24	2.55	2.90	2.14		
	P ₈₀	2.48	2.17	2.33	2.10		
Leaf biomass (g plant ⁻¹)	P ₀	0.44	0.51	0.51	0.49	0.031	0.06
	P ₄₀	0.47	0.53	0.59	0.44		
	P ₈₀	0.52	0.42	0.47	0.44		
Root and shoot biomass (g plant ⁻¹)	P ₀	1.69	1.88	1.95	1.95	0.110	0.23
	P ₄₀	1.77	2.02	2.31	1.69		
	P ₈₀	1.96	1.75	1.86	1.66		

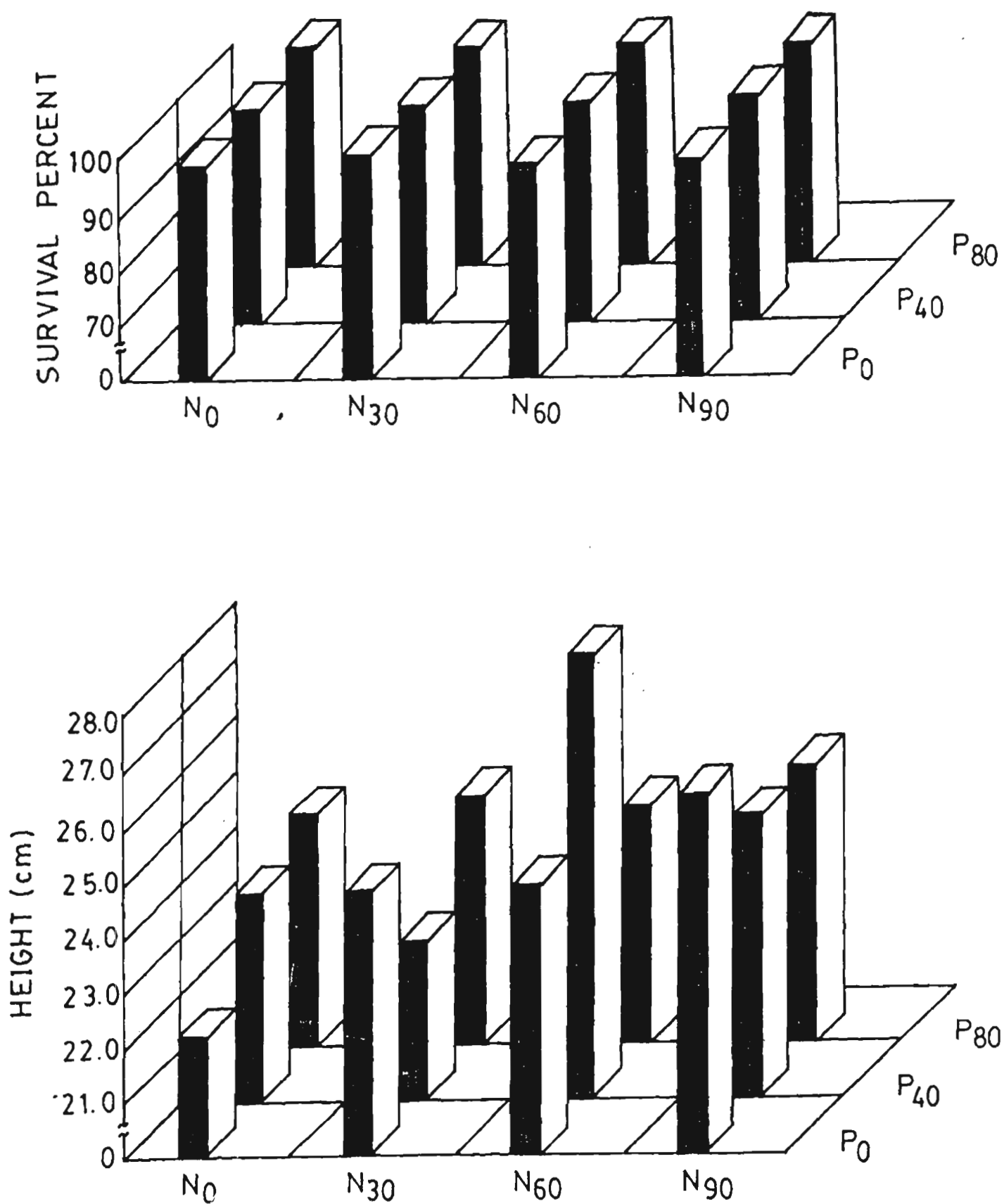


FIG. 14. Effect of N×P interaction on seedling growth

NxP interaction did not reflect any consistent pattern with respect to number of internodes (Table 13 and Fig. 16). The data indicates maximum number of internodes at $N_{60}P_{40}$ which was found to be significantly superior to all other combinations except $N_{90}P_0$.

4.3.2 Biomass production

NxP interaction effect were found to be significant for total biomass, leaf biomass and root and shoot biomass, (Table 14 and Fig. 18-19). Whereas it did not show any significant effect on green weight of the plants.

A perusal of table 14 revealed that for all characters exhibiting statistically significant values, the combination of P_{40} with N_{30} and N_{60} resulted in an increase in the values with maximum values at $N_{60}P_{40}$ combination. Strangely the values observed at N_0P_{80} also showed an increase in the total biomass, leaf biomass and root and shoot biomass, which were at par with $N_{30}P_{40}$ values. Interaction effects, however, decreased at N_{90} with all P combinations and was found to be ineffective.

4.3.3 Nutrient content

NxP interaction influenced N content in root and

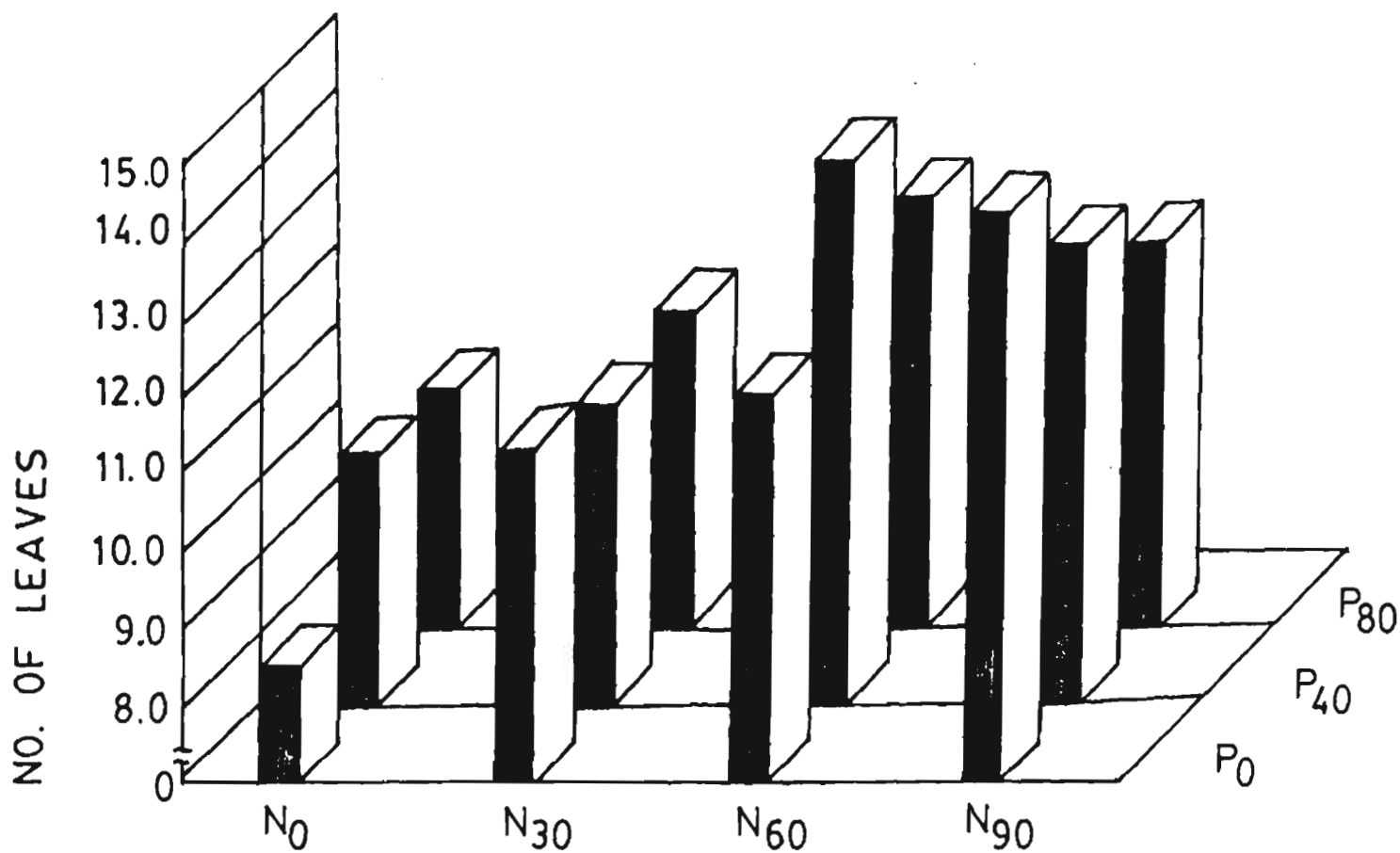
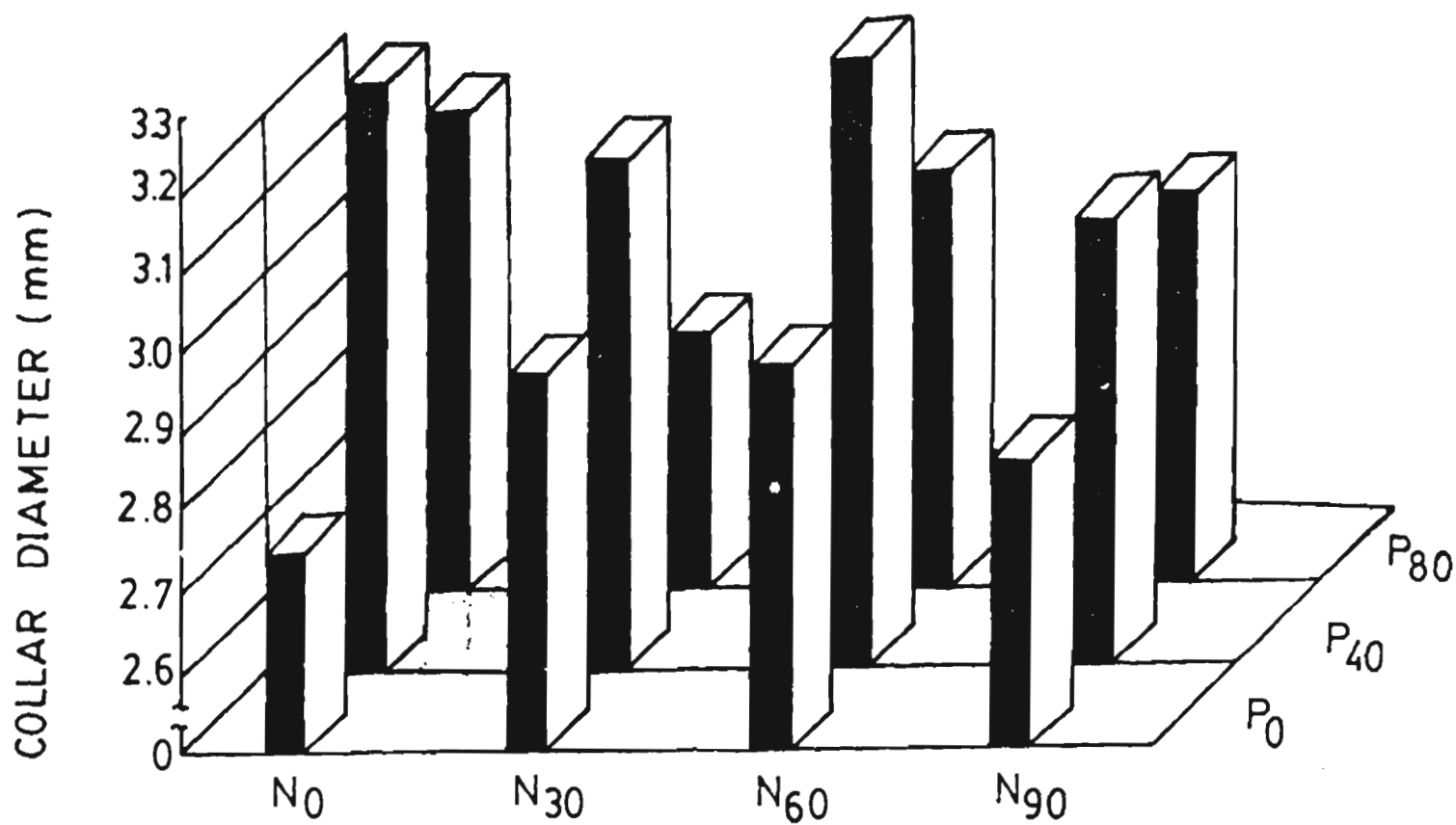


FIG.15. Effect of N x P interaction on seedling growth.

shoot significantly (Table 16 and Fig. 20), but failed to reflect any systematic pattern. However, it was recorded that $N_{60}P_{40}$, $N_{90}P_0$ and $N_{90}P_{40}$ showed identical values. All these values remained at par with $N_{30}P_0$ and $N_{60}P_0$, but significantly better than all other combinations.

P content in leaves increased with increase in P level from P_0 to P_{40} and N level from N_0 to N_{60} except $N_{30}P_{40}$ treatment (Table 17 and Fig. 21). Maximum P content was observed with $N_{60}P_{40}$ combination, which was found to be at par with $N_{60}P_{80}$ but superior to all other interaction effects.

N content in leaf (Table 15 and Fig. 20), P content in root and shoot (Table 18 and Fig. 21) and K content in leaf as well as root and shoot (Table 19-20 and Fig. 22) did not confirm significant influence due to N X P interaction.

4.3.4 Nutrient uptake

The interaction effect for N uptake were found to be statistically significant (Table 21 and Fig. 20). The data indicate that maximum N uptake of 41.40 mg by the plant was recorded in $N_{60}P_{40}$ combination followed by $N_{90}P_0$, $N_{60}P_0$,

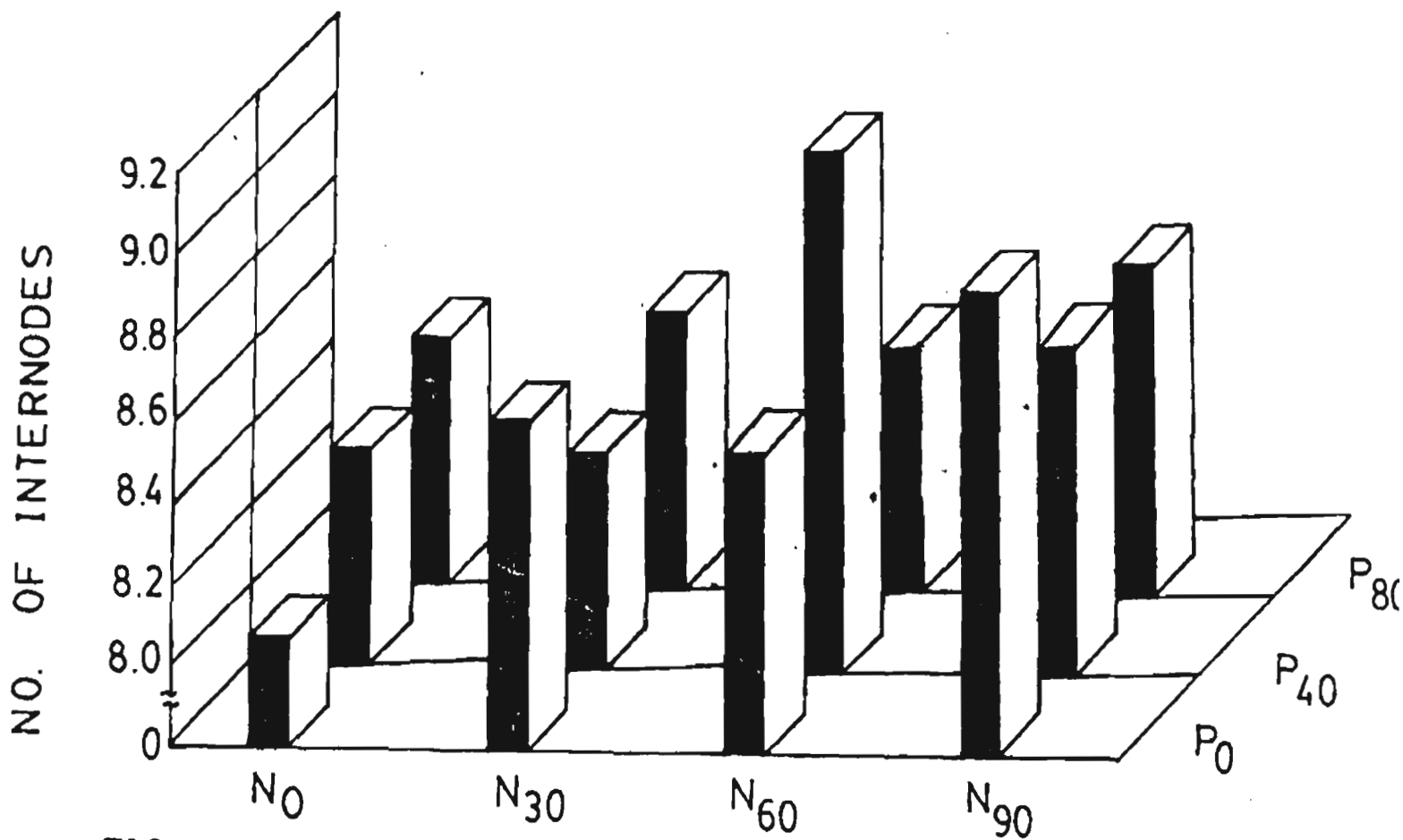
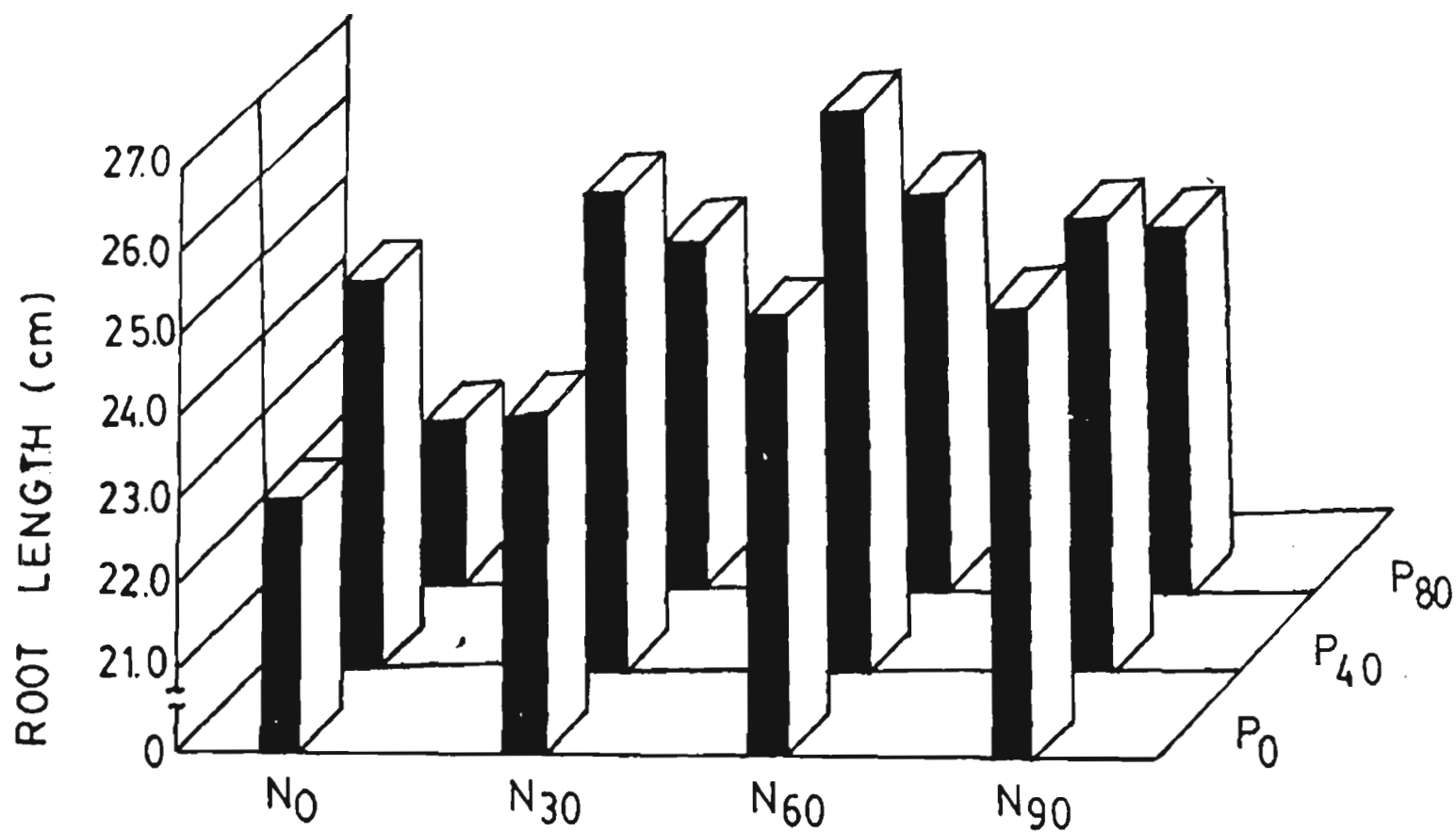


FIG. 16. Effect of N×P interaction on seedling growth.

Table 15. Effect of N X P interaction on N content of Bauhinia variegata leaves.

N levels/ P levels	N content %			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	2.10	2.33	2.61	2.61
P ₄₀	2.01	2.43	2.61	2.57
P ₈₀	2.01	2.15	2.33	2.33
S.Ed/S.Em $\pm$ 0.067				C.D at 5% N.S

Table 16. Effect of N X P interaction on N content of Bauhinia variegata root and shoot.

N levels/ P levels	N content %			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	0.84	1.03	1.03	1.12
P ₄₀	0.89	0.84	1.12	1.12
P ₈₀	0.79	0.89	0.75	0.93
S.Ed/S.Em $\pm$ 0.075				C.D at 5% 0.15

Table 17. Effect of N X P interaction on P content of Bauhinia variegata leaves.

N levels/ P levels	P content %			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	0.258	0.260	0.277	0.270
P ₄₀	0.281	0.277	0.301	0.273
P ₈₀	0.281	0.284	0.288	0.263
S.Ed/S.Em $\pm$ 0.007				C.D at 5% 0.014

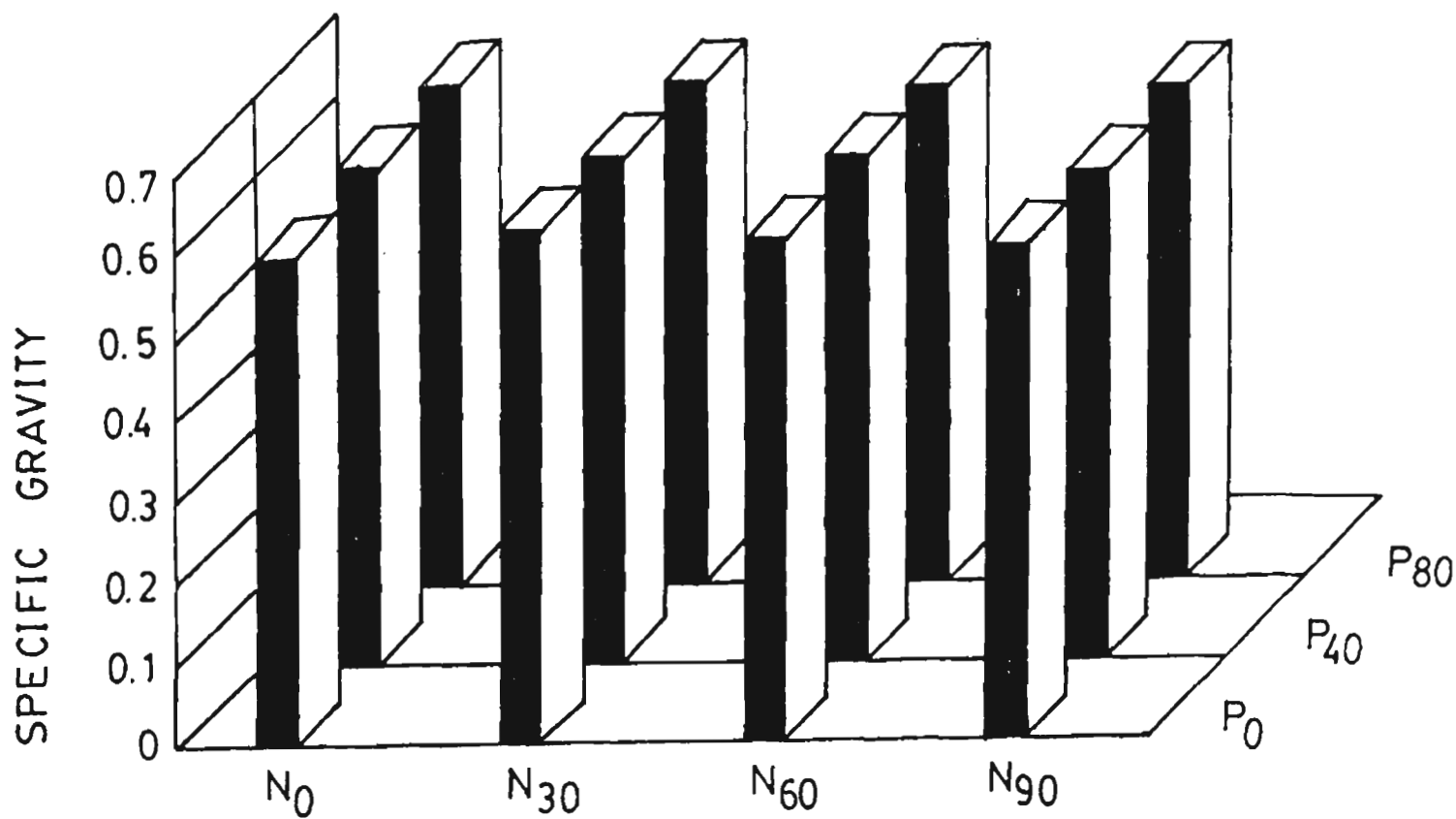
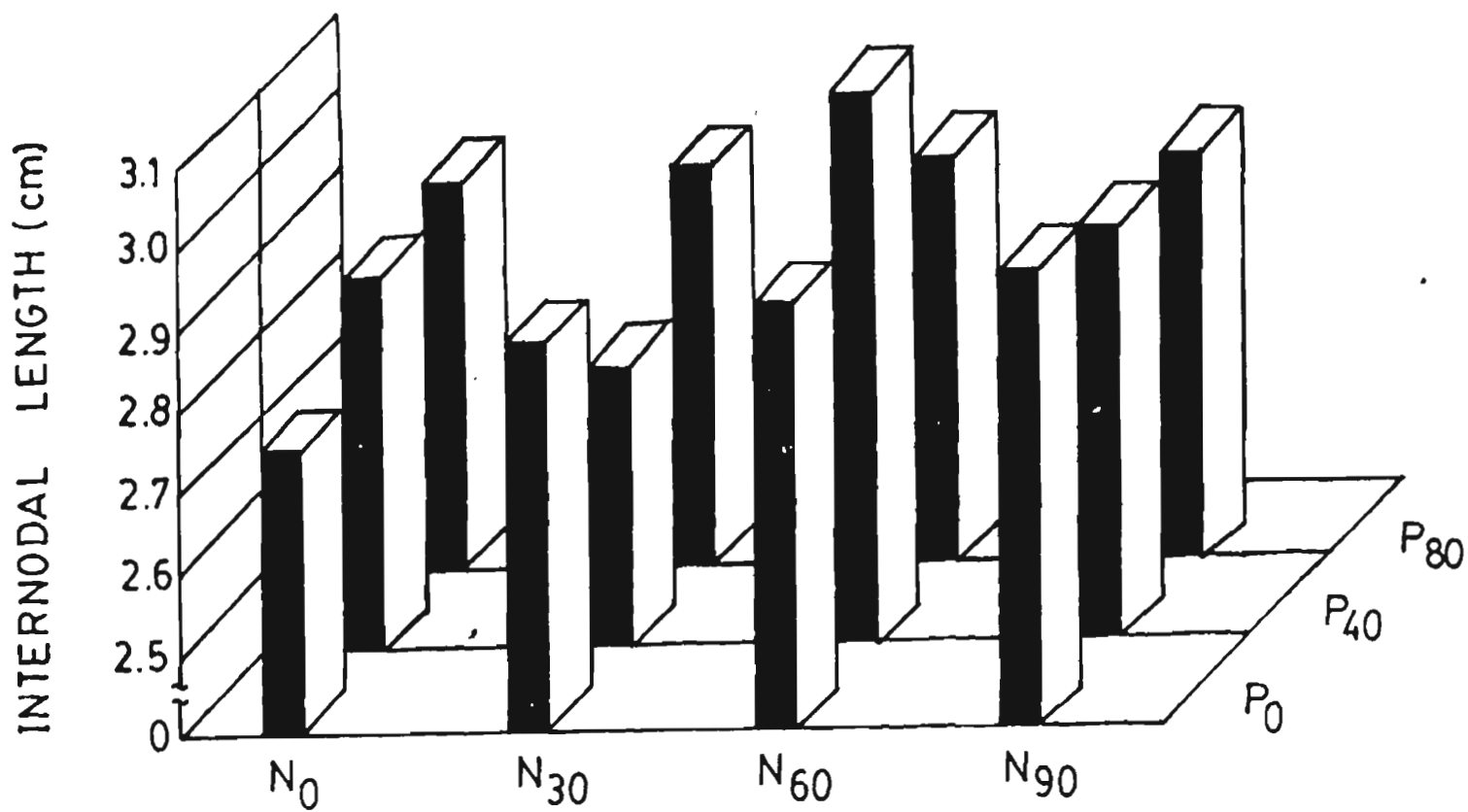


FIG.17. Effect of N×P interaction on seedling growth.

Table 18. Effect of N X P interaction on P content of Bauhinia variegata root and shoot.

N levels/ P levels	P content %			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	0.217	0.220	0.218	0.185
P ₄₀	0.220	0.230	0.230	0.207
P ₈₀	0.226	0.228	0.230	0.207
S.Ed/S.Em $\pm$		C.D at 5%		
0.004		N.S		

Table 19. Effect of N X P interaction on K content of Bauhinia variegata leaves.

N levels/ P levels	K content %			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	1.36	1.35	1.31	1.27
P ₄₀	1.35	1.30	1.31	1.28
P ₈₀	1.35	1.31	1.30	1.27
S.Ed/S.Em $\pm$		C.D at 5%		
0.032		N.S		

Table 20. Effect of N X P interaction on K content of Bauhinia variegata root and shoot.

N levels/ P levels	K content %			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	1.07	0.98	0.90	0.89
P ₄₀	1.03	0.95	0.91	0.87
P ₈₀	0.97	0.98	0.88	0.87
S.Ed/S.Em $\pm$		C.D at 5%		
0.025		N.S		

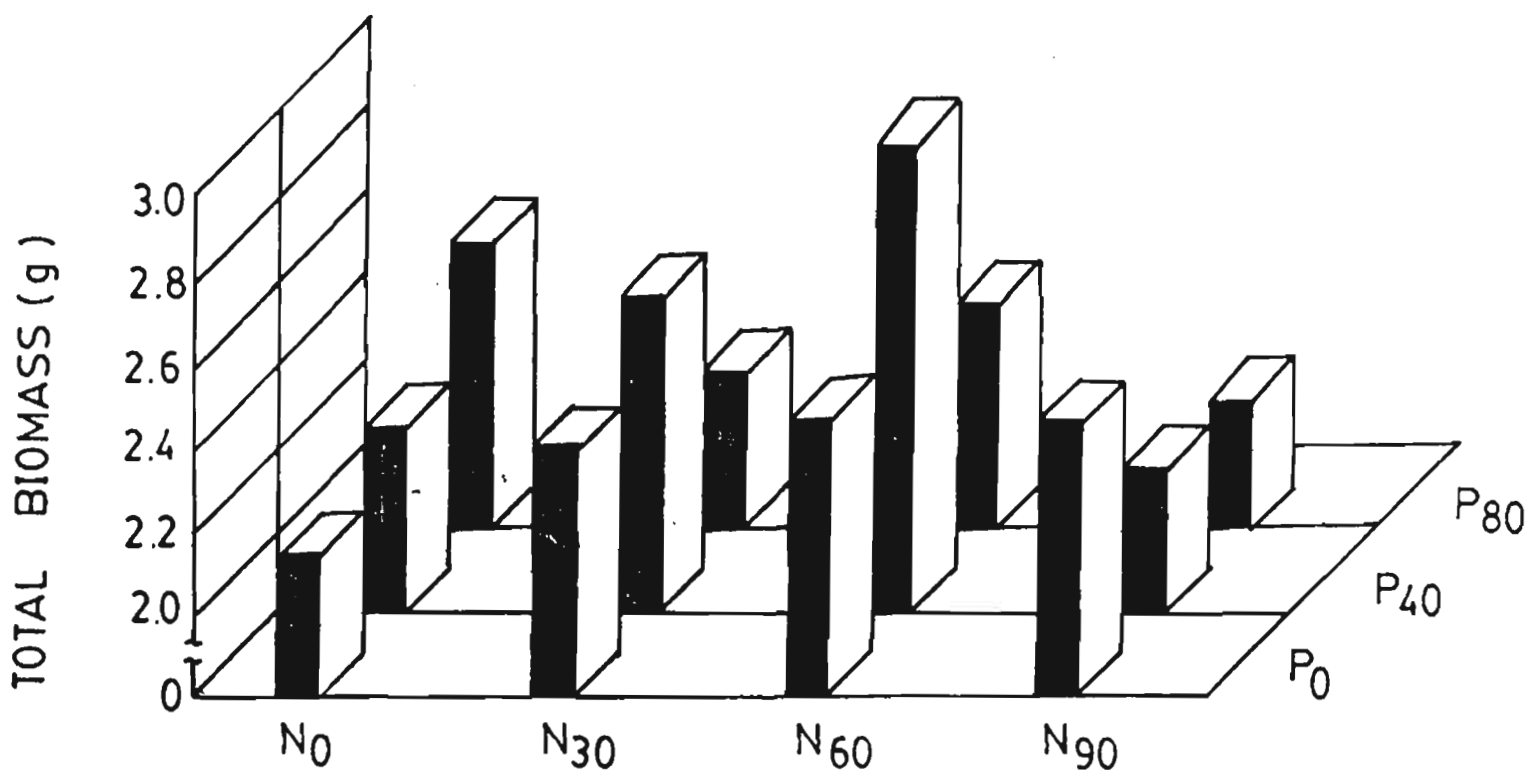
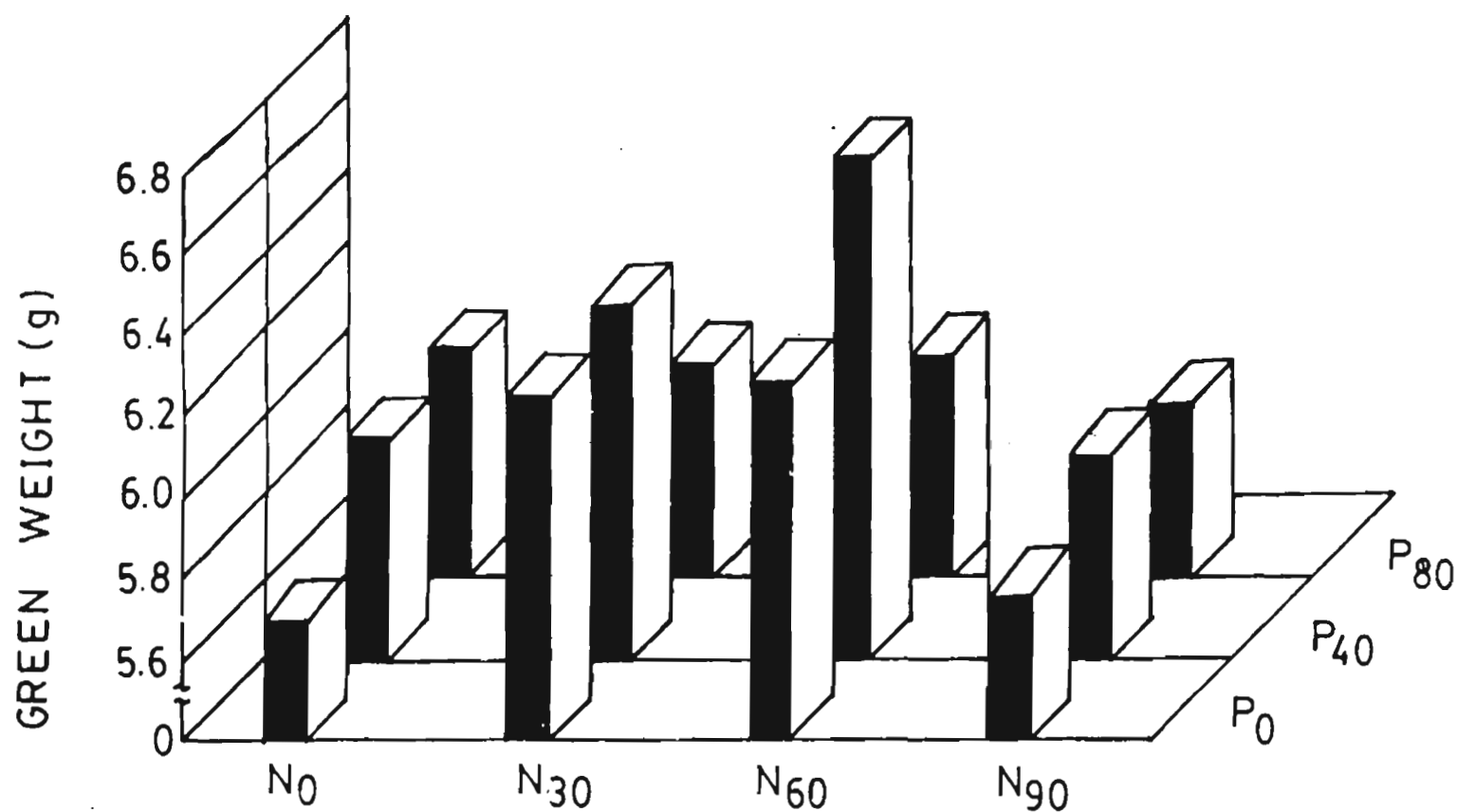


FIG.18. Effect of N×P interaction on biomass production.

Table 21 Effect of N X P interaction on N uptake of Bauhinia variegata

N levels/ P levels	N uptake (mg plant ⁻¹)			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	23.46	31.34	33.23	34.75
P ₄₀	25.04	29.95	41.40	30.34
P ₈₀	25.98	24.65	24.82	25.90
S.Ed/S.Em ±				C.D at 5%
2.068				4.29

Table 22. Effect of N X P interaction on P uptake of Bauhinia variegata.

N levels/ P levels	P uptake (mg plant ⁻¹)			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	4.80	5.47	5.65	4.95
P ₄₀	5.20	6.11	7.17	4.72
P ₈₀	5.87	5.20	5.63	4.59
S.Ed/S.Em ±				C.D at 5%
0.300				0.62

Table 23. Effect of NxP interaction on K uptake of Bauhinia variegata.

N levels/ P levels	K uptake (mg plant ⁻¹)			
	N ₀	N ₃₀	N ₆₀	N ₉₀
P ₀	24.05	25.34	24.15	23.71
P ₄₀	24.66	26.07	28.73	20.37
P ₈₀	25.91	22.70	22.56	20.12
S.Ed/S.Em ±				C.D at 5%
1.095				2.27

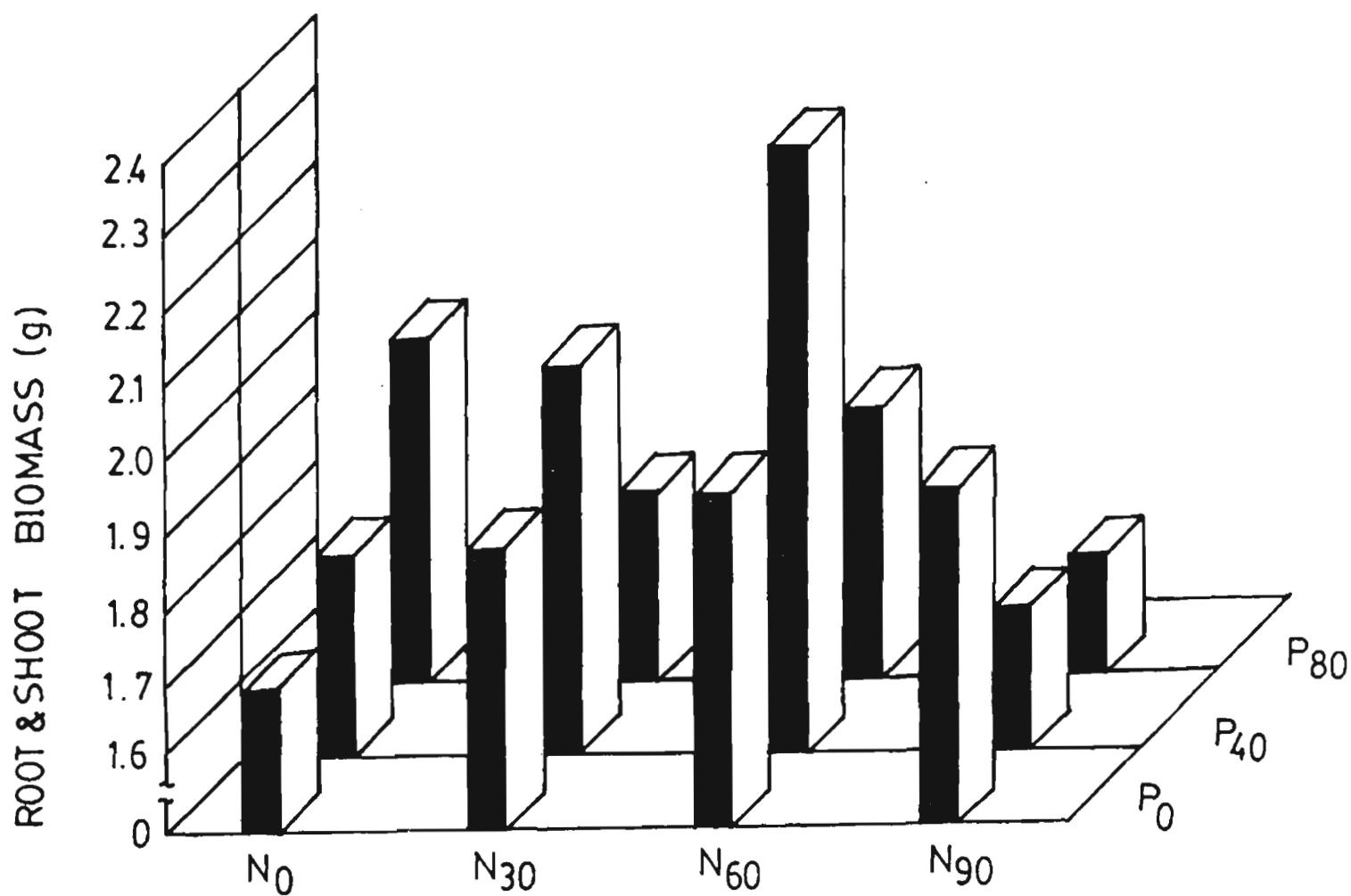
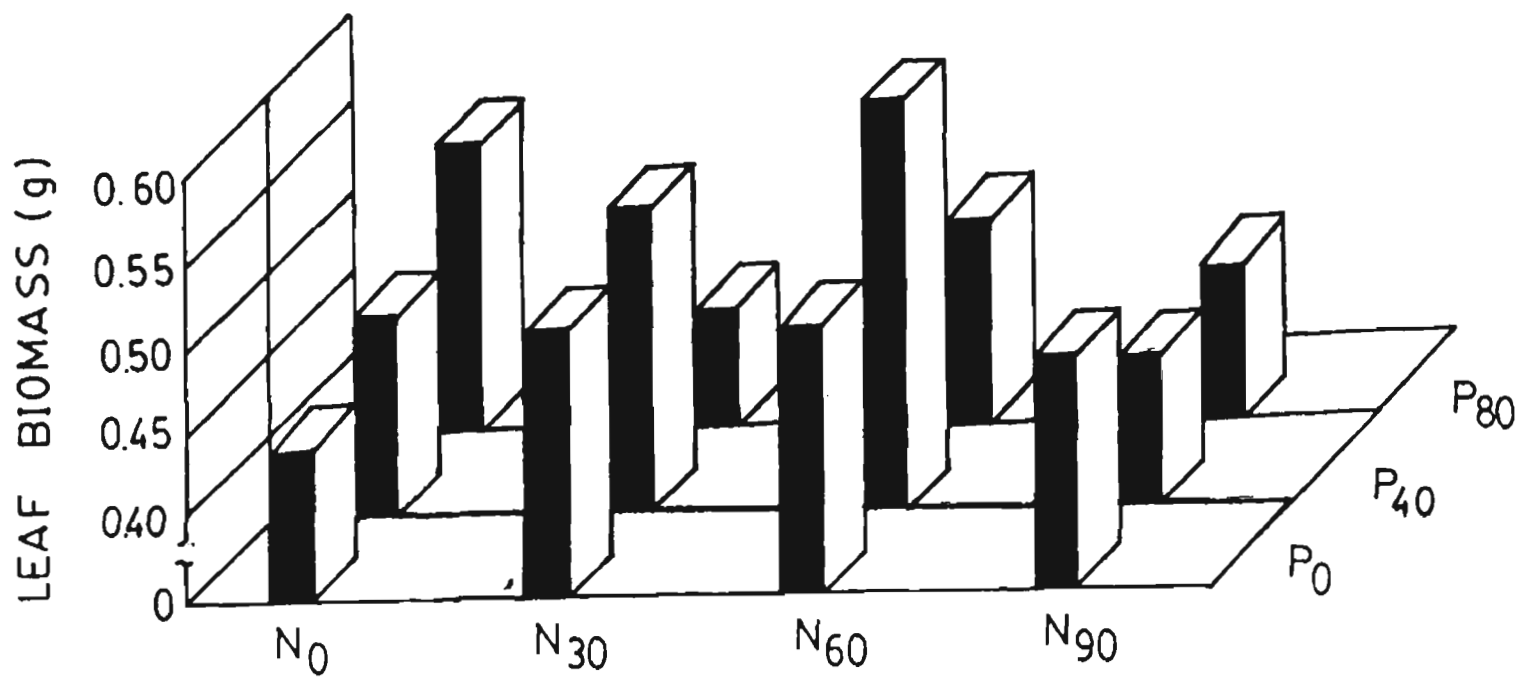


FIG.19. Effect of N×P interaction on biomass production.

$N_{30}P_0$ and $N_{90}P_{40}$ respectively. Combination of $N_{60}P_{40}$ recorded significantly highest N uptake amongst all other combinations. Other listed combinations though were at par with each other but had significantly higher N uptake than control. The percent increase in N uptake with the application of $N_{60}P_{40}$ was recorded to be 76.47 over control.

At all the levels of nitrogen it was observed that increase in phosphorus level from P_0 to P_{40} resulted in higher P uptake except at $N_{90}P_{40}$ which had lower interaction effect (Table 22 and Fig. 21). At P_0 and P_{40} levels of phosphorus increase in nitrogen from N_0 to N_{60} enhanced P uptake $N_{60}P_{40}$ indicated maximum P uptake which proved to be significantly superior to all other combinations. The percent increase in P uptake due to $N_{60}P_{40}$ treatment was recorded to be 49.37 over control.

NxP interaction have significant effect on K uptake (Table 23 and Fig. 22). $N_{60}P_{40}$ combination recorded significantly higher K uptake than all other combinations. This combination enhanced K uptake over control by 19.46 percent.

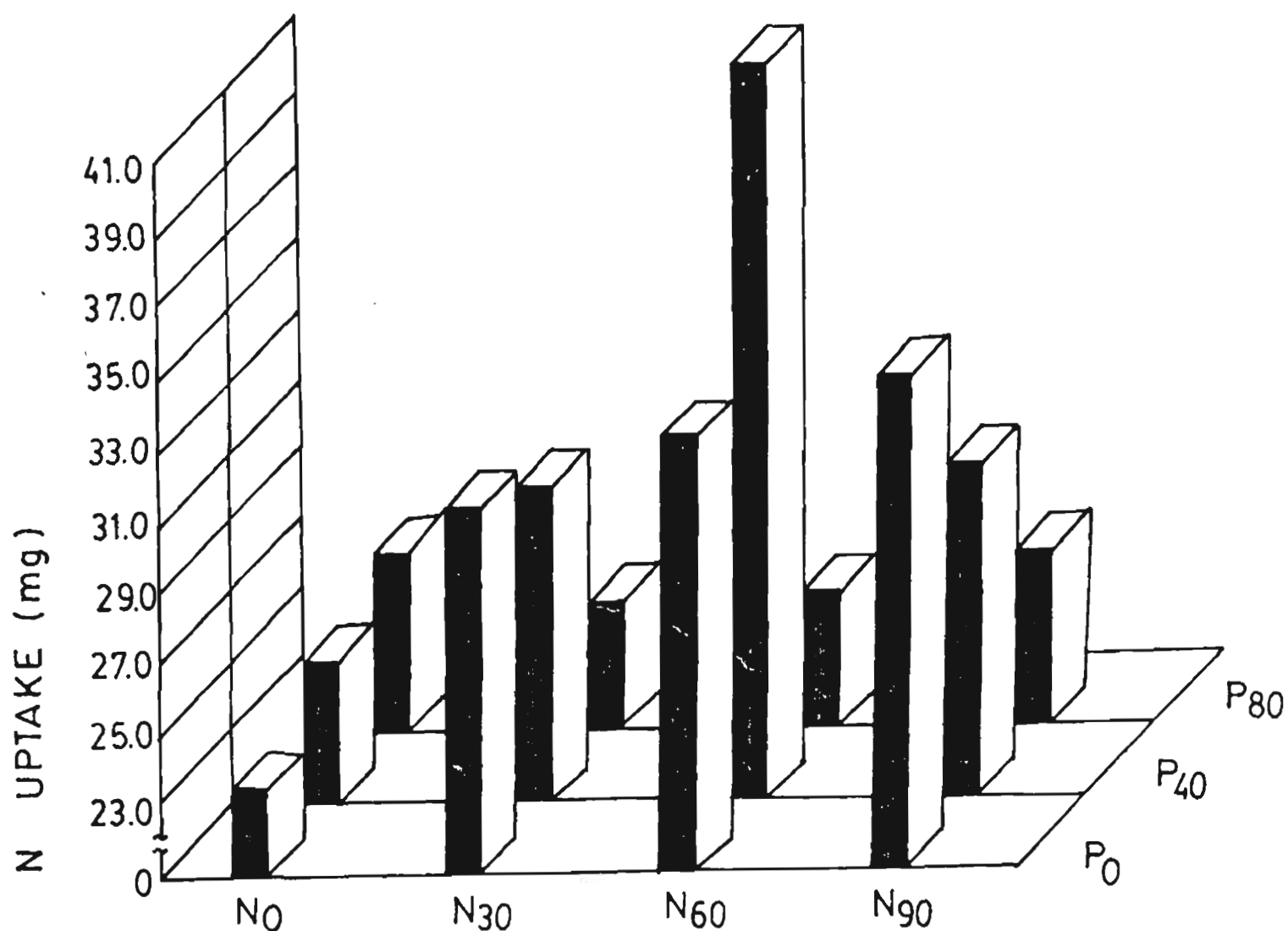
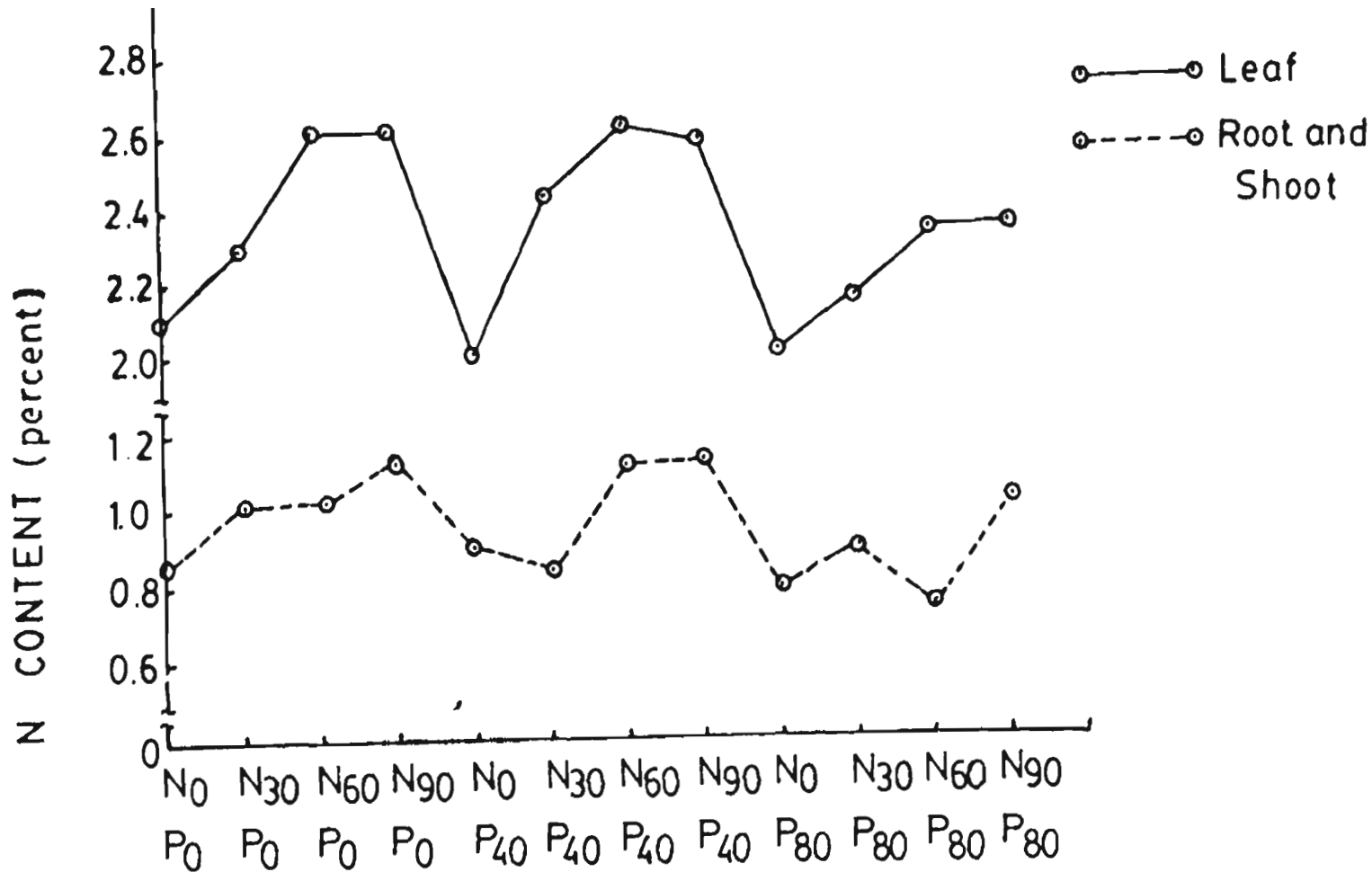


FIG.20. Effect of N×P interaction on nutrient content and uptake.

CHAPTER V

DISCUSSION

CHAPTER V

DISCUSSION

The results obtained in present investigation on "Effect of different doses of nitrogen and phosphorus on selected growth parameters of Bauhinia variegata Linn. during nursery stage" are discussed in this chapter under the following heads.

5.1 Effect of nitrogen on growth, biomass production, nutrient content and uptake.

5.2 Effect of phosphorus on growth, biomass production, nutrient content and uptake.

5.3 Effect of NxP interaction on growth, biomass production, nutrient content and uptake.

5.1 Effect of nitrogen on growth, biomass production, nutrient content and uptake.

5.1.1 Growth

The main function of both ammonical and nitrate form of nitrogen in plant growth is directly supplying nitrogen as constituent of protein, chlorophyll, nucleic acid and protoplasm and indirectly interacting with phytohormones. The close correlation between nitrogen supply and formation of cytokinin in root and their export to shoot has clearly been demonstrated by Wagner and Michael (1971). N supply

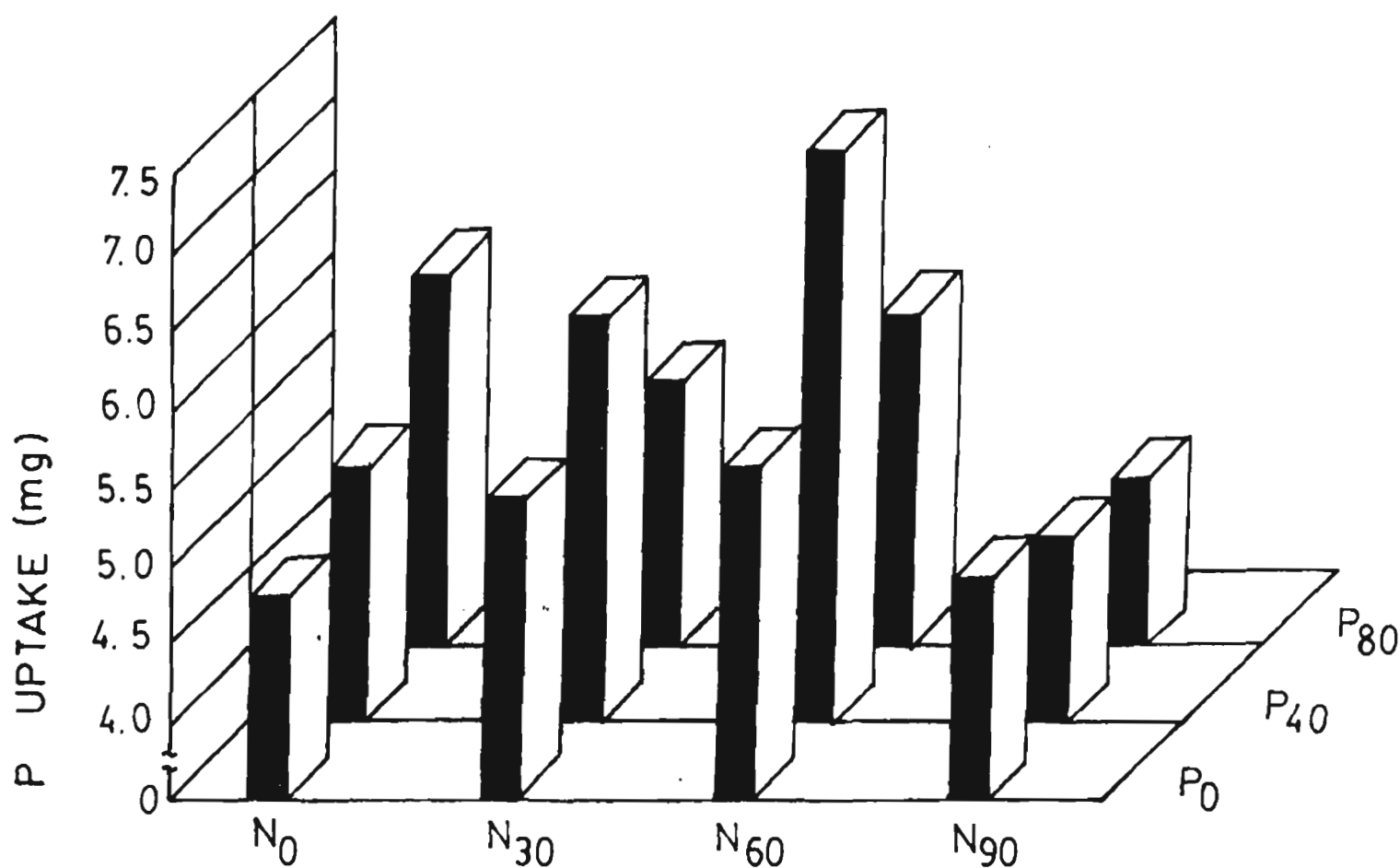
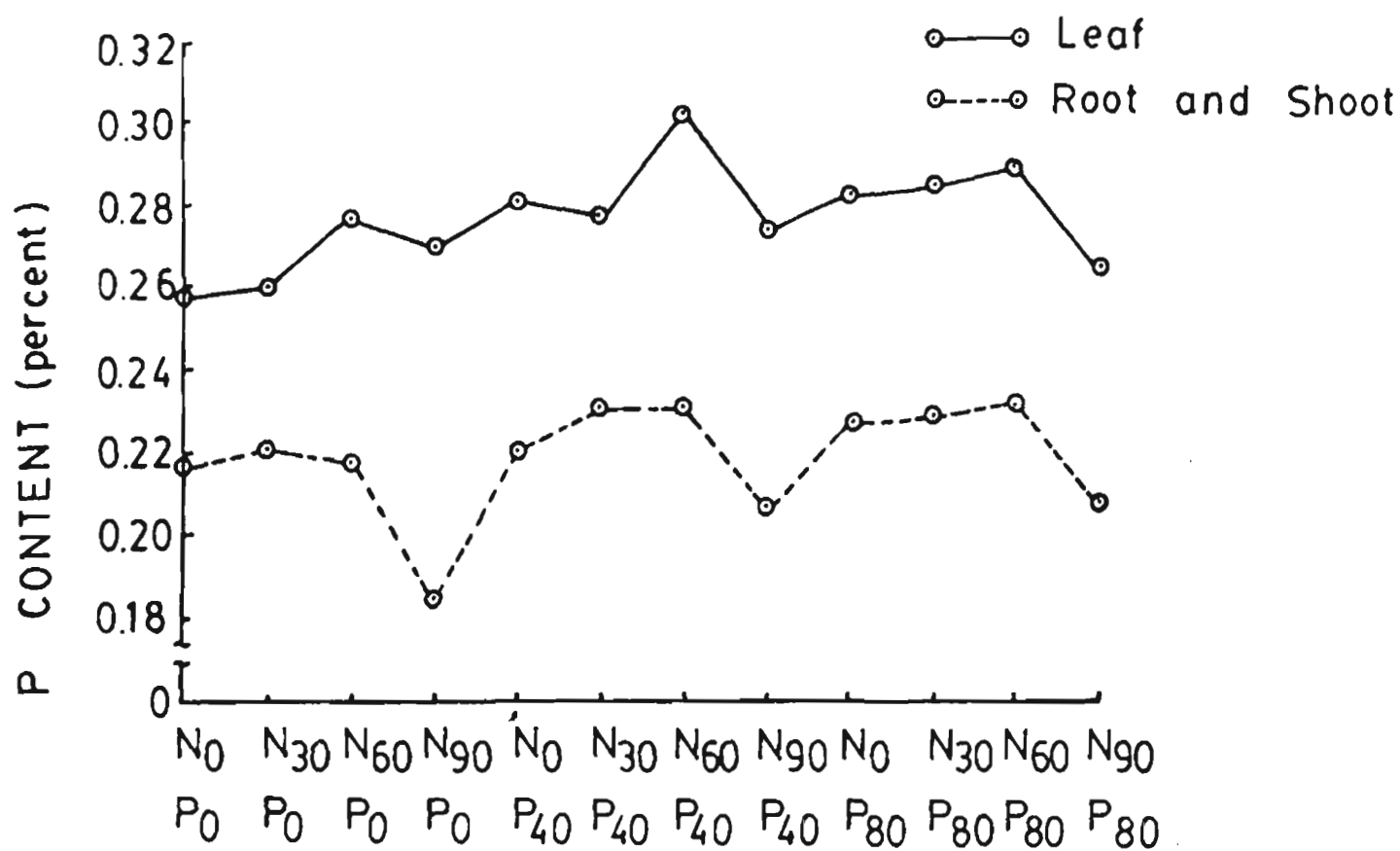


FIG. 21. Effect of N × P interaction on nutrient content and uptake.

effects on abscisic acid (ABA) content of sunflower (Goldbach et al., 1975). Nitrogen supply has prominent effect on gibberellin (GA) levels (Krauss and Marshner, 1982). Cytokinins and Gibberellins are involved in cell division, cell expansion, R.N.A. stimulation and protein synthesis which ultimately lead to enhanced growth. Contrary to this increase in ABA retards growth.

Nitrogen application has significant effect on growth characters, viz, plant height, collar diameter, number of leaves, root length, number of internodes and internodal length (Table 3). The mean values of these characters increased with the increasing levels of nitrogen upto N₆₀ except number of leaves and number of internodes per plant. These two parameters registered the maximum value at N₉₀ level. Similar response to vegetative growth of other plant species for nitrogen application has been reported by Giulimondi (1961) in Poplars, Brar and Katoch (1980) in Populus deltoides, Deol and Khosla (1983) in Populus ciliata, Kaul et al., (1968) in Eucalyptus grandis, Prasad et al., (1984) in Eucalyptus grandis, Malik (1987) in Eucalyptus tereticornis, Grove (1988) in Eucalyptus diversicolor, Hussain et al., (1980) in Acacia mearnsii and Reinsvold and Pope (1987) in Robinia pseudoacacia. Bhardwaj et al., (1986)

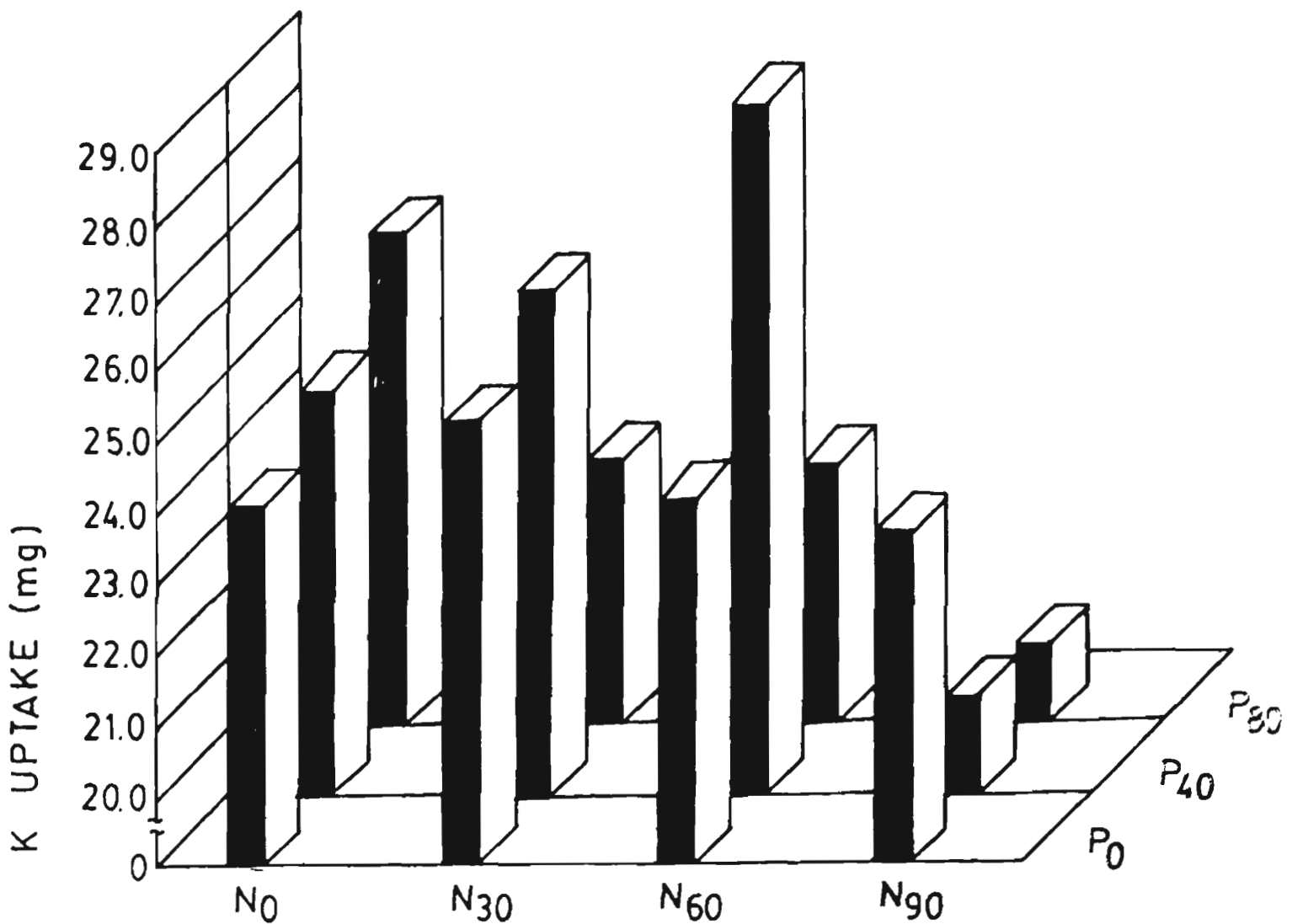
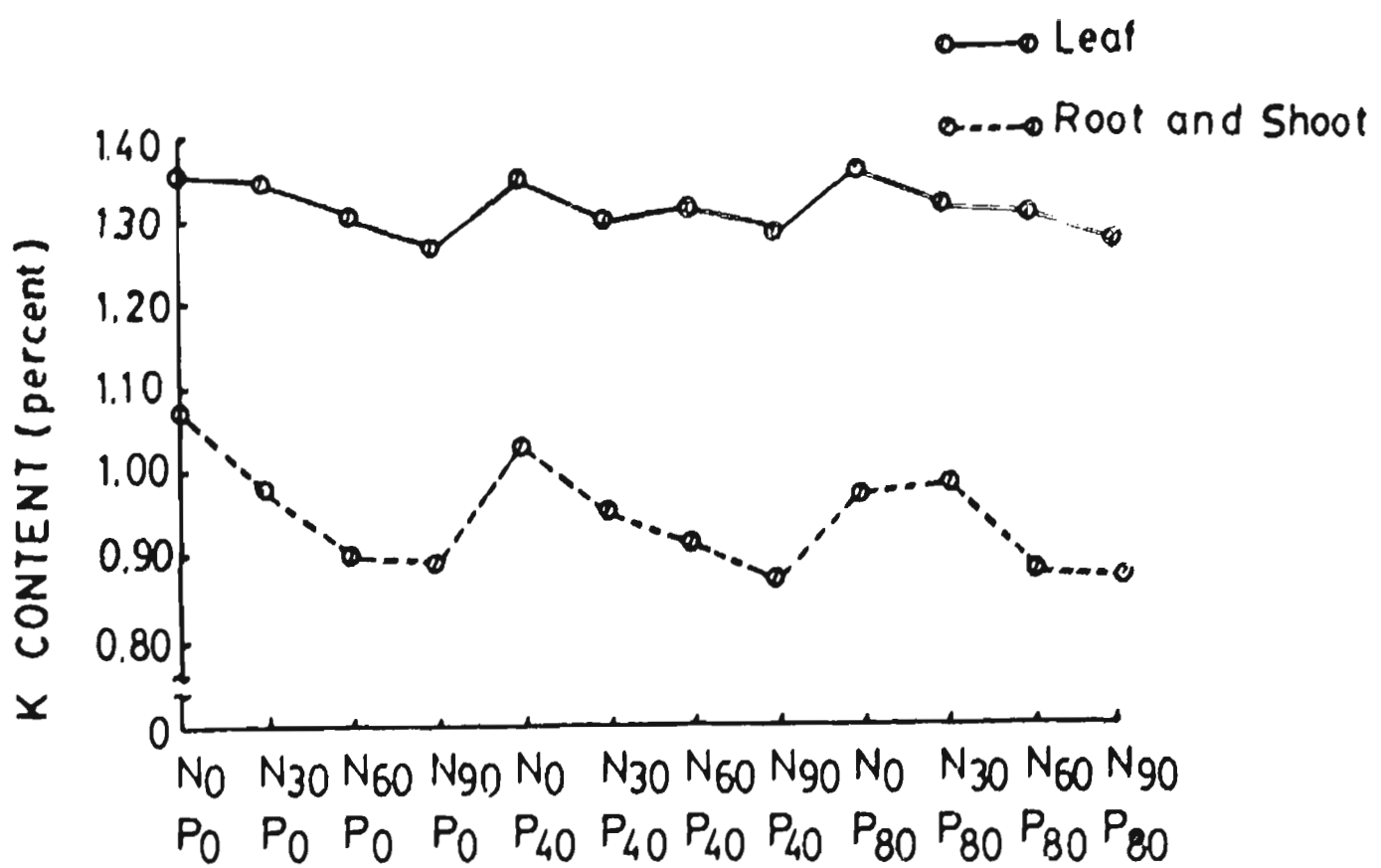


FIG. 22. Effect of N×P interaction on nutrient content and uptake.

also obtained maximum height and diameter by applying 75 kg N ha⁻¹ in Bauhinia variegata seedlings.

Specific gravity and shoot/root ratio failed to respond significantly to nitrogen fertilization (Table 3). For specific gravity similar results were found by Hans and Burley (1972) and Malik (1987) while working on Eucalyptus grandis and Eucalyptus tereticornis respectively. Contrary to this Deol and Khosla (1983) reported that specific gravity in Populus ciliata was reduced when N dose was increased beyond 50 kg N ha⁻¹. It is just possible that wood of Bauhinia variegata seedlings were not succulent enough due to early stage of growth to confirm reduction in specific gravity. Non significant effect of N application on shoot/root ratio can be ascribed to invariable increase in length of both shoot as well as root.

5.1.2 Biomass production

Biomass yield attributes like green weight, total biomass as well as those of its component i.e leaf and root and shoot biomass increased with the increase in nitrogen level upto N₆₀ (Table 4). Rao (1985) in a study on biomass production of Acacia mollissima also recorded that nitrogen

application @ 60 kg ha⁻¹ significantly increased green shoot weight and dry shoot weight in comparison to control. Similar response to N application has also been reported in Albizia procera by Hussain et al., (1986). and in Leucaena leucocephala by Sivasupiramaniam et al., (1986). Lack of positive response to the higher doses of nitrogen can be attributed to the initial medium status of available nitrogen in experimental soil which when supplemented with 60 kg ha⁻¹ proved sufficient to meet nitrogen requirements of the plant in the nursery and increased dosage of nitrogen may have depressed the effect of other ions which resulted in unbalanced nutrient concentration in plant as is again evident from Table 7 lowest P and K uptake at N₉₀ level. Toxic effect of urea at higher rates has also been reported by Stephan and Waid (1963). The germination have been reported to be affected even if urea contain 1-2% biuret (Brage et al., 1960). Biuret which occurs in urea as an impurity is toxic to plants (Nijjar 1985).

5.1.3 Nutrient content and uptake

N concentration in leaf as well as in root and shoot increased steadily with the increase in nitrogen levels (Table 5 and 6) Deol and Khosla (1983) and Malik (1987) also

observed increase in folliar nitrogen content with nitrogen fertililization in Populus ciliata and Eucalyptus tereticornis respectively.

Total uptake by plant was maximum at N₆₀ level of N application (Table 7). Higher N uptake results into higher biomass and nutrient content as well. Maximum dry matter accumulation can be ascribed to higher N uptake at this stage. Nitrogen application resulting in higher N uptake over control has also been reported by Hussain et al., (1986) in Albizia procera.

P and K content in both leaf as well as root and shoot has been minimum at N₈₀ (Table 5 and 6). This negative trend may be attributed to the antagonistic effect of N at higher doses. Present results are in conformity with the findings of Prasad et al., (1984) and Rao (1985) who also observed similar response to nitrogen fertilizer in Eucalyptus grandis and Celtis australis respectively.

The negative impact of P and K uptake (Table 7) at higher level of nitrogen (N₉₀) can be ascribed to lower P and K concentration and relatively lower biomass.

5.2 Effect of phosphorus on growth biomass production, nutrient content and uptake.

5.2.1 Growth

Phosphorus is found in plants as a constituent of nucleic acid, phospholipids and enzymes, Nicotinamide adenine-dinucleotide (NAD) and Nicotinamide adenine-dinucleotide phosphate (NADP) and most important constituent of Adenosine triphosphate (ATP). The coenzymes are important in plant processes as photosynthesis, glycolysis, respiration and fatty acid synthesis (Devlin, 1981). Phosphorus also play important role in synthesis and export of Cytokinins (Horgan and Wareing 1980). Therefore, expected deficiency of P would have wide ranging effect on cell functions which ultimately will effect growth.

Among selected growth parameters only collar diameter, and root length showed significant effect. Both these parameters exhibit the maximum value at P₄₀ (Table 8). Similar findings i.e. the application of phosphorus stimulates collar diameter have been reported by Dutt and Pathania (1984) in Sesbania sesban. Sharma (1988) also observed that collar diameter and root length put up significant increase in Robinia pseudacacia with application of 30 kg P₂O₅ha⁻¹ as compared to control.

Plant height, number of leaves, number of internodes and internodal length failed to show any significant effect, however, maximum values for these characters are observed under P_{40} level of phosphorus (Table 8). These findings are in agreement with those of Miyazaki et al., (1954), in Robinia Pseudacacia seedlings. The lack of positive impact to the higher dose of phosphorus (P_{80}) lie in the fact that experimental site where the investigations were conducted initially had high available phosphorus. It is just possible that $40 \text{ kg } P_{2O_5} \text{ ha}^{-1}$ (lowest dose tried) in the study could be sufficient enough to meet the requirement of phosphorus and plant must have been sensitive at higher level of phosphorus. Howell and Bernard (1961) have also reported some soyabean cultivars which were sensitive to higher doses of phosphorus.

Specific gravity and shoot/^{root}~~shoot~~ ratio too failed to exhibit any significant response to N application,. The reason may be that like N fertilization (discussed earlier) P fertilization too could not have any influence on specific gravity. Phosphorus did not have any significant effect on shoot/root ratio. Similar response has been found by Kharitonov (1978) for shoot/root ratio in Fagus sylvatica, Quercus robur and Tilia cordata.

5.2.2 Biomass production

So far the biomass production is concerned the mean values of green weight, total biomass, leaf biomass and root and shoot biomass per plant increased upto P_{40} level (Table 9). Thereafter at P_{80} showed appreciable reduction. Significant effect could be observed only in case of total biomass and leaf biomass. Increase in dry matter yield through phosphorus application has also been reported by Mccracken (1970) in Alnus viridis, Dutt and Pathania (1986) and Garza et al., (1987) in Leucaena leucocephala.

5.2.3 Nutrient content and uptake

The N and K content in leaves as well as in root and shoot decreased with increasing levels of phosphorus (Table 10 and 11). Significant effect could only be observed for N content. Such inverse relationship of P application over N and K content has also been observed by Prasad et al., (1984) in Eucalyptus grandis and Rao (1985) in Celtis australis and Acacia mollissima. These results are in conformity with the findings of Beraya (1986) who also observed lowest N content when phosphorus was applied in Eucalyptus viminalis.

Higher uptake of N and K (Table 12) at P₄₀ level can be attributed to relatively higher biomass and lower uptakes at P₈₀ level due to lower biomass.

P content in leaves as well as root and shoot increased with increasing levels of phosphorus. The results are in conformity with findings of Aluko and Advayi (1983) who reported increase in P content in Terminalia ivorensis with phosphorus application.

Total P uptake exhibited a significant increase at P₄₀ level over control. The results are in line with the findings of Sharma (1988) who revealed that 30 kg P₂O₅ ha⁻¹ significantly resulted in maximum P uptake in Robinia pseudacacia.

5.3 Effect of NxP interaction on growth, biomass production, nutrient content and uptake.

5.3.1 Growth

Among growth parameters only plant height, collar diameter, number of internodes are significantly affected by N X P interaction (Table 13). All these characters registered

maximum value under $N_{60}P_{40}$, which are significantly superior to control. Critical observation of data reveal that number of leaves, root length and internodal length, though differ insignificantly, yet, has higher value under $N_{60}P_{40}$. The positive response to NXP interaction has also been reported by Quershi and Yadav (1967) with 336kg N ha^{-1} and 224 Kg P ha^{-1} in sand culture experiment with Eucalyptus tereticornis. Loffler (1971) in Tilia cordata, Babaev (1978) in Canadian poplars and Stewart and Gwaze (1988) in Acacia albida.

NXP interaction failed to ascertain any significant effect on specific gravity and shoot/root ratio. Separate N and P fertilization too failed to support any significant response to specific gravity as discussed earlier. The reason may be that fertilization have little effect on specific gravity during the early stage of growth. Non significant effect of NXP interaction on shoot/root ratio may be due to the invariable increase in length of both shoot and root.

5.3.2 Biomass production

Biomass yield attributes like total biomass as well as its components leaf and root and shoot biomass have been significantly effected by NXP interaction (Table 14). All

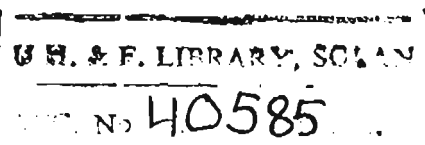
these parameters have highest values under $N_{60}P_{40}$ combination, and lowest under control. Present findings are in line with those of Dutt and Pathania (1986) who reported combination of N and P significantly increasing total dry weight per seedling, and stem and root weight per seedling over control in Leucaena leucocephala. Moloney et al., (1986) also noticed that application of phosphorus significantly increases dry matter yields in the presence of applied nitrogen in Adenanthera pavonina, Albizia falcataria and Schleinitzia insularum. The same observations have also been recorded by Grove (1988) in Eucalyptus diversicolor.

5.3.3 Nutrient content and uptake

N content in leaf as well as in root and shoot have been found maximum at higher levels of nitrogen when no phosphorus was applied and combination of P_{40} with N_{60} and N_{90} respectively (Table 15 and 16). P content in leaf and root and shoot has not shown any systematic effect however, it has also shown maximum value at $N_{60}P_{40}$ (Table 17 and 18). The present findings are in conformity with those of Stranberry and clore (1950) who reported N content in leaf from N and NP treatments increased on the same pattern of P content from P and NP treatments in Bing cherries.

K content in leaf and root and shoot has shown non significant response to NxP interaction (Table 19 and 20). However, critical scrutiny indicates that NxP interaction reduced K content as compared to control at all levels. Srivastava(1972) and Rao (1985) also revealed NxP interaction inhibits K assimilation in Shorea robusta and Accacia mollissima respectively.

NxP interaction witnessed a significant increase in case of N,P and K uptake (Table 21,22 and 23). The maximum values of these parameters were witnessed under N₆₀P₄₀ combination which can be seen by highest biomass production put up under this treatment.



SUMMARY

The present investigations "Effect of different doses of nitrogen and phosphorus on selected growth parameters of Bauhinia variegata Linn. during nursery stage" was carried out at the forest nursery of Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni (Solan) during the year 1987.

The experiment was laid out in a factorial randomised block design replicated thrice with all possible combinations of four nitrogen levels (0, 30, 60 and 90 kg N ha⁻¹) and three phosphorus levels (0, 40, 80 kg P₂O₅ ha⁻¹) 40 kg K₂O in form of murate of potash was applied as a basal dose. Entire dose of phosphorus and potash was mixed in soil uniformly before filling it into the polybags. Nitrogen was applied in two split doses half as basal dose at the time of sowing and another half top dressed after two months.

The influence of N and P levels and their interactions were studied for the parameters survival percentage, plant height, collar diameter, number of leaves, root length, number of internodes, internodal length, specific gravity, shoot/root ratio; green weight, total biomass, leaf biomass, root and shoot biomass; N, P and K

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content in leaf as well as in root and shoot and their uptake in nursery plants.

Application of nitrogen reflected a significant increase in growth parameters. viz, plant height, collar diameter, number of leaves, root length, number of internodes and internodal length. These characters were generally observed to be highest at N₆₀ levels.

Biomass yield attributes i.e. green weight, total biomass, leaf biomass and root and shoot biomass increased with increase in N levels upto N₆₀. However, subsequent increase in nitrogen beyond this level had a negative effect.

N and P content in leaves as well as in root and shoot evoked significant response to N fertilization. K content in leaves too followed same pattern. N and P uptake in seedling showed significant improvement at N₆₀ over control.

Phosphorus application registered significant effect on collar diameter and root length only. Both these characters revealed highest value at P₄₀ level.

Total biomass as well as leaf were affected by phosphorus application but failed to reflect any significance over control.

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Original not seen.

APPENDICES

Appendix - I
Analysis of variance
Growth

Sources of variation	Mean sum of squares									
	d.f.	Survival percentage	Plant height	Collar diameter (mm)	Number of Leaves plant ⁻¹	Root length (cm)	Number of internodes plant ⁻¹	Internodal length	Specific gravity ratio	Shoot/ root ratio
Replication	2	2.7765	0.8303	0.0148	1.2233	0.4233	0.0411	0.0027	0.000174	0.001223
Nitrogen	3	2.4733	11.5726*	0.0270*	23.3937*	6.66*	0.3744*	0.414*	0.000523	0.002744
Phosphorus	2	0.923	0.6619	0.2483*	1.4933	8.6025*	0.0411	0.0013	0.000324	0.006947
NxP	6	2.1663	21.6364*	0.0382*	3.1526	0.5125	0.1967*	0.0218	0.00023	0.008754
Error	22	4.8106	1.7572	0.0082	2.1627	0.7515	0.0484	0.0095	0.000909	0.003524

* Significant at 5 percent

Appendix - II

Analysis of variance
Biomass production

Sources of variation	d.f	Mean sum of squares			
		green weight (g plant ⁻¹)	Total biomass (g plant ⁻¹)	Leaf biomass (g plant ⁻¹)	Root and shoot biomass (g plant ⁻¹)
Replication	2	0.1291	0.010045	0.000194	0.007586
Nitrogen	3	0.4182*	0.1915*	0.00692*	0.127233*
Phosphorus	2	0.2372	0.1047*	0.006029*	0.060626
NxP	6	0.1027	0.1602*	0.007506*	0.101270*
Error	22	0.1305	0.020454	0.001417	0.018235

* Significant at 5 percent

Appendix - III

Analysis of variance
Nutrient content

Sources of variation	d.f	Mean sum of squares					
		Leaf			Root and shoot		
		N content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
Replication	2	0.0397	0.000019	0.001059	0.0114	0.000005	0.001892
Nitrogen	3	0.4566*	0.000667*	0.009369	0.0746*	0.001452*	0.040434*
Phosphorus	2	0.1671*	0.000917*	0.000903	0.0996*	0.000597*	0.003403
NxP	6	0.0161	0.000188*	0.000533	0.0277*	0.000053	0.002153
Error	22	0.0136	0.000072	0.003142	0.0085	0.000055	0.001873

* Significant at 5 percent

Appendix - IV

Analysis of variance
Nutrient uptake

Sources of variation	d.f	Mean sum of squares		
		N uptake (mg plant ⁻¹)	P uptake (mg plant ⁻¹)	K uptake (mg plant ⁻¹)
Replication	2	13.2970	0.0805	3.6761
Nitrogen	3	108.9808*	3.0664*	28.0030*
Phosphorus	2	139.9237*	1.1525*	14.3487*
NxP	6	55.7662*	0.9405*	13.5456*
Error	22	6.4184	0.1353	1.7988

* Significant at 5 percent

Appendix - V

Soil analysis after experiment for available N,P and K.

Treatments	Kg ha ⁻¹		
	N	P	K
N ₀ P ₀	302.09	26.05	302.13
N ₀ P ₄₀	298.97	36.37	296.47
N ₀ P ₈₀	298.96	44.21	300.53
N ₃₀ P ₀	316.74	23.81	302.40
N ₃₀ P ₄₀	318.83	36.57	294.93
N ₃₀ P ₈₀	327.19	47.89	302.40
N ₆₀ P ₀	350.19	20.14	298.67
N ₆₀ P ₄₀	348.10	29.97	283.83
N ₆₀ P ₈₀	359.59	46.29	300.53
N ₉₀ P ₀	357.50	24.64	302.40
N ₉₀ P ₄₀	388.86	37.33	306.13
N ₉₀ P ₈₀	390.95	48.53	306.13

