

**EFFECT OF ORGANIC AND INORGANIC FERTILIZERS
ON GROWTH PERFORMANCE OF TREE BORNE
OILSEEDLING (*Jatropha curcas* Linn.)
IN NURSERY**

M.Sc.(Agroforestry) THESIS

by

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**DEPARTMENT OF FORESTRY
COLLEGE OF AGRICULTURE
INDIRA GANDHI AGRICULTURAL UNIVERSITY
RAIPUR (C.G.)**

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by

R. Koulini Sri

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REQUIREMENTS FOR THE
DEGREE OF**

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CERTIFICATE – I

This is to certify that the thesis entitled “**EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH PERFORMANCE OF TREE BORNE OIL SEEDLING (*Jatropha curcas* Linn.) IN NURSERY**” submitted in partial fulfillment of the requirements for the degree of “**Master of Science in Agroforestry**” of the Indira Gandhi Agricultural University, Raipur, is a record of the bonafide research work carried out by **Miss. R. Koulini Sri** under my guidance and supervision. The subject of the thesis has been approved by Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by her.

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CERTIFICATE - II

This is to certify that the thesis entitled “**EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH PERFORMANCE OF TREE BORNE OIL SEEDLING (*Jatropha curcas* Linn.) IN NURSERY**” submitted by **R. Koulini Sri** to the Indira Gandhi Agricultural University, Raipur in partial fulfilment of the requirements for the degree of **M.Sc. (Agroforestry)** in the **Department of Forestry** has been approved by the Student's Advisory Committee after an oral examination in collaboration with the external examiner.

Date:

EXTERNAL EXAMINER

Major Advisor

Head of the Department

Director of Instructions

Dedicated

To My Parents

Shri R.P. Rao and Smt. R. Kalyani

Who Taught Me

Life Is an Open Book

And

Only Education Helps You

To Write Your Success Story

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	per cent
&	And
°C	Degree Centigrade
AGB	Above ground biomass
BGB	Below ground biomass
CD	Critical difference
cm	Centimeter
DAT	Days after transplanting
<i>et al.</i>	Co- workers
FYM	Farmyard manure
g	Grams
ha ⁻¹	per hectare
i.e.	that is
K	Potassium
Mm	Millimeter
N	Nitrogen
P	Phosphorus
PM	Poultry manure
viz.	Namely

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In the wise word's of the great sage, Swami Vivekananda "We are responsible for what we are, and whatever we wish ourselves to be, we have the power to make our selves whatever we think, that you will be, you can do anything and everything. Faith, faith, faith in ourselves; faith, faith, faith in God; this is the secret of success."

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CHAPTER –I

INTRODUCTION

The Indian forest flora is rich in under-exploited tropical oil bearing plants with promising economic value. The shortage of diesel lubricants and oil for fuel purpose and energy sector in our country is well known. At the moment, this problem is being tackled by imports and consequently huge foreign exchange is lost in this sector. Now we have to shift our researches to tackle with self-sufficiency in the field of oil fuel like bio-diesel and other source of energy. The green revolution certainly brought self sufficiency in food grains, but it failed to give adequate attention to the important field of oils and fats that account for 11 per cent of cost of our living. The natural forest of our country having several tree borne oil seeds those are also yet to be explored properly.

Minor oil seeds of tree origin have assumed great importance. A large quantity of tree borne oil seeds are collected and utilized now-a-days, but still more tree borne oil seeds are in demand in industries (Rai, 1983). The growing demand for edible and non-edible seed fats has necessitated the survey of oil seed potential in our country. Although the oil obtained from the tree borne oil seeds are not necessarily edible but it can be used for such non edible purpose as making of soap, lubricants, in leather industries and for medicinal purpose (Verma and Sharma, 1978). To meet the rising demand, fats and oil of tree origin have come under focus in recent years. Potentials of Neem, Sal, Mahua,

Karanj, Ratanjyot, Kusum and Dhupa have already been estimated (Vimal and Naphade, 1980, Banerji *et al.*, 1983)

Among the oil seeds of forest origin *Jatropha curcas* (Family: Euphorbiaceae), popularly known as Ratanjyot, immense potential for producing *Jatropha* oil which finds large-scale industrial use. This tropical plant is native to Mexico and Central America but it is cultivated in many other Latin American, Asian, and African countries as a live hedge. A large deciduous soft wooded shrub or small tree attains 3-4 meter height, which occur almost throughout India and in Andaman Islands. In India, it flowers between September to December. The fruits mature in two-four months after flowering, turning yellow when mature. It can be grown over a wide range of arid or semi-arid climatic conditions, well adapted to harsh conditions of soil and climate (Tewari, 1994; Diwakar, 1993). It is recommended, as a drought resistant plant suitable for erosion control (Heller, 1996). It is proposed that this shrub should be included in agroforestry program's to ameliorate the environmental, social and economic status of the country.

Jatropha, also called as physic nut, grows quickly and needs little water or nurturing, reaching maturity after two years, and yielding small black seeds that are covered in light, white husk and which can be picked up by hand. India has about 175 million hectares of wasteland which needs re-vegetation (Singh, 1994). In Chhattisgarh, *Jatropha curcas* is mainly grown for plantation purpose to rehabilitate the wasteland. It is commonly grown as village hedges, roadside plantations and as live fencing. Its propagation is very easy as it can be raised either by seeds or cuttings. It can be grown over a wide range of arid and semi-

arid climatic conditions. A hot and humid climate provides better condition for early germination of seeds (Tewari, 1994). *Jatropha* can be successfully cultivated world wide, as there is no report of having any major diseases or pests. It is non-palatable to livestock so it will not be grazed or browsed even during the time of fodder scarcity. Newly developed biotechnological process related to the exploitation of *Jatropha curcas* includes the genetic improvement of the plant biological pest control, enzyme supported oil extraction, anaerobic fermentation of the press cake and the isolation of anti inflammatory substances and wound-healing enzymes (Gubitz *et al.*, 1999). *Jatropha* is locally popular for its valuable medicinal properties. The paste of young twigs is used for treatment of leucorrhoea in women, application of latex is helpful for curing eczema, latex and lemon juice are mixed (2:1), this mixture is used to treat the mouth sores. The fruits and seeds are antihelmenthic, useful in chronic dysentery, urinary discharges, anemia and heart diseases. Seed oil is used for treatment of tumor. Folk medicine practitioners in Peru employ plant preparations as wound-healing agents on superficial and internal wounds (gastric ulcers) (Villegas *et al.*, 1977). The milky sap of *Jatropha curcas* is used in America for the treatment of different dermatomucosal diseases. Effectiveness in terms of total disappearance of warts was 100 per cent. The sap contained coumarins, volatile oils, flavonoids and polyphenols (Marroquin *et al.*, 1997).

The growing emphasis on agroforestry and afforestation program has resulted in increasing demand of various tree seedlings. Therefore, standardization of nursery techniques is the first step to raise the successful

plantations. Potting media can influence the quality of seedlings to a greater extent. The seedlings raised in good media can ensure better establishment and growth when planted in the field. The ultimate advantage of good potting media is good drainage, water holding capacity and thereby, it gives excellent disease free growth of the seedlings (Nobel, 1993).

Nursery potting media with minimal nutrients induce resistance in seedlings enable the seedlings to be adaptable in adverse situation on out-planting. There are reports of increase in survival, height, diameter and biomass of the seedlings as a result of supplementary nursery nutrition in some species such as *Leucaena* (Dutt and Patharia, 1986), *Robinia pseudocacia* (Reinvoid, 1982). However, studies on black spruce (*Picea mariana*) have shown that exponential and optimum fertilization in nursery promotes growth in the first year of planting out (Timmer *et al.*, 1991). Hence fertilizers play an important role in boosting the initial growth and development of the plants in nursery. However, the optimum requirement of different fertilizers varies with the species as well as the soil fertility. In addition the fertilizer use efficiency also varies with the species.

Jurgensen (1979) pointed out that organic amendments assist plant establishment by improving moisture regime, moderating surface temperature, decreasing erosion, improving fertility, increasing CEC and detoxifying toxic metals. Mixing of compost and fertilizers in coal (Singh *et al.*, 1995) and in copper mine overburden (Williams *et al.*, 1994) responded positively towards increasing growth and biomass production of *Albizia procera*, application of inorganic fertilizers on seedlings in the nursery helps in production of healthy

stock with higher biomass and sturdy root system which are capable of growing successfully when transplanted in field. Inorganic fertilizers are useful to cut short the period required for raising seedlings of transplantable size (Qureshi and Yadav, 1997; Mohan *et al.*, 1991). As, it is well known that quality-planting stock plays a significant role for the success of commercial as well as traditional plantations. Therefore, keeping these points in view the present investigation was carried out to estimate the mineral requirement of *Jatropha curcas* in nursery, to obtain the healthy and vigorous growth of seedlings for plantations with following objectives:

1. To study the effect of organic manure and inorganic fertilizer on growth performance of *Jatropha curcas* seedlings.
2. To study the biomass accumulation in *Jatropha curcas* seedlings.
3. To study the nutrient uptake by seedlings in nursery.

CHAPTER –II

REVIEW OF LITERATURE

The literature available is pertinent to the present study have been reviewed in this chapter under the following broad outlines

2.1 Effect of organic and inorganic fertilizer on growth performance of seedlings.

2.2 Biomass accumulation in the seedlings.

2.3 Nutrient uptake by the seedlings.

2.1 Effect of organic and inorganic fertilizer on growth performance of seedlings

Ahmed and Puzari (1991) conducted an experiment on seedlings of seven tree species viz. *Anthocephalus cadamba*, *Azadirachta indica*, *Bombax ceiba*, *Albizia procera*, *Lagerstroemia speciosa*, *Albizia lucida* and *Terwia nudiflora* were screened for growth, development and different uses. The growth performance of all the seedlings were compared and it was found that the greatest average plant height and girth was observed in *Azadirachta indica* (6.21 m and 40 cm), *Trewia nudiflora* had the lowest plant height (2.65 m) while *Albizia lucida* had the lowest girth (3.00 m), respectively.

Shrivastava and Behl (2002) conducted study to assess the growth, productivity and nutrient use efficiency of *Terminalia arjuna* seedlings in various potting media. There were four treatments of potting media. Sand (T₁), Sandy loam soil (T₂), alkaline soil mixed with sand (T₃), alkaline soil with sand

and decomposed FYM (T₄). The seedlings of T₃ and T₄ excelled others in height (130 cm and 140 cm) and diameter increment (1.2 and 1.4 mm) respectively.

Jha *et al.* (2000) studied the effect of nitrogen levels on growth and biomass production in *Dalbergia sissoo* seedlings in nursery. N, P and K were applied in combinations. Nitrogen was applied at the rate of 0, 25, 50, 75, 100-ppm and Phosphorus and Potassium were applied 25 ppm in uniform dosages. The height and diameter of seedlings after one year have increased from 75.29 to 99.93 cm and 0.84 to 1.16 cm respectively.

Banerjee *et al.* (1999) studied the effectiveness of compost and nitrogenous fertilizer on growth of *Dalbergia sissoo* in iron mine over burden and reported that after six months seedlings exhibited increase of 364.9 per cent in height and 63.9 per cent increase in collar diameter due to mixing of compost in 1:2 proportion to spoil. The urea applied @ 150 ppm resulted the maximum increase in height (36.2%) and collar diameter (25.4%) were recorded respectively.

Devaranavadagi and Sajjan (1997) conducted experiment on effect of potting media in *Acacia nilotica* in the nursery and concluded that the potting media with black sand: black soil and FYM in ratio (1:3:1) were found to be superior showing maximum shoot length of (76.8 cm) which is followed by red earth: white sand and FYM in ratio, (3:2:1) showing lowest shoot length of (57.1 cm) for collar diameter black sand: black soil and FYM in ratio of (1:1:1) proved to be superior showing maximum collar diameter of (0.50 cm) and red earth; white sand and FYM showing the lowest collar diameter of (0.36 cm).

Prasad *et al.* (1998) conducted the experiment on seedling growth in two multipurpose trees viz., *Albizia procera* and *Ongenia dalbergioides* under the influence of inorganic fertilizers. The results showed that *Albizia procera* responded well to fertilizer attaining shoot length of (40 cm) and *Ongenia dalbergioides* showing shoot length of (30 cm) as compared to control of both the species viz. (27 cm for *A. procera* and 15 cm for *O. dalbergioides*)

Jaiswal and Misra (1993) conducted studies on *Grevillea robusta* four potting mixtures i.e., loam soil, loam soil + FYM (1:1), loam soil + sand + FYM (1:1:1) and loam soil + sand + FYM (2:1:1). The results showed that maximum shoot length (107.16 cm) was observed in loam soil + sand + FYM (1:1:1) followed by loam soil + sand + FYM (2:1:1) and loam soil + FYM (1:1) showing height of (107.78 cm and 96.74 cm) respectively.

Prasad and Rawat (1991) studied the response of N, P, and K by *Acacia nilotica* seedlings. Height of *Acacia nilotica* significantly increased with increasing doses of nitrogen upto 100 ppm (63 cm), after 3 months of growth it decreased due in 150 and 200-ppm of Nitrogen treatments. At 100 ppm N, maximum height of *Acacia nilotica* was recorded, throughout the period of observations it was 195 cm after 6 months when 100 ppm P_2O_5 was applied in presence of 100 ppm N and 50 ppm, K_2O from 3rd month onward and was 195 cm after 6 month of growth. Application of 50 ppm K_2O gave maximum height growth when applied with 100 ppm each of N and P_2O_5 . There was an increase of 61 per cent height in $N_{100}P_{100}K_{50}$ treatment (195 cm) from no nutrient ($N_0P_0K_0$) application (121 cm) after 6 months of growth. Leaf number increased from 337 in N_0 treatment to 1791 in N_{150} treatment (431%) increase.

Increase in leaf number was also significant due to P_2O_5 application and was 1490 (202%) in treatment P_{100} from 493 in P_0 treatment. Application of K_2O however did not significantly effect the leaf number, which varied between 1251 and 1490.

Sonakar *et al.* (1993) concluded from the experiment done on the effect of N and P on growth of *Eucalyptus tereticornis* seedlings, the maximum height (147.47cm) of seedlings was obtained in treatment receiving 300 kg/ha nitrogen and phosphorus (100 kg/ ha) and was found to be best.

Gopikumar *et al.* (2002) conducted experiment on the growth performance of four tree species, *Tectona grandis*, *Ailanthus triphysa*, *Albizia falcataria* and *Terminalia paniculata* by using different potting mixture containing garbage and the results showed that among all the potting media T_1 (Soil: sand: cowdung) and T_7 (Soil: four week decomposed garbage: cowdung) in 1:1:1 ratio had recorded 100% success with regard to both initial establishment after one week of planting and final survival after eight months. Among the spp. teak seedling showed the maximum height increment of (13.90cm) in T_6 (soil: 2 weeks decomposed garbage: cowdung) followed by girth increment (2.47cm), maximum number of leaves (9.87) and root number (19.33). Only T_7 treatment recorded maximum root length (29.67cm). In *Ailanthus* maximum girth increment (5.20cm) and number of leaves (10.10) were found with T_7 treatment. Maximum root length (18.93cm) and root number (19.83) was found in T_3 (soil: 2 weeks decomposed garbage: cowdung) was recorded maximum root length (29.67cm) and maximum root number (21.67) was recorded with (soil: 4 weeks decomposed garbage) and T_1 (Soil: sand: cowdung). Number of

leaves was found maximum (29.91) in T₇ treatment. Root length was found maximum (45.83cm) in T₁ and root number was found to be highest (25.00) for T₄ treatment.

Jadhav *et al.* (1995) A field experiment was conducted on sloppy lateritic soils to find out the effect of different plant densities and fertilizer levels on growth of *Jatropha curcas*. The different spacing (2x1 and 2x2 m) did not affect growth. However, with increase in levels of fertilizer the plant height, girth, leaves/plant progressively increased. Application of 3.68 each of Nitrogen and single super phosphate and 2.0 g Muriate of potash/plant at the wider spacing produced maximum height (67.2 cm), girth (7.5 cm) and AGR of height (7.30 cm/month) whereas leaves/plant were maximum at closer spacing. The interaction effects between spacing and fertilizers were not significant.

Biradar *et al.* (1998) revealed from the experiment done of combination of different potting media such as red earth, fym, sand, vermicompost in different ratios. The potting media containing vermicompost alone recorded significantly more (0.51cm) collar diameter and was on par with treatment R: V: S (1:3:1) (red earth: vermicompost: sand). The medium with vermicompost alone and R: V: S (1:3:1) recorded highest root length (34.0cm) and shoot length was also highest (37.7cm). These treatments proved to be significantly superior over the rest.

Chauhan and Sharma (1995) conducted an experiment on response of nitrogen and phosphorus on the growth of *Ulmus villosa* brandis seedlings for two years, the results showed that seedling height was (66.85 and 83.01 cm) respectively when nitrogen @ 80 kg ha⁻¹ was applied alone, the collar diameter

was recorded (0.718 and 0.887). In same way results were obtained when 30-kg ha⁻¹ phosphorus was applied alone, seedling height was (63.44 and 78.89 cm) and collar diameter was (0.638 and 0.841) respectively. The results obtained when N and P were applied in combination of 80-kg ha⁻¹ nitrogen and 30-kg ha⁻¹ phosphorus the collar diameter was recorded maximum of (0.760 and 0.960).

Ginwal *et al.* (2001) reported that the proper potting mixture for raising *Acacia nilotica* seedling is sand + compost (20%+80%) treatment combination which recorded highest value with maximum height (76.85 cm) and collar diameter (5.79cm), followed by number of leaves (43) and root length (7.70cm). Also another combination of compost (0%) + charcoal (20%) recorded maximum seedling height (64.07%) and 25%sand + soil25% + compost 50% recorded highest collar diameter (4.71 mm) as compared to other charcoal, rice husk and compost combinations.

Jha *et al.* (2000) reported from the experiment done on the effect of nitrogen levels on growth in *Dalbergia sissoo* seedlings in nursery that among the different rate of N (0, 25, 50, 75, 100 ppm), and uniform dose of 25 ppm P₂O₅, K₂O fertilizers when planted in sandy loam soil. The application of 100 ppm of nitrogen enhances the height to 8.33 cm and collar diameter to (0.96%). Hence, this dose was recommended for growing *D. sissoo* seedling in polythene bags.

Devaranavadagi *et al.* (1997) concluded that among the different potting media for *Acacia nilotica* seedlings maximum height was observed in black sand + black soil + FYM (1:3:1) with (76.8 cm). Root length and collar

diameter was showed maximum in black soil + black sand + FYM in (1:1:1) ratio with (36.3 cm) and (0.50cm) but leaf area was recorded highest in sand slit + black soil + FYM in (1:3:1) ratio with (1050.68cm). They also reported that black soil lessen the expenditure of potting mixture for raising *A. nilotica* seedlings.

Singh and Banerjee (1999) conducted a study on *Albizia procera* using four doses of nitrogen (0,75, 150 and 300 kg ha⁻¹), four doses of phosphorus (0, 10, 25 and 50 kg ha⁻¹) and three doses of K₂O (0,50,100 kg ha⁻¹) in skeletal soil. Results obtained exhibited better growth in respect of height, collar diameter when fertilizers were applied in combinations maximum height (63.0 cm), collar diameter (1.53 cm) was obtained when fertilizer were applied at the rate of N-150, P₂O₅-50 and K₂O-50 kg ha⁻¹ in combined form.

Sundararaju and Chinnathurai (1990) conducted a study on improved practice in *Eucalyptus globulus* in nursery by application of inorganic fertilizers combinations using four doses of nitrogen (0.2g, 0.4g and 0.8g), four doses of single super phosphate (0.5g, 1.0 g, 1.5 g, 2.0 gm), four doses of Muriate of potash (0.15 gm, 0.3 g, 0.45 gm and 0.6 gm) respectively. The seedlings produced the height of 86.3 cm in 128 days.

2.2 Biomass accumulation in seedlings.

Mohan *et al.* (1990) concluded that potting mixtures using (sand, loam and clay) and application of nutrient (50 ppm each of N, P and K) could increase or decrease the biomass in effective manners in different tree species *Acacia lenticularis*, *A. planiforms*, *Albizia amara*, *A. lebbek* *Azadirachta indica*, *Eucalyptus tereticornis*, *Hardwickia binata*, *Peltaphorum pterocarpum* and

Tamarindus indica results showed that *A. lebbek*, *P. pterocarpum* and *E. tereticornis* are highly responsive to the nutrient application. *A. lenticularis*, *Albizia amara*, *A. indica*, *H. binata* and *T. indica* showed decreased in biomass due to nutrient application. Result showed that leaf biomass (5.57 g/pot) shoot biomass (8.75g/pot). Above ground biomass and below ground biomass (17.13) was comparatively maximum in *Albizia lebbek* with (50 ppm N, P and K) application, leaf biomass of *Azadirachta indica*, *P. pterocarpema*, *E. tereticornis* have attained maximum under fertilizer application. Shoot biomass was observed maximum in *E. tereticornis*, *P. pterocarpum*, *T. indica*, *A. plainfrom* and *A. tenticularis*. For above ground biomass *P. pterocarpum*, *T. indica*, *A. plainfrom* have attained maximum with fertilizer. *A. indica*, *P. pterocarpum*, *E. tereticornis*, *T. indica*. Below ground biomass is maximum in *A. indica*, *P. pterocarpum*, *E. tereticornis*, *T. indica*, *A. amara*, *A. planiforms*, *A. tenticularis*, *H. binata*.

Ahmed and Puzari (1991) conducted an experiment for screening the growth and development of seven forest tree species viz. *Anthocephalus cadamba*, *Azadirachta indica*, *Bombax ceiba*, *Albizia procera*, *Lagerstroemia speciosa*, *Albizia lucida* and *Trewia nudiflora* and found that there was large variability in the moisture content of different tree species. Maximum was recorded in *Azadirachta indica* with (25%) followed by *Albizia procera* (36.14%) and *Bombax ceiba* (60.80%). Dry matter accumulation was also maximum in *Azadirachta indica* (77.544 kg /ha).

Banerjee *et al.* (1999) conducted two experiments to assess the effectiveness of compost and different sources of nitrogen fertilizer towards

biomass production of *Dalbergia sissoo* in iron mine overburden. The results showed the effect of different combinations of spoil and compost on biomass production of *D. sissoo* were maximum in 1:2 combination of soil: compost, where leaf biomass was maximum in (32.10 g/plant) stem biomass was upto (85.30 g/plant) and root biomass was (27.20 g/plant) where as in different sources of nitrogen fertilizer, application of urea showed the best results as compared to others. Leaf biomass was (41.07 g/plant) stem biomass was (109.65 g/plant) and root biomass was recorded as (28.85 g/plant).

Bharadwaj *et al.* (1991) A little work has done on the effect of fertilizer on the growth and development of nursery stock (Reinsvoid and Pope, 1982). Keeping this in view, they conducted an experiment to find optimal N, P, K levels for healthy growth of *Robina pseudocacia* Linn. Different treatment combinations of N, P, K were applied to the seedlings. Total dry biomass increased significantly with different treatment combinations. For dry weight the main effects of nitrogen and potash were found significant for total biomass production. As compared by scheffe's critical difference at 5% level of significance, the treatment $N_3P_2K_2$ ($N_{375}P_{250}K_{250}$ mg plant⁻¹) gave maximum response in total biomass.

Bhuiyan *et al.* (1991) aimed to find out the effect of inorganic fertilizers on the initial growth of *Casuarina equisetifolia* seedling in the nursery. Three levels of N, P, K were applied in combinations. The results showed that combination $N_2P_2K_2$ showed maximum stem biomass (7.51 g/plant) and root biomass (3.23 g/plant) was observed in $N_2P_3K_3$ combination.

Chauhan and Sharma (1995) According to them plants require all essential nutrient, still N, P and K play a key role in boosting the initial growth, biomass. With this objective, the present studies were undertaken to elucidate the response of fertilizer on (*Ulmus villosa* Brandis) seedlings. The application of N also manifested identical effect on the biomass characters. However, the effect was only significant on shoot and seedling dry weight (34.20 and 46.41 g). Mishra (1987) *Celtis australis* and Purshottam (1993) in *Ulmus laevigata* have reported that application of nitrogen upto 80-kg ha⁻¹ depicted a positive response. However, increase in phosphatic fertilizer that however, did not effect the biomass characters significantly. Brandis *et al.* (1978) reported beneficial effect of phosphorus on growth as well as on biomass in other forest tree species but no such report is available for *Ulmus villosa*. Nitrogen and phosphorus (N x P) interaction significantly affected the seedling dry weight. Positive response of (N x P) interaction have also been reported by many other workers like Quershi and Yadav (1967) for *Eucalyptus tereticornis*, Loffler (1971) in *Tilia*, Babaev (1978) in Canadian poplars, Hussain *et al.* (1980) in *Acacia mollissima* and Koul (1989) in *Bauhinia variegata*.

Ginwal *et al.* (2001) performed an experiment to find out the extent to which the quality of *Acacia nilotica* seedling is affected with varying the potting mixtures and its ingredients. Two different potting mixtures viz. sand, soil, compost and another potting mixture having organic ingredients (charcoal, rice husk and compost). The dry matter allocation to various components of the seedlings raised under the test treatment. The shoot biomass and above ground biomass almost showed a similar pattern in respect to the performance of

various treatments. The shoot biomass root biomass and leaf biomass were recorded significantly maximum (5.21 g/plant, 1.64 g/plant, 1.52 g/plant) for T₄ treatment (20% sand 80%compost) for another combination of potting mixture. The P₄ is the out ranking treatment among other showing maximum shoot biomass (3.24 g/ seedling). The leaf biomass was also recorded maximum in P₄ (0.87g seeling⁻¹). The performance of treatment P₄ appeared to be the best one in root biomass (1.60g seedling⁻¹).

Gopikumar *et al.* (2002). An experiment was performed to see the influence of garbage on the production. Four species were used for the study viz., *Teak*, *Ailanthus*, *Albizia*, *Terminalia*, ten treatments were included in experiment comprising different ratio of cowdung and garbage. The results of study for various species revealed significant differences between treatments with regard to biomass production. Maximum biomass for teak seedling were obtained in treatment T₁ (sand: soil: cowdung) of 11.47 g and root length was recorded (29.67cm) in treatment T₇ (4 weeks decomposed garbage, cowdung). For *Ailanthus* T₆ (Soil, 2 weeks decomposed garbage, and cowdung) proved to be best showing (9.41g) biomass and root length of (18.93 cm). For *Albizia* and *Terminalia* species T₅ and T₁ were having maximum biomass production (7.56 and 9.97 g) and T₄ and T₁ were having highest root length of (29.67 and 45.83 cm).

Jha *et al.* (2000) studied the effect of nitrogen levels on growth and biomass production in *Dalbergia sissoo* seedlings in nursery. Biomass of leaves, stem and roots has increased with period of growth in each treatment. The total biomass of (4.13 g/seedling) was found maximum in treatment where

N was applied upto 100 ppm. Mohan (1992) have recorded increase in biomass of *Gmelina arborea* seedlings in the nursery with increase in levels of nitrogen.

Prasad *et al.* (1991) carried out green house experiment to see the response of N, P and K by *Acacia nilotica* seedlings. Highest total dry biomass (49.89 g/plant) was observed in treatment N₁₀₀ which was greater than to treatment when nutrient were applied in combinations, highest dry biomass (52.92 g/pot) was recorded in treatment N₁₀₀, P₁₀₀ K₅₀ followed by N₁₀₀ P₀ K₀ (45.46 g/pot), N₁₀₀ P₀ K₅₀ (42.06 g/pot) and N₁₀₀ P₁₀₀ K₀ (41.49 g/pot).

Vashista *et al.* (1997) studied the growth in nursery stage together with different fertilizers on *Gmelina arborea*, *Dalbergia sissoo* and *Dendrocalamus strictus*. The different treatments combinations of FYM, Nitrogen (20 ppm), Phosphorus (10 ppm) and Potassium (20 ppm). Dry weight was maximum in S₂ L₄F₂ treatment (FYM, 2:1:4 sand soil, NPK) was (1.700 g) for *Dendrocalamus strictus*, (1.867g) for *Dalbergia sissoo* and (5.167 g) for *Gmelina arborea* in S₁L₄F₂ treatment (Pressmud, N, P and K 20,10,20 ppm)

2.3 Nutrient uptake in seedlings

Srivastava and Behl (2002) Studied the nutrient use efficiency in *Terminalia arjuna* seedlings grown in various potting mixtures. Nutrient concentrations varied in treatments and in various parts of the plant within a treatment, leave of T₄ (alkaline soil, sand, and FYM in (4:1:1) ratio) had substantially higher N% as compared to other treatment (2.9%). In root and stem also T₄ had highest concentration of N% (1.00 and 1.3 %). Difference in P concentration was higher in potting media of T₂, T₃, and T₄ as compared to T₁

(control). However, difference in K concentration in plant parts among T₂, T₃ and T₄ did not showed any specific pattern.

Banerjee *et al.* (1999) studied the effectiveness of compost and nitrogenous fertilizers and nutrient accumulation of *Dalbergia sissoo* in Ironmine overburden. In general, nutrient concentration was higher in leaves than stems and roots. N concentration in leaves increased with increase in the proportion of compost (1.63 to 3.59 %). Though phosphorus concentration also followed the same trend, the difference between control and treatment 1:0:5 (spoil soil and compost) as well as 1:1 and 1:2 combination were not significant. Potassium concentration in leaves exhibited significantly higher values in the treatment receiving 1:1 and 1:2 combinations (1.27 and 1.31%, while the value of 1:0:5 combination (1.21%) did not differ significantly from that of control (1.22%). Nutrient distribution in stem exhibited slightly different trend. Highest N per cent was in combination of 1:2 ratio (2.69%). Increasing proportion of compost did not effect the concentration of phosphorus (0.05 to 0.054 %) and for potassium it was highest in 1:2 ratio (0.63%). Roots exhibited somewhat different trend in nutrient concentration in presence of compost. Nitrogen increased with the proportional increase of compost in the spoil. However, its concentration in control and in combination of 1:0:5 was not significantly different (0.28 and 0.31%). Phosphorus concentration declined inspite of increase of compost upto 1:1 level (0.25-0.22%) again, there was an increase in 1:2 combination (0.32%). Alternate increase and decrease were noted in potassium concentration of root with the increase of the proportion of compost. Different sources of nitrogen exhibited differential

effect on nutrient concentration in plant parts urea responded at par in respect of nitrogen concentration in leaves (4.96%) and stems (2.87%) while control showed least concentration (2.16%) respectively. The concentration of P and K, were found to be non-significant. Whereas in stem N, P, K concentration was found to be highest in urea (2.82 %, 0.066% and 0.89% and in root NPK % were found (0.64%, 0.034%, 0.58%) respectively.

Gopikumar *et al.* (2002) conducted a study to see the effect of potting media on nutrient uptake in four species of tree seedling. The nutrient content in the four species, In Teak, the presence of cow dung along with 4 weeks decomposed garbage in Treatments T₇ (soil: 4 weeks decomposed garbage: cow dung) and T₄ (soil: 4 week decomposed garbage) resulted in high tissue nitrogen content (4%, 3.5%). In seedling of *Terminalia* where the highest value was with treatment T₄ (soil: 4 weeks decomposed garbage) also showed the same trend. Seedlings of *Ailanthus* have the highest value of (4.2%) when grown in media containing soil and 2 weeks decomposed garbage (T₃). Generally the *Albizia* seedlings grown in different media possessed high nitrogen concentration (4.3%). Generally, phosphorus plays an important role in a very large number of enzyme reactions that depend on phosphorylation (Greulach, 1973). This influence shoot growth parameter such as height, leaf area, collar girth, etc., by acting as structural component of all constituents and other metabolically active compounds (Agarwala and Sharma, 1976). Guarg *et al.* (1997) used sewage sludge as a component of potting media for raising *Phaseolus vulgaris* seedlings and found that the plant samples showed less concentration of nutrient especially phosphorus. In Teak, maximum

concentration of phosphorus was recorded for treatment T₂ (soil: fresh garbage). Similar trend was observed in the seedlings of *Terminalia* also, where the maximum value for phosphorus was found for treatment T₂ (Soil fresh garbage). *Albizia* recorded a maximum value of 0.246 for the treatment T₁ (Soil: sand: cowdung). Potassium has several physiological and biochemical roles in protein synthesis (Wild, 1988). In all the four species, potassium per cent was found to be greater than the phosphorus content. In Teak potassium content ranges from (0.3-0.5 %) in T₃. In *Ailanthus* seedling potassium concentration ranges from (0.2-0.8%) in T₉. In *Albizia* seedlings (0.3-0.5%) in T₅, in *Terminalia* seedlings it ranged from (0.1-0.4%) in T₇ respectively.

CHAPTER –III

MATERIALS AND METHODS

The present investigation entitled as “Effect of organic and inorganic fertilizers on growth performance of tree borne oil seedling (*Jatropha curcas* Linn.) in nursery” was carried out in experimental field of Department of Forestry, Indira Gandhi Agricultural University, Raipur (C.G.), from March 2003 to July 2003. The details of materials used, experimental procedures followed and techniques adopted in the study are described in this chapter.

3.1 Study area

The geographical situations, climate, and soil of the experimental site are described below.

3.1.1 Geographic situation

The experiment was carried out at Raipur which is located in the eastern part of Chhattisgarh situated between 21°33' to 21°76' North latitude and 81°30' to 81°36' East longitude having an altitude of 289.56 m above mean sea level.

3.1.2 Climate

The climatic condition of experimental site is sub-humid dry tropical. The region receives an average annual rainfall of 1250mm, of which 80% occurs during rainy season from June to end of September and occasional rainfall during October to February. May is the hottest and December is the coolest month of the year. The mean monthly maximum temperature ranges from 27 °C in December to 42 °C in May and minimum temperature varies from 13.2 °C in December to 28.3 °C in May. The maximum temperature

sometimes even rises as high as 46 °C in May and minimum as low as 6 °C in December. The relative humidity is high from July to August which reaches upto 80 per cent while minimum relative humidity of 29 per cent is observed during April-May while, wind velocity is high from May to August.

Weekly average meteorological data during the span of experiment as recorded at meteorological observatory, IGAU, Raipur are presented in Appendix-I and Fig. 3.1. The seedlings received 41.6mm rainfall during the experimental span. The maximum temperature varied from 46°C in first week June to 30.7°C in first week of July. The minimum temperature varied from 20 °C in first week of April to 33.6°C in second week of June.

3.1.3 Geology

Raipur has three district geological formations viz., Bijapur-Cuddapha, Dharwar and Archean, Lithographically it is classified into seven areas, namely, Raipur shale and limestone, Gunderdehi shale, Khairagarh sand stone, Cuddapha charmar limestone, Chandrapur sand stone grit, Dharwar rocks, granite and gneisses.

3.1.4 Physiography

In agroclimatic zone of Chhattisgarh plain there are 10 districts viz., Raipur, Bilaspur, Durg, Rajnandgaon, Kawardha, Mahasamund, Dhamtari, Janjgir, Korba and Raigarh. This zone is also known as upper Mahanadi basin, which is a saucer, shaped. The longer part of the basin is undulating, flat terrain, gentle slopes from west to east. The general geological features of the zone comprises of laterites, alluvium capping over horizontally bedded sequence of sedimentary rocks of limestone and dolomite, on the top followed

by limestone shale, quartzite sand stone, gneisses and metasediments of old age. These formations have very limited primary porosity and permeability to water.

3.1.5 Soil Type

The soil is classified as vertisols. It is black in colour with fine texture and sticky nature having low to medium nitrogen of 217.39 to 318.47 kg ha⁻¹ and high potassium of 402.12 to 503.61 kg ha⁻¹, phosphorus 9.56 to 15.7kg ha⁻¹.

3.2 Experimental Details

The experiment was performed at experimental field of Department of Forestry at IGAU, Raipur. For this experiment tree borne oil seedling *Jatropha curcas* was selected. The effect of organic and inorganic fertilizers on production of superior seedlings of *Jatropha curcas* was measured. Therefore, a study was formulated to generate information on the effect of organic and inorganic fertilizers on seedlings. Healthy six month old seedlings were selected for study.

3.2.1 Treatments

Seedlings of *Jatropha curcas* were treated with two different kinds of fertilizers viz., organic manure consisting of farm yard manure and poultry manure each having three levels, respectively. In same way inorganic fertilizers i.e. N, P and K each having three levels and were applied in combinations.

The details of treatments are as follows

Organic manure

Farm Yard Manure	OFT ₁ :	25 gm
	OFT ₂ :	50 gm
	OFT ₃ :	100 gm

Poultry Manure

OPT₁ : 25 gm

OPT₂ : 50 gm

OPT₃ : 100 gm

T₀ : Control

Inorganic fertilizers :

Treatment combination are N: 4.6 g, 6.9g, 9.2g, P: 3.2 g, 4g, 4.8g, K:0.8g, 1.6g, 2.4g.

Treatment	N	P	K
N ₁ P ₁ K ₁	4.6	3.2	0.8
N ₁ P ₁ K ₂	4.6	3.2	1.6
N ₁ P ₁ K ₃	4.6	3.2	2.4
N ₁ P ₂ K ₁	4.6	4.0	0.8
N ₁ P ₂ K ₂	4.6	4.0	1.6
N ₁ P ₂ K ₃	4.6	4.0	2.4
N ₁ P ₃ K ₁	4.6	4.8	0.8
N ₁ P ₃ K ₂	4.6	4.8	1.6
N ₁ P ₃ K ₃	4.6	4.8	2.4
N ₂ P ₁ K ₁	6.9	3.2	0.8
N ₂ P ₁ K ₂	6.9	3.2	1.6
N ₂ P ₁ K ₃	6.9	3.2	2.4
N ₂ P ₂ K ₁	6.9	4.0	0.8
N ₂ P ₂ K ₂	6.9	4.0	1.6
N ₂ P ₂ K ₃	6.9	4.0	2.4
N ₂ P ₃ K ₁	6.9	4.8	0.8
N ₂ P ₃ K ₂	6.9	4.8	1.6
N ₂ P ₃ K ₃	6.9	4.8	2.4
N ₃ P ₁ K ₁	9.2	3.2	1.6
N ₃ P ₁ K ₂	9.2	3.2	1.6
N ₃ P ₁ K ₃	9.2	3.2	2.4
N ₃ P ₂ K ₁	9.2	4.0	0.8
N ₃ P ₂ K ₂	9.2	4.0	1.6
N ₃ P ₂ K ₃	9.2	4.0	0.8
N ₃ P ₃ K ₁	9.2	4.8	2.4
N ₃ P ₃ K ₂	9.2	4.8	2.4
N ₃ P ₃ K ₃	9.2	4.8	2.4

3.2.2 Establishment of the experiment

The following practices were applied for the establishment of the experiment.

3.2.3 Soil preparation and polybag filling

Good nursery soil was prepared thoroughly by crushing it, so that it becomes fine, firm which helps for good root establishment. Care was taken that the soil is free from weeds and other soil borne pathogens. For filling, the polybags of 6 x 9 inches were selected having perforations for the removal of excess water.

3.2.4 Fertilizer application

A uniform dose of organic manure i.e. farmyard manure and poultry manure each having three levels viz., 25 g, 50 g, 100 g were applied to the seedlings, respectively. Inorganic fertilizers were applied in combinations. A dosage of 4.6 g, 6.9 g, 9.2 g of nitrogen was applied in the form of urea, 3.2 g, 4 g, 4.8 g, of phosphorus was applied in the form of single super phosphate (SSP) and 0.8g, 1.6 g and 2.4 g of potassium in the form of Muriate of Potash (MOP).

3.2.5 Transplanting of seedlings in polybags

Six month old seedlings were carefully uprooted from old polybags and care was taken that the root system should not be disturbed. These seedlings were transplanted into new polybags having different levels of organic manure and inorganic fertilizers. After transplanting of seedlings polybags were irrigated with light showers.

3.2.6 Weed management

Weeding operations were carried out twice during the experiment first weeding was carried out after 30 days and second after 75 days of transplanting.

3.2.7 Plant protection measures

As such there was no pest attack observed during the period of experiment therefore no plant protection measure were undertaken.

3.3 Observations

The below mentioned observations were recorded to measure the monthly growth rate of the seedlings in different organic and inorganic fertilizer levels.

3.3.1 Growth parameters

3.3.1.1 Shoot length

Height of the seedlings were measured in centimeters from the base of the plant to the tip of the shoot with the help of the scale at 30, 60, 90 and 120 days after transplanting.

3.3.1.2 Collar Diameter

Collar diameter of the seedlings were recorded near the base of the stem in millimeter at 30, 60, 90, 120 days with the help of digital Vernier Calliper

3.3.1.3 Number of leaves per plant

Number of leaves per plant was recorded by simple count method at 30, 60, 90, 120 days.

3.3.2 Biomass accumulation

Three seedlings of each treatment were uprooted without damaging the roots randomly at monthly interval. After uprooting the seedlings root length

were recorded and then root and shoot were separated. Roots were washed properly with water to remove adhering soil particles. Afterwards roots were weighed to record the fresh weight. The fresh weight of leaves was also measured in grams. The sample of root, stem and leaves were brought to laboratory in paper bags and kept in oven for drying at 80 °C until constant weight. The biomass was calculated on the basis of dry weight.

3.3.3 Nutrient uptake

To determine the nutrient uptake in the seedlings, the dried samples were ground to powder and passed through one-mm mesh screen for chemical analysis. Nitrogen concentration was determined following Micro-Kjeldahl method by digesting plant samples in triacid (5:1 ratio of conc. H_2SO_4 and perchloric acid) and three-gram catalyst mixture (5:1 ratio of sodium sulphate and copper sulphate). To analyze the phosphorus content in plant sample method outlined by Allen *et al.* (1974) was used, 0.2 g plant samples were digested in 10 ml triacid mixture (nitric acid, sulphuric acid and perchloric acid in 5:1:1 ratio), and then digests were cooled and diluted to 100 ml. Using 10ml aliquots total phosphorus content was determined by spectrophotometer after developing vanado-molybdophosphoric acid yellow colour and potassium was estimated by flame photometer.

3.4 Statistical analysis

Data recorded on the basis of various observations were subjected to analysis of variance and the experiment was laid out in Completely Randomized Design as outlined by Gomez and Gomez (1984).

CHAPTER-IV

RESULTS

Results of the experiment on growth, biomass and nutrient accumulation of *Jatropha curcas* Linn. seedlings in nursery in response to organic and inorganic fertilization are presented in this chapter. A brief description along with statistically analysed data in tables and figures has been given here. Interpretations of only significant findings have been narrated. The observations of the experiment are divided into three parts. The first part deals with morphological characters of *Jatropha curcas* seedlings, the second part deals with biomass accumulation in the seedlings and the third part deals with the nutrient status in the seedlings.

4.1 Growth attributes of *Jatropha curcas* seedlings

4.1.1 Growth attributes of *Jatropha curcas* seedling in response to organic manure

The effect of organic manure on growth parameters of *Jatropha curcas* seedlings is furnished in Table 4.1.

Root length

Root length of seedlings was measured after 30 days interval till the last observation of the experiment. The root length significantly increased with the higher doses of FYM and poultry manure. The root length was recorded maximum (34.64 cm) in OFT₃ followed by OFT₂ and OFT₁ (30.47 cm and 28.45 cm) respectively. The range of root length was recorded minimum (8.21

to 28.45 cm) in OFT₁ and maximum (10.48 to 30.74 cm) and (11.37 to 34.60 cm) in OFT₂ and OFT₃ respectively. Similar observation was recorded with poultry manure. The maximum root length (35.33 cm) was found in OPT₃ followed by OPT₂ and OPT₁ (34.24 and 30.44 cm) respectively. The range of root length varied from (12.90 to 30.44 cm), (13.94 to 34.34 cm) and (14.08 to 35.33 cm) in OPT₁, OPT₂ and OPT₃ respectively. The maximum root length was recorded in poultry manure as compared with FYM, it was also recorded that the root increment was found maximum within 30 to 60 DAT, and afterwards it decreased with the age of the seedlings. The results of control showed the minimum root length (24.33cm) and it varied from (6.67 to 24.33 cm.) till the end of the experiment.

Collar diameter

Collar diameter also increased with the application of higher doses of poultry manure and FYM. It was maximum (31.75 mm) in OFT₃, followed by (29.26 and 28.68 mm) in OFT₂ and OFT₁ treatments respectively. The collar diameter varied from (6.44 to 28.63 mm), (6.47 to 29.26 mm) and (7.02 to 31.75 mm) in OFT₃, OFT₂ and OFT₁ respectively. The poultry manure treatment showed maximum collar diameter (35.25 mm), in OPT₃ and lowest (28.24 mm) in OFT₁. The range of collar diameter was recorded (7.16 to 28.24 mm), (7.24 to 35.19 mm) and (8.18 to 35.25 mm) in OPT₁, OPT₂ and OPT₃ respectively. The performance of collar diameter in control was recorded minimum as compared with organic manure. The above result shows that the higher dose of poultry manure and FYM showed significant increment in collar diameter, as compared with control.

Shoot length

Significant difference in seedling height was also recorded among the treatments. Shoot length gradually increased with the application of higher doses of poultry manure and FYM. Maximum increment was recorded (51.00 cm) in OFT₃ followed by (47.67 and 46.33 cm) in OFT₂ and OFT₁ treatments respectively. The range of shoot length was recorded from (29.67 to 46.33 cm), (33.33 to 47.67 cm) and (34.00 to 51.00 cm) in OFT₁, OFT₂ and OFT₃ respectively. The poultry manure showed the maximum shoot length (56.67 cm) in OPT₃ followed by (55.30 and 52.67 cm) for OPT₂ and OPT₁ respectively. The range of shoot length was recorded (14.00 to 52.64 cm), (16.33 to 55.30 cm), (18.33 to 56.67 cm) in OPT₁, OPT₂ and OPT₃ respectively as compared with control it was recorded (43.00 cm). The maximum growth of shoot was recorded in poultry manure followed by FYM.

Number of leaves

The number of leaves increased significantly with the age of seedlings except during June. The number of leaves was recorded maximum in OFT₃ (47.46) followed by OFT₂, OFT₁ (44.67 and 43.67) respectively. The number of leaves varied from (10.67 to 43.67), (11.00 to 44.67) and (13.33 to 47.76) in OPT₁, OPT₂ and OPT₃ respectively. The control showed minimum number of leaves (39.00). The maximum number of leaves was recorded in Poultry manure followed by FYM.

4.1.2 Influence of inorganic fertilizer on growth attributes of *Jatropha curcas* seedlings

4.1.2.1 Effect of nitrogen on growth attributes

Influence of nitrogen on growth attributes, of *Jatropha curcas* seedlings are presented in Table 4.2.

Root length

Nitrogen did not showed any significant effect on root length increment with higher level at 120 DAT. It was significant during 30 to 90 DAT. Maximum value was recorded (17.37 cm) in N₃ followed by N₂ and N₁ showed similar values (15.65 and 14.40 cm) respectively. The range varied from (7.02 to 14.40 cm), (9.10 to 15.65 cm) and (10.11 to 17.37 cm) in N₁, N₂ and N₃ respectively.

Collar diameter

Higher doses of nitrogen influenced the increase in collar diameter. Maximum value was recorded (25.32 mm) in N₃ followed by N₂ and N₁ treatments (22.77 and 20.56 mm) respectively. The range varied from (5.81 to 20.56 mm), (6.01 to 22.77 mm) and (6.22 to 25.32 mm) in N₁, N₂ and N₃ treatments respectively.

Shoot length

Significant effect of nitrogen was recorded in shoot length with higher level of nitrogen application. The maximum shoot length was recorded (47.50 cm) in N₃ followed by (42.3 and 40.33 cm) in N₂ and N₁ treatments respectively. The shoot length range varied from (10.37 to 40.33 cm), (12.33 to 42.33cm) and (13.14 to 47.50 cm) in N₁, N₂ and N₃ respectively.

Number of leaves

Number of leaves was increased significantly with the higher doses of nitrogen. Maximum number of leaves was recorded (40.14) in N₃ followed by N₂ and N₁ (35.07 and 33.11) respectively. The number of leaves varied from (9.03 to 33.11), (10.11 to 35.07) and (11.23 to 40.14) in N₁, N₂ and N₃ respectively.

4.1.2.2. Effect of phosphorus on growth attributes of *Jatropha curcas* seedlings

The effect of phosphorus on growth attributes of *Jatropha curcas* seedlings is presented in Table 4.3.

Root length

Phosphorus showed a significant effect on root length, it was increased with in the higher level. Maximum root length was recorded (19.16 cm) in P₃ followed by (17.23 and 16.17 cm) in P₂ and P₁ respectively. The range of root length varied from (8.10 to 16.17 cm), (10.14 to 17.23 cm) and (10.75 and 19.16 cm) in P₁, P₂, P₃ respectively.

Collar diameter

Higher levels of phosphorus significantly influenced the collar diameter increment in of seedlings. Maximum value was recorded (27.07 mm) in P₃ followed by P₂ and P₁ (23.34, 21.10 mm) respectively. The range of collar diameter varied from (6.9 to 21.10 mm), (7.04 to 23.34 mm) and (7.17 to 27.07 mm) in P₁, P₂ and P₃ treatments respectively.

Shoot length

Higher levels of Phosphorus significantly influenced the increment in shoot length. Maximum increment was recorded (47.19 cm) in P₃ followed by P₂ and P₁ (44.22 and 41.77 cm), respectively. The shoot length range varied from (10.75 to 41.77 cm), (12.01 to 44.22 cm) and (14.50 to 47.14 cm) in P₁, P₂ and P₃, treatments respectively.

Number of leaves

Number of leaves significantly increased with the higher levels of phosphorus. Maximum number of leaves was recorded (41.04) in P₃ followed by P₂ and P₁ (37.99 and 35.17) respectively. The number of leaves varied from (10.54 to 35.17), (11.10 to 37.99), (11.17 to 41.04) in P₁, P₂ and P₃ respectively.

4.1.2.3 Effect of potassium on growth attributes of *Jatropha curcas* seedlings

The effect of potassium on growth of different parts of seedlings has been presented in Table 4.4.

Root length

The root length significantly increased with the higher levels of potassium application. Maximum root length was recorded (19.33 cm) in K₃ followed by (18.10 and 17.73 cm) in K₂ and K₁ respectively. The range of root length varied from (7.71 to 17.73 cm), (9.56 to 18.10 cm) and (10.33 to 19.33 cm) in K₁, K₂ and K₃, treatments respectively.

Collar diameter

Collar diameter also showed the significant increment with the higher level of potassium application. The maximum collar diameter was recorded

(28.88 mm) in K₃ followed by (25.06 mm and 23.11 mm) in K₂ and K₁ treatments respectively. The range of collar diameter varied from (7.03 to 23.11mm), (8.18 to 25.06mm) and (8.13 to 28.88mm) K₁, K₂ and K₃ treatments respectively.

Shoot length

Shoot length was also significantly increased with higher level of potassium. The maximum shoot length was recorded (48.68 cm) in K₃ followed by (45.55 and 42.08 cm) in K₂ and K₁ treatments respectively. The range of shoot length varied from (11.23 to 42.08 cm), (12.13 to 45.55 cm) and (13.17 to 68.00 cm) in K₁, K₂ and K₃ respectively.

Number of leaves

Number of leaves significantly increased with the higher level of potassium application. Maximum number of leaves was recorded (42.13) in K₃ followed by K₂ and K₁ (38.91 and 35.01) treatments respectively. The number of leaves varied from (11.10 to 35.01), (12.16 to 38.91) and (13.02 to 42.13) in K₁, K₂ and K₃ treatments respectively.

4.1.2.4 Interaction effect of Nitrogen and Phosphorus (N x P) on growth attributes of *Jatropha curcas* seedlings

The results of interaction of nitrogen and phosphorus are presented in Table 4.5. The table shows that there is a significant influence of nitrogen and phosphorus interaction on growth attributes in the seedlings.

Root length

The interaction of N x P showed non-significant results during 90 and 120 DAT. The results were significant during 30 and 60 DAT. Maximum value

was recorded (14.01 cm) in N_3P_1 followed by N_1P_3 , N_3P_2 and N_2P_3 (13.56, 13.19 and 13.18cm) respectively. Minimum value was recorded (11.17cm) in N_1P_2 treatment.

Collar diameter

Collar diameter also influenced with the higher dose of N x P. Maximum collar diameter was recorded (25.11 and 25.00 mm) in N_3P_3 and N_3P_1 treatments respectively, followed by (24.17 and 24.05 mm) in N_3P_2 and N_2P_2 respectively. Minimum collar diameter was recorded (20.17 and 20.18 mm) in N_1P_3 and N_1P_1 combinations respectively. The range of collar diameter varied from (12.23 to 25.11 mm), (11.71 to 25.00 mm) in N_3P_3 and N_3P_1 followed by (9.13 to 20.17 mm), (8.19 to 20.18 mm) in N_1P_1 and N_1P_3 treatment respectively.

Shoot length

Shoot length was also influenced with the higher level of N x P. The maximum shoot length was recorded (43.41 cm) in N_3P_3 combination followed by N_3P_2 (42.43 cm). The minimum shoot length was recorded in N_2P_2 (35.07 cm) followed by (35.17 and 35.40 cm) in N_1P_1 and N_1P_2 combination respectively. The range of shoot length varied from (18.91 to 43.41 cm) in N_3P_3 and (17.11 to 42.23 cm) in N_3P_2 . The minimum range varied from (13.01 to 35.17 cm), (14.03 to 35.40 cm) in N_1P_1 , N_1P_2 combinations respectively.

Number of leaves

A significant interaction of N x P was found with higher level of these nutrients. The maximum number of leaves was recorded (35.88, 35.37 and 35.16) in N_3P_3 , N_3P_2 and N_3P_1 while minimum (28.13) in N_1P_1 treatment. The

number of leaves varied from (16.31 to 35.16), (16.32 to 35.37) and (17.19 to 35.88) in N_3P_1 , N_3P_2 and N_3P_3 treatments respectively. The minimum number of leaves was recorded (12.73 to 28.13) in N_1P_1 combination.

4.1.2.5 Interaction effect of Nitrogen and Potassium (N x K) on growth attributes of *Jatropha curcas* seedling

The interaction of nitrogen and potassium on growth attributes is presented in Table 4.6.

Root length

Effect of N x K combinations on root length increment of *Jatropha curcas* seedlings gave non significant results at 120 DAT. The results were significant at 30 to 90 DAT. The maximum value was recorded (19.03 cm) for N_3K_1 followed by N_2K_3 (18.96 cm) respectively. The minimum value was recorded (16.99 cm) for N_1K_1 treatment.

Collar diameter

Collar diameter increment was also found non-significant while using different levels of N and K combination at 120 DAT. The results were significant at 30 to 90 DAT. The maximum value was recorded (20.86 cm) for N_3K_3 followed by N_3K_2 (19.39 cm) respectively. The minimum value was recorded (14.00 cm) for N_1K_1 treatment.

Shoot length

Shoot length also showed non-significant effect of different level of N and K combination at 30 and 120 DAT. The results were significant at 60 to 90 DAT. The maximum value was recorded (29.06 cm) for N_3K_3 followed by

N₃K₂ (28.01 cm) respectively. The minimum value was recorded (23.01 cm) for N₁K₁ treatment.

Number of leaves

Different combination of N x K showed significant effect on increase in number of leaves. Maximum number of leaves were recorded (35.02, 35.03) in N₂K₂ and N₃K₃ followed by N₃K₁ (34.94), while minimum number of leaves were recorded (28.00) in N₁K₁. The number of leaves varied from (14.47 to 35.02), (17.29 to 35.03) in N₂K₂ and N₃K₃ followed by (15.91 to 34.94) in N₃K₁. The minimum number of leaves varied from (12.39 to 28.00) in N₁K₁ treatment.

4.1.2.6 Interaction effect of Phosphorus and Potassium (P x K) on growth attributes of *Jatropha curcas* seedling.

The interaction of Phosphorus and Potassium on growth attributes of *Jatropha curcas* seedlings have been presented in Table 4.7

Root length

No significant interaction of Phosphorus and Potassium was recorded on root length increment at 30 and 120 DAT. The results were significant at 60 to 90 DAT. The maximum value was recorded (19.01 cm) for P₃K₃ followed by P₃K₂ (18.93 cm) respectively. The minimum value was recorded (15.96 cm) for P₁K₁ treatment.

Collar diameter

The interaction phosphorus and potassium in different levels showed a significant effect on collar diameter increment. The maximum collar diameter was recorded (26.31 mm) in P₃K₂ combinations followed by (25.13 mm) in

P₃K₃. The minimum value was recorded (21.23 and 21.78mm) in P₁K₁ and P₁K₂ combinations respectively. The range of collar diameter was recorded (12.04 to 26.31 mm), (13.01 to 25.31mm) in P₃K₂ and P₃K₃ followed by (8.40 to 21.23 mm), (8.73 to 21.78 mm) in P₁K₁ and P₁K₂ combinations respectively.

Shoot length

The phosphorus and potassium interaction influenced the shoot length significantly with the higher level of these nutrients. The maximum shoot length was recorded (42.48 cm) in P₃K₃ followed by (39.33 cm) P₃K₂ in while minimum value was recorded (32.3 cm) in P₁K₁. The shoot length range varied (19.89 to 42.48 cm), (17.44 to 39.33 cm) in P₃K₃ and P₃K₂ treatments, respectively. The minimum range was recorded (12.78 to 32.33 cm) in P₁K₁.

Number of leaves

Different levels of P x K significantly influenced the number of leaves with the higher level of these nutrients. Maximum number of leaves was recorded (28.09) in P₃K₃ respectively followed by (27.00 and 27.36) in P₃K₁ and P₃K₂ respectively. Minimum number was recorded (28.23) in P₁K₁. The number of leaves ranges from (18.04 to 28.09) in P₃K₃. It was (17.00 to 27.00), (17.83 to 27.36) in P₃K₁ and P₃K₂ treatments, respectively. The minimum value varied from (11.98 to 23.23) in P₁K₁ treatment.

4.1.2.7 Interaction effect of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on growth attributes of *Jatropha curcas* seedlings.

The interaction of N x P x K on growth attributes of *Jatropha curcas* seedlings has been presented in Table 4.8.

Root length

Interaction of N x P x K showed significant effect on root length increment it increases with the higher level combination of N, P and K. Maximum root length was recorded in three combinations recording (25.00, 25.11 and 25.78 cm) in $N_3P_1K_3$, $N_3P_3K_1$ and $N_3P_3K_3$, respectively, followed by (24.98 cm) in $N_3P_3K_2$. Minimum value was recorded (22.19 cm) in $N_1P_1K_1$ treatment. The root length varied (18.19 to 25.00 cm), (14.00 to 25.11 cm) and (19.47 to 25.78 cm) in $N_3P_1K_3$, $N_3P_3K_1$ and $N_3P_3K_3$ respectively. The minimum root length varied (13.04 to 22.19 cm) in $N_1P_1K_1$ treatment.

Collar diameter

The interaction of N x P x K on collar diameter showed significant effect with higher level of these nutrients. Maximum collar diameter was recorded (34.0 mm) in $N_3P_3K_3$ followed by (33.66 and 33.89 mm) in $N_3P_3K_1$ and $N_3P_3K_2$ treatments, respectively. The minimum value was recorded (26.11 and 26.98 mm) in $N_1P_1K_1$ and $N_1P_1K_2$ treatments, respectively. The collar diameter varied from (17.11 to 33.66 mm) (17.17 to 33.89 mm) and (18.00 to 24.00 mm) in $N_3P_3K_1$, $N_3P_3K_2$ and $N_3P_3K_3$ treatments, respectively. The minimum range of collar diameter was recorded (13.01 to 26.11 mm) in $N_1P_1K_1$.

Shoot length

The interaction of N x P x K in different levels also showed significant increase on shoot length with the higher level of these nutrients. Maximum length was recorded (47.09 and 47.38 cm) in $N_3P_3K_2$ and $N_3P_3K_3$ treatments, followed by (46.09 and 46.89 cm) in $N_3P_2K_3$ and $N_3P_3K_1$. The minimum values

were recorded (35.77 and 35.98 cm) in $N_1P_1K_1$ and $N_1P_1K_2$ combinations, respectively. The shoot length varied from (15.04 to 35.77 cm), (15.34 to 35.98 cm) in $N_1P_1K_1$ and $N_1P_1K_2$ followed by (22.94 to 47.08 cm), (23.01 to 47.88 cm) in $N_3P_3K_2$ and $N_3P_3K_3$ combinations, respectively.

Number of leaves

Different levels of N x P x K interaction reveals that the number of leaves increased significantly with the higher levels of nutrients. Maximum number of leaves was recorded (40.05) in $N_3P_3K_3$ followed by (39.01, 39.32 and 39.48) $N_3P_2K_3$, $N_3P_3K_1$ and $N_3P_3K_2$ treatments, respectively. The minimum number of leaves was recorded (31.06, 31.73 and 31.94) in $N_1P_1K_1$, $N_1P_1K_2$ and $N_1P_1K_3$ treatments, respectively. The number of leaves varied from (21.01 to 41.05) in $N_3P_3K_3$ and (14.98 to 31.06) in $N_1P_1K_1$ combinations, respectively.

4.2 Biomass accumulation in *Jatropha curcas* seedlings

4.2.1 Biomass accumulation in response to organic manure

4.2.1.1 Above ground biomass

The above ground biomass of *Jatropha curcas* seedlings are presented in Table. 4.9. This table represents the effect of FYM and PM on above ground biomass and sole crop of the seedlings. The above ground biomass was calculated by summing up the foliage + stem. The results obtained with this experiment revealed that the above ground biomass increased with the higher level of FYM and PM. The maximum above ground biomass was recorded (47.58 g/ seedling) in OFT_3 followed by (43.31 g/ seedling and 39.70 g/ seedling) in OFT_2 and OFT_1 , respectively. The PM gave maximum above ground biomass (63.23 g/ seedling) in OPT_3 followed by (40.52, 33.42 g/

seedling) in OPT₂ and OPT₁ respectively. While in control it was minimum (28.24 g/seedling) respectively.

4.2.1.2 Below ground biomass

Below ground biomass is calculated by summing up taproot + fine roots, the values are presented in Table 4.9. Similar trend was recorded, as it was in above ground biomass, it slightly increased with the higher level of FYM it was recorded maximum (8.43 g/ seedling) in OPT₃ followed by (8.26 and 8.12 g/seedling) OPT₂ and OPT₁ treatment respectively. The poultry manure treatment showed the maximum below ground biomass (9.40 g/seedling) in OPT₃ followed by (8.30 and 8.10 g/seedling) in OPT₂ and OPT₁ treatment, respectively. While it was recorded minimum (6.33 g/ seedling) in control.

4.2.2 Biomass accumulation in response to inorganic fertilizers

4.2.2.1 Influence of Nitrogen on biomass accumulation

The higher level of nitrogen showed a significant response on above and below ground biomass of the seedlings which is represented in Table 4.10. Above ground biomass was recorded maximum (50.44 g/seedling) in N₃ followed by (45.07 and 43.59 g/seedling) in N₂ and N₁ treatment, respectively. Similar trend was recorded in below ground biomass, maximum below ground biomass was recorded (15.95 g/seedling) in N₃ followed by (14.58, 13.38 g/seedling) in N₂ and N₁ treatments, respectively.

4.2.2.2 Influence of Phosphorus on biomass accumulation

The effects of phosphorus on biomass accumulation have been tabulated in Table 4.10. Phosphorus also showed significant effect on above ground biomass accumulation. Maximum above ground biomass was recorded (53.12

g/seedling) in P_3 followed by (48.98, 45.0 g/seedling) in P_2 and P_1 respectively. Below ground biomass was also recorded maximum (15.60 g/seedling) in P_3 followed by (14.70, 13.14 g/seedling) in P_2 and P_1 , respectively.

4.2.2.3 Influence of Potassium on biomass accumulation

The effect of potassium on above and below ground biomass is represented in table 4.10. The above and below ground biomass showed significant increment with the higher level of potassium. The maximum above ground biomass was recorded (55.80 g/seedling) in K_3 followed by (48.36, 45.94 g/ seedling) in K_2 and K_1 treatments, respectively. Similar trend was recorded in below ground biomass it was recorded maximum (15.85 g/seedling) in K_3 followed by (14.78, 13.31 g/seedling) in K_2 and K_1 treatments, respectively.

4.2.2.4 Interaction effect of Nitrogen and Phosphorus (N x P) on biomass accumulation

The interaction of N x P presented in Table 4.11. The interaction of N x P on above ground biomass had a significant influence with higher levels of nutrients. The maximum above ground was recorded (50.48 g/seedling) in N_3P_3 followed by (49.09, 48.75 g/seedling) in N_3P_2 and N_3P_1 . While the minimum biomass was recorded (43.02 g/seedling) in N_1P_1 . The similar trend was also found in below ground biomass. Maximum below ground biomass was recorded (15.68 g/seedling) in N_3P_3 followed by (14.46, 13.85, 13.49 g/seedling) N_3P_2 , N_2P_2 and N_2P_1 treatments, respectively. The minimum below ground biomass was recorded (12.57 g/seedling) in N_3P_1 treatment. In this

treatment the below ground biomass decreased statistically as compared with other treatments.

4.2.2.5 Interaction effect of Nitrogen and Potassium (N x K) on biomass accumulation

The effect of N x K on above ground and below ground biomass is presented in Table 4.12. The above ground biomass slightly influenced statistically with the higher level of nutrient but below ground biomass showed non-significant effect of N x K. The maximum above ground biomass was recorded (51.33 g/seedling) in N_3K_2 followed by (49.79, 46.42, 45.99 g/seedling) in N_3K_3 , N_3K_1 and N_1K_3 combinations, respectively. The minimum value was recorded (42.32 g/seedling) in N_1K_1 combination. The interaction between N x K did not showed any significant effect on below ground biomass.

4.2.2.6 Interaction effect of Phosphorus and Potassium (P x K) on biomass accumulation

Table 4.13 represents the interaction effect of P x K on biomass accumulation in *Jatropha curcas* seedlings. The interaction of P x K on above and below ground biomass accumulation influenced significantly with the higher level of P and K. The above ground biomass was recorded maximum (48.30, 48.10 g/seedling) in P_3K_2 and P_3K_3 followed by (47.41 and 46.65 g/seedling) for P_1K_3 and P_2K_3 treatments, respectively. The minimum biomass was recorded (43.53 g/ seedling) in P_1K_1 combination. The below ground biomass showed very less difference. The maximum below ground biomass was recorded (14.33, 14.33 g/seedling) in P_1K_1 and P_3K_3 combinations, respectively. The minimum value was recorded (12.98, 12.82 g/seedling) in P_2K_2 and P_2K_3 combinations, respectively.

4.2.2.7 Interaction effect of Nitrogen, Phosphorus and Potassium (N x P x K) on biomass accumulation in seedlings

Table 4.14 shows the effect of N x P x K interaction on biomass accumulation in seedlings. The interaction of N x P x K on biomass accumulation influenced significantly with the higher level of nutrients. The below ground biomass showed not much differences in biomass accumulation with the higher level of nutrients. There were 27 combinations, among the entire, maximum above ground biomass was recorded (53.61 of seedling) in $N_3P_3K_2$ followed by (50.65 and 50.35 g/seedling) in $N_3P_1K_2$ and $P_3P_2K_3$ combinations, respectively. Minimum above ground biomass was recorded (39.41 g/seedling) in $N_2P_1K_2$. The below ground biomass was recorded maximum (17.74 g/seedling) in $N_2P_2K_1$ combination, followed by $N_1P_1K_3$ combination (16.27 g/seedling). While, minimum was recorded (11.88 g/seedling) in $N_2P_1K_3$ combination.

4.3 Nutrient uptake by *Jatropha curcas* seedlings

4.3.1 Effect of organic manure on nutrient uptake

4.3.1.1 Nitrogen uptake

The nitrogen uptake by root, stem, and leaves are presented in Table 4.15.

Nitrogen uptake by roots

Results on different levels of FYM and poultry manure showed significant results on uptake of nitrogen it was increased with the higher level of FYM and poultry manure. The nitrogen uptake from FYM was recorded maximum (0.083g/seedling) in OFT_3 , followed by (0.080 and 0.078 g/seedlings) in OFT_2 and OFT_1 treatments, respectively. The nitrogen uptake by

the root varied from (0.026 to 0.078 g/ seedlings), (0.027 to 0.080 g/ seedlings) and (0.033 to 0.083 g/ seedling) in OFT₁, OFT₂ and OFT₃ treatments, respectively. The poultry manure also showed the maximum values (0.095g/ seedling) in OPT₃ followed by (0.084 and 0.082 g/ seedling) in OPT₂ and OPT₁ respectively. The nitrogen uptake range varied from (0.029 to 0.082 g/ seedling), (0.032 to 0.084 g/ seedling) and (0.036 to 0.095 g/ seedling) in OPT₁, OPT₂ and OPT₃ treatments, respectively. In control, the uptake was recorded relatively less than PM and FYM treatment

Nitrogen uptake by stem

Nitrogen uptake increases with the higher level of FYM and poultry manure. The nitrogen uptake was recorded maximum (0.39 g/ seedling) in OFT₃ followed by (0.25 and 0.23 g/ seedling) in OFT₂ and OFT₁, respectively. The uptake values varied from (0.14 to 0.23 g/ seedling), (0.17 to 0.25 g/ seedling) and (0.09 to 0.39 g/ seedling) in OFT₁, OFT₂ and OFT₃, respectively. The poultry manure also showed maximum nitrogen uptake (0.40 g/ seedling) in OPT₃ followed by (0.18 g/ seedling) in OPT₂ and minimum value was recorded (0.14 g/ seedling) in OPT₁. The uptake range varied from (0.21 to 0.14 g/ seedling), (0.20 to 0.18 g/ seedling) and (0.27 to 0.40 g/ seedling) in OPT₁, OPT₂ and OPT₃ treatments, respectively. The nutrient uptake in control, was relatively lower as compared to the seedlings treated with organic manure.

Nitrogen uptake by leaves

Effect of different level of FYM and poultry manure on uptake of nitrogen by the leaves significantly influenced the number of leaves increment with the higher level of these organic manure. Nitrogen uptake was recorded

maximum (0.32 g/ seedling) in OFT₃ followed by (0.30 g, 0.22g/ seedling) in OFT₂ and OFT₁ treatments, respectively. The nitrogen uptake varied from (0.065 to 0.22 g/ seedling), (0.073 to 0.30 g/ seedling) and (0.081 to 0.32 g/ seedling) in OFT₁, OFT₂, OFT₃, respectively. The nitrogen uptake from poultry manure showed maximum (0.39 g/seedling) in OPT₂ followed by (0.32, 0.31 g/ seedling) for OPT₁ and OPT₃ respectively. The nitrogen uptake varied from (0.079 to 0.31, 0.10 to 0.39 and 0.11 to 0.32 g/ seedling) in OPT₁, OPT₂ and OPT₃, respectively. The high and low level of poultry manure showed decrease in number of leaves in seedlings. The nutrient uptake in control was relatively lower as compared to the seedlings treated with organic manure.

4.3.1.2 Phosphorus uptake

The effect of different levels of FYM and poultry manure on uptake of phosphorus by root, stem and leaves are presented in Table 4.16.

Phosphorus uptake by roots

Effect of different levels of FYM and poultry manure on uptake of phosphorus by the root did not influenced significantly. Only 90 DAT showed significant result in root development. The maximum value recorded was (0.064 g/ seedling) in OPT₃ treatment. The minimum was recorded (0.036 g/ seedling) in OFT₁ treatment. The nutrient uptake in control , was relatively lower as compared to the seedlings treated with organic manure.

Phosphorus uptake by stem

Phosphorus uptake by stem showed significant results with the higher levels of organic manure uptake was more. The maximum value was recorded (0.53 g/ seedling) in OFT₃ followed by (0.32 and 0.34 g/ seedling) in OFT₂ and

OFT₁, respectively. The phosphorus uptake varied from (0.11 to 0.32 g/ seedling), (0.16 to 0.34 g/ seedling), (0.19 to 0.53 g/ seedling) in OPT₁, OPT₂, OPT₃ treatment, respectively. The phosphorus uptake from the poultry manure was recorded maximum (0.54 g/ seedling) in OPT₃ followed by (0.25 and 0.19 g/ seedling) in OPT₂ and OPT₁, respectively). The phosphorus uptake varied from (0.26 to 0.19 g/ seedling), (0.26 to 0.25, 0.32 to 0.54 g/ seedling) for OPT₁, OPT₂ and OPT₃, respectively. The nutrient uptake in control was relatively lower as compared to the seedlings treated with organic manure.

Phosphorus uptake by leaves

Results on phosphorus uptake from different levels of FYM and poultry manure showed significant results. It was observed that number of leaves increases with higher level of organic manure. The phosphorus uptake was recorded maximum (0.19 g/ seedling) in OFT₃ followed by (0.19 and 0.16 g/ seedling) in OFT₂ and OFT₁ treatments, respectively. The phosphorus uptake ranges from (0.02 to 0.16, 0.02 to 0.19 and 0.02 to 0.19 g/ seedling) in OFT₁, OFT₂ and OFT₃ treatments, respectively. In poultry manure, phosphorus uptake was recorded maximum (0.31 g/ seedling) in OPT₃ followed by (0.27, 0.23 g/ seedlings) in OPT₂ and OPT₁ treatments, respectively. The phosphorus uptake varied from (0.028 to 0.23, 0.030 to 0.27 and 0.032 to 0.31 g/ seedling) for OPT₁, OPT₂ and OPT₃ treatments, respectively. The nutrient uptake in control, was relatively lower as compared to the seedlings treated with organic manure.

4.3.1.3 Potassium uptake

The potassium uptake by leaves, stem and roots for FYM and poultry manure is presented in Table 4.17.

Potassium uptake by roots

The rate of potassium uptake from FYM and poultry manure by roots showed significant results with the higher level except at 90 days after transplanting. The uptake of potassium by root from FYM was recorded maximum (0.086 g/ seedling) in OFT₃ followed by (0.085 and 0.082 g/seedling) for OFT₂ and OFT₁ treatments. The potassium uptake varied from (0.019 to 0.082 g/ seedling) (0.020 to 0.085 g/ seedling) and (0.021 to 0.086 g/ seedling) in OFT₁, OFT₂ and OFT₃ treatments, respectively. The potassium uptake from poultry manure showed maximum (0.099 g/ seedling) in OPT₃ followed by (0.086 and 0.084 g/ seedling) for OPT₂ and OPT₁ treatment. The potassium uptake varied from (0.020 to 0.084 g/ seedling), (0.022 to 0.086 g/ seedling) and (0.023 to 0.099 g/ seedling) in OPT₁, OPT₂ and OPT₃ treatment respectively. In control low nutrient uptake was observed as compared to the seedlings treated with PM and FYM.

Potassium uptake by stem

The potassium uptake by stem from different levels of FYM and poultry manure increased significantly with the higher level of organic manure application. The uptake of potassium by stem from FYM was recorded (0.47 g/ seedling) in OFT₃ followed by (0.30 and 0.28 g/ seedling) OFT₂ and OFT₁ treatments respectively. The potassium uptake varied from (0.040 to 0.28 g/ seedling), (0.40 to 0.301 g/ seedling) and (0.041 to 0.47 g/ seedling) in OFT₁, OFT₂, OFT₃ treatments, respectively. The poultry manure showed maximum uptake value (0.048 g/ seedling) in OPT₃ followed by (0.21 and 0.17 g/ seedling) in OPT₂ and OPT₁ treatments, respectively. The uptake varied from

(0.041 to 0.14, 0.043 to 0.21 and 0.044 to 0.48 g/ seedling) in OPT₁, OPT₂, OPT₃ treatment respectively. In control low nutrient uptake was observed as compared to the seedlings treated with PM and FYM.

Potassium uptake by leaves

Results on potassium uptake from different levels of FYM and poultry manure increased significantly with the higher level of manure application (0.27 g/ seedling). The potassium uptake was recorded maximum (0.27 g/ seedling) in OPT₃ followed by (0.27 and 0.21 g/ seedling) OPT₂ and OPT₁ treatments respectively. The potassium uptake varied from (0.06 to 0.21, 0.06 to 0.27 and 0.07 to 0.27 g/ seedling) in OPT₁, OPT₂ and OPT₃ treatments, respectively. The potassium uptake from poultry manure showed maximum (0.37 g/ seedling) in OPT₃ followed by (0.32 and 0.27 g/ seedling) in OPT₂ and OPT₁ treatments respectively. The potassium uptake varied from (0.06 to 0.27, 0.07 to 0.32 and 0.078 to 0.37 g/ seedling) in OPT₁, OPT₂, and OPT₃ treatments respectively. In control low nutrient uptake was observed as compared to the seedlings treated with PM and FYM.

4.3.2 Influence of inorganic fertilizers on nutrient uptake

4.3.2.1 Influence of Nitrogen on nutrient uptake

The values of nutrient uptake by root, stem, leaves from inorganic fertilizer have been presented in Table 4.18.

Nutrient uptake by roots

The values of nutrient uptake by roots showed very less variation in quantity in different level of inorganic fertilizer. Statistically the values were found significant. Maximum uptake was recorded (0.083 g/seedling) in N₃

followed by (0.082g/seedling) in N_1 while, minimum was recorded (0.050 g/seedling) in N_2 treatment. The uptake values varied from (0.19 to 0.083, 0.012 to 0.083 and 0.015 to 0.080g/seedling) for N_3 , N_1 and N_2 treatments, respectively.

Nutrient uptake by stem

The nutrient uptake from inorganic fertilizers significantly increased with the higher level. The uptake by stem was recorded maximum (0.30g/seedling) in N_3 followed by (0.17g/seedling) in N_1 and minimum was recorded (0.13g/seedling) in N_2 . The uptake range varied from (0.052 to 0.30, 0.033 to 0.17, and 0.043 to 0.13 g/seedling) in N_3 , N_1 , and N_2 treatments, respectively.

Nutrient uptake by leaves

Different levels of nitrogen showed significant effect on nutrient uptake in leaves with higher levels. In leaves the uptake of nitrogen was recorded maximum (0.40 g/ seedling) in N_3 followed by (0.09 g/seedling) in N_2 treatment. While, minimum was recorded (0.05 g/ seedling) in N_1 treatment. The nitrogen uptake was varied from (0.19 to 0.051, 0.023 to 0.095 g/ seedling 0.031 to 0.40 g/ seedling) in N_1 , N_2 , and N_3 treatment, respectively.

4.3.2.2 Influence of Phosphorus on nutrient uptake

The values of phosphorus uptake by root, stem and leaves have been presented in Table 4.19.

Nutrient uptake by roots

The nutrient uptake by roots from phosphorus increased significantly with the higher levels. The uptake of phosphorus was recorded maximum (0.041g/ seedling) in P_3 followed by (0.032 g/ seedling) in P_2 and P_1

treatments, respectively. The uptake of phosphorus varied from (0.010 to 0.032, 0.015 to 0.032 and 0.016 to 0.041 g/ seedling) in P_1 , P_2 and P_3 treatments, respectively.

Nutrient uptake by stem

The rate of nutrient uptake from phosphorus increased significantly with the higher levels. The phosphorus uptake was recorded maximum (0.36 g/ seedling) in P_3 followed by (0.35 g/ seedling) in P_2 while minimum was recorded (0.13/ seedling) in P_1 treatment. The phosphorus uptake varied from (0.045 to 0.13, 0.053 to 0.35 and 0.068 to 0.36 g/ seedling) in P_1 , P_2 , and P_3 treatments, respectively.

Nutrient uptake by leaves

Uptake of phosphorus by leaves has been found significant. Maximum value was recorded (0.056 g/ seedling) in P_2 followed by (0.037 g/ seedling) in P_1 while minimum was recorded (0.021 g/ seedling) in P_3 treatment respectively. The uptake of phosphorus varied from (0.018 to 0.037, 0.023 to 0.056 and 0.024 to 0.021 g/ seedling) P_1 , P_2 and P_3 treatments, respectively.

4.3.2.3 Influence of Potassium on nutrient uptake

The value of potassium uptake by roots, stem and leaves has been presented in Table 4.20.

Nutrient uptake by roots

The uptake of potassium by roots showed that higher level adversely affected the low uptake of potassium while medium level of fertilizer gave significant results followed by lower level. In these treatments maximum values was recorded (0.48 g/ seedling) in K_2 treatment followed by (0.40, 0.053 g/

seedling) in K_1 and K_3 treatments respectively. The potassium uptake varied from (0.011 to 0.40, 0.015 to 0.048 and 0.017 to 0.053 g/ seedling) in K_1 , K_2 and K_3 treatments, respectively.

Nutrient uptake by stem

The uptake of potassium by stem increased significantly with the higher level. Maximum value was recorded (0.10 g/ seedling) in K_2 and K_3 treatments minimum was recorded (0.057 g/ seedlings) in K_1 . The potassium uptake varied from (0.027 to 0.10, 0.051 to 0.10 and 0.018 to 0.057 g/ seedling) in K_2 , K_3 and K_1 treatments respectively.

Nutrient uptake by leaves

The uptake of potassium by leaves increases significantly with the higher level. The potassium uptake was recorded maximum (0.034 g/ seedling) in K_2 followed by (0.032 g/ seedling) K_3 and minimum was recorded (0.024 g/ seedling) in K_1 treatment respectively. The potassium uptake varied from (0.013 to 0.024, 0.016 to 0.034 and 0.019 to 0.032 g/ seedling) in K_1 , K_2 and K_3 treatments, respectively.

4.3.2.4 Interaction effect of Nitrogen and Phosphorus (N x P) on nutrient uptake

The interaction of nitrogen and phosphorus by different plant parts has been tabulated in Table 4.21.

Nutrient uptake by roots

Statistically, nitrogen and phosphorus interaction did not showed any significant influence on nutrient uptake by roots. Seedlings of 60 DAT only

gave significant influence of N x P. The maximum value recorded was (0.04 g/ seedling) for N₂P₂, N₃P₁, N₃P₃ treatments respectively.

Nutrient uptake by stem

Interaction of N x P on stem was found significant the uptake was more in higher level of nutrients. The maximum value was recorded (0.22 g/ seedling) in N₃P₂ and N₃P₃ treatments followed by (0.21 g/ seedling) N₁P₃, N₂P₃ and N₃P₁, combinations respectively. It was recorded minimum (0.19 g/ seedling) in N₂P₂ treatment. The uptake varied from (0.07 to 0.22, 0.08 to 0.22, 0.06 to 0.19 g/ seedling) in N₃P₃, N₃P₂ and N₂P₂ treatments, respectively.

Nutrient uptake by leaves

Interaction of N x P on uptake of nutrients by leaves showed significant result. The uptake was more with the higher levels of these nutrients. The maximum value was recorded (0.11 g/ seedling) in N₃P₃ followed by (0.10 g/ seedling) in N₃P₂ while minimum was recorded (0.05 g/ seedling) in N₂P₁. The uptake varied from (0.06 to 0.11, 0.05 to 0.10 and 0.04 to 0.05 g/ seedling) in N₃P₃, N₃P₂ and N₂P₁ treatments, respectively. The interaction was found non-significant during 60 to 90 DAT in the seedlings

4.3.2.5 Interaction effect of Nitrogen and Potassium (N x K) on nutrient uptake

The interaction of nitrogen and potassium on different plant parts has been tabulated in Table 4. 22.

Nutrient uptake by roots

Interaction of N x K on roots during 120 DAT of seedling was statistically non significant. It was significant during 30 to 90 DAT. The

maximum value was recorded (0.07 g/ seedling) in N_3K_3 and minimum in (0.04 g/ seedling) in N_2K_1 treatments respectively. The uptake varied from (0.01 to 0.04, 0.02 to 0.04 g/ seedling) in N_1K_1 and N_1K_2 combinations respectively.

Nutrient uptake by stem

The interaction of nitrogen and potassium was found to be statistically significant. The different levels of N x K showed that stem uptake values were recorded maximum (0.21 g/ seedling) in N_3K_3 , N_3K_2 and N_2K_3 combinations followed by (0.20, 0.19 g/ seedling) in N_3K_1 , N_2K_2 , N_3K_3 , N_1K_2 and N_1K_1 , treatments respectively. Minimum was recorded (0.18 g/ seedling) in N_2K_1 . The range varied from (0.07 to 0.19 g/ seedling), (0.07 to 0.21 g/ seedling) in N_1K_1 and N_3K_3 combinations respectively.

Nutrient uptake by leaves

Higher levels of nitrogen and potassium showed significant effect on uptake of nutrients by leaves. Maximum values were recorded (0.11 g/ seedling) in N_3K_2 followed by (0.10 g/ seedling) in N_3K_3 while minimum was recorded (0.05 g/ seedling) in N_1K_1 treatments respectively. The uptake by leaves varied from (0.03 to 0.05, 0.04 to 0.11 and 0.05 to 0.10 g/ seedling) in N_1K_1 , N_3K_2 and N_3K_3 combinations, respectively.

4.3.2.6 Interaction effect of Phosphorus and Potassium (P x K) on nutrient uptake

The values of phosphorus and potassium uptake by roots, stem and leaves have been presented in table 4.23.

Nutrient uptake by roots

The interaction of phosphorus and potassium on uptake of nutrients by roots was non significant during 30 and 120 DAT. The interaction was found significant during 60 and 90 DAT. The maximum value recorded (0.06 g/seedling) in P₃K₂ and P₃K₃ combinations respectively. The minimum was recorded (0.04 g/seedling) in P₁K₁ and P₁K₂ combinations respectively.

Nutrient uptake by stem

The interaction of phosphorus and potassium on uptake of nutrients by stem showed non significant results during 120 DAT. It was found significant during 30 to 90 DAT. The maximum value recorded (0.12 g/seedling) in P₃K₂ and P₃K₃ combinations respectively. The minimum was recorded (0.10 g/seedling) in P₁K₁ and P₁K₂ combinations respectively.

Nutrient uptake by leaves

The interaction of phosphorus and potassium on uptake of nutrients by leaves was non-significant during 30 and 120 DAT. The interaction was found significant during 60 and 90 DAT. The maximum value recorded (0.07 g/seedling) in P₃K₃ combination respectively. The minimum was recorded (0.05 g/seedling) in P₁K₁, P₁K₃, P₂K₁, P₂K₂ combinations respectively.

4.3.2.7 Interaction effect of Nitrogen, Phosphorus and Potassium (N x P x K) on nutrient uptake

The interaction of nitrogen, phosphorus and potassium uptake by roots, stem and leaves have been presented in table 4.24.

Nutrient uptake by roots

The interaction of N x P x K showed significant results for uptake of nutrients by roots. Maximum values were recorded (0.12 and 0.09 g/seedling) for $N_3P_3K_3$ and $N_3P_2K_3$ followed by (0.08 g/seedling) in $N_3P_3K_3$ and $N_3P_3K_2$. Minimum values were recorded (0.06 g/seedling) in $N_1P_3K_1$, $N_1P_3K_2$ and $N_2P_1K_2$ combinations respectively. The uptake varied from (0.03 to 0.09 g/seedling) and (0.04 to 0.09 g/ seedling) in $N_2P_3K_3$ and $N_3P_2K_3$, (0.03 to 0.06 g/seedling) and (0.02 to 0.06 g/seedling) in $N_1P_3K_1$, $N_1P_3K_2$ and $N_2P_1K_2$ combinations respectively.

Nutrient uptake by stem

The interaction of N x P x K showed statistically significant results for uptake of nutrient by stem. Maximum value was recorded (0.21g/seedling) in $N_3P_3K_3$ and $N_3P_1K_3$ followed by (0.20 g/seedling) in $N_3P_2K_2$, $N_3P_2K_3$ and $N_3P_3K_1$ combinations respectively. Minimum value was recorded (0.15 g/seedling) in $N_2P_2K_1$, $N_2P_1K_2$ and $N_1P_3K_1$ combinations respectively. The range recorded was (0.09 to 0.21 g/seedling), (0.08 to 0.21g/seedling) in $N_3P_3K_3$ and $N_3P_1K_3$ combination.

Nutrient uptake by leaves

The leaves also showed the significant effect on nutrient uptake. The maximum value was recorded (0.15 g/seedling) in $N_3P_3K_2$ followed by (0.13g/seedling) by $N_3P_2K_2$. It was recorded minimum (0.05 g/ seedling) in $N_1P_1K_1$, $N_1P_3K_1$ treatments respectively. The nutrient uptake varied from (0.03 to 0.05 g/ seedling), (0.04 to 0.05 g/ seedling) in $N_1P_1K_1$ and $N_1P_3K_1$ treatments respectively.

CHAPTER-V

DISCUSSION

The results of the experiment entitled “Effect of organic and inorganic fertilizers on growth behavior of oil yielding plant *Jatropha curcas* seedlings in nursery are discussed. The discussion is based on the results obtained in the experiment and past work done on similar studies by other workers under the following heads:

- 5.1 Effect of organic manure and inorganic fertilizers on growth behavior of *Jatropha curcas* seedlings in nursery
- 5.2 Biomass accumulation as influenced by organic manure and inorganic fertilizers
- 5.3 Nutrient uptake as influenced by organic manure and inorganic fertilizers
- 5.1 Effect of organic manure and inorganic fertilizers on growth behavior of *Jatropha curcas* seedlings in nursery**

The perusal of data on growth attributes influenced by different level of organic manure i.e. farm yard manure and poultry manure revealed that the growth of seedlings increased with the higher level of manure application. It is evident from the results (Table 4.1) that the higher level of poultry manure influenced the root, shoot length, collar diameter and number of leaves as compared to FYM, while in control it was minimum. The poultry manure showed maximum growth of root, shoot length (35.33 and 56.67 cm) and collar diameter, number of leaves (35.25 mm and 52.33) respectively, while FYM

showed root, shoot length (34.60 and 51.00 cm) and collar diameter, number of leaves (31.75 mm and 47.76) respectively. The reduction in overall growth of the seedling under FYM may be due to fewer amount of available N, P and K as compared to poultry manure. Similar observations were obtained by (Banerjee *et al.*, 1999) they reported that addition of compost to the spoil in various proportions has been found to increase the height of *D. sissoo* significantly with the maximum value (60.9 cm) in (1:2) spoil: compost combination, while it was minimum in control.

The effect of organic matter on growth of nursery seedlings were higher, similar results have been reported by (Vashishta *et al.*, 1997). This may be due to higher amount of simpler form of carbohydrates in pressmud than in FYM. Therefore, the higher amount of readily available energy source (sugar and carbohydrates) in pressmud might have resulted in building up more microbial population and activities under pressmud than FYM, consequently releasing more amount of available nutrients in pressmud than FYM. This is evident in the present study. Similar results were reported by (Gopikumar *et al.*, 2002). It was observed that that potting mixture consisting of soil and cowdung with two weeks decomposed garbage were found to be most promising. The height, diameter and leaf area could be considered as important criteria for measuring vigour of seedling as is reported by (Hendraman, 1998). Similar results were also obtained by (Tripathi and Bajpai, 1984). El-Nour and El-Hasan, (1987) reported the best growth for *Eucalyptus camaldulensis* seedlings. These above results are in confirmation with the findings of the present investigation.

The effect of inorganic fertilizers in growth of the seedlings is presented in Table 4.2. The present investigation revealed that the higher level of nutrients generally increase the growth rate of *Jatropha curcus* as compared with lower level of fertilizers and control. In case of root, nitrogen gave non-significant results at 120 DAT, while it was significant during 30 to 90 DAT. This may be nitrogen play a little role in root development in later stage. In case of collar diameter, shoot length and number of leaves all the parameters revealed the higher growth with the increase of nitrogen.

Influence of phosphorus revealed that root, shoot, collar diameter and number of leaves increased significantly with the higher level of phosphorus application. It was observed non-significant during 30 DAT in collar diameter and during 30 to 60 DAT for number of leaves. This may be that *Jatropha curcas* seedlings require less amount of phosphorus during early age.

Effect of potassium on growth of *Jatropha curcus* seedlings is presented in Table 4.4. It is evident from the results obtained from this investigation that potassium play a significant role in overall growth of seedling. The growth of root, shoot, collar diameter and number of leaves increased significantly with the higher level of potassium application in the potting media (Singh *et al.*, 1995) reported that mixing of compost and fertilizers in coal mine over burden, while (Williams *et al.*, 1994) in copper mine overburden responded positively towards increasing growth of *Albizia procera*. The above finding shows that application of inorganic fertilizers at seedling stage in nursery helps in production of healthy stock with higher biomass and sturdy root system capable of growing successfully when transplanted in field.

Inorganic fertilizers play an important role to enhance the growth of the seedling and minimize the time as required for the transplantable size (Qureshi and Yadav, 1977; Mohan *et al.*, 1990; Rangaswamy *et al.*, 1991). The data presented in Table 4.2 and 4.8 revealed that the shoot length, collar diameter, number of leaves and root length of *Jatropha curcus* seedlings have been increased significantly with the higher level of fertilizer application. However, control showed minimum growth for all the parameters of the seedlings as compared by the inorganic fertilizer. Similar results have been reported by Jha *et al.* (2000) in *Dalbergia sissoo* seedlings it was recorded that the application of higher doses of inorganic fertilizer results in increase number of leaves, plant height, collar diameter with the increase in age of seedling in each treatment. The values obtained for plant height were (8.33) and (0.96 cm) for collar diameter respectively this resulted with the higher level of N.

The other workers who conducted the nursery experiment regarding seedling growth and biomass are (Sonkar and Kumbhare, 1991; Sonkar *et al.* 1991; Totey *et al.* 1988) indicated that a balance dose of nutrients may boost up the growth of seedling and make them early as a plantable size within a period of 4-5 months. Similar findings were given by Sonkar *et al.* (1993) on *Eucalyptus tereticornis* seedlings when increasing levels of N alone and in combinations with P and K as a basal dose given to the seedling. They reported that the shoot length (147.47cm) was obtained when 300kg/ha nitrogen and 100 kg/ha phosphorus, were applied. Similar findings were also reported by Seshagiri *et al.* (1984) in *Eucalyptus citridora*. The above reports are conformation with the results obtained in the present investigation.

The application of N accompanied with phosphors boosts up the growth of seedlings as compared to separate application of N and P. The interaction of N and P showed significant increase in shoot length with the higher level of these nutrients, while root it was nonsignificant during 90 and 120 DAT. Collar diameter and number of leaves also showed significant results. This may be ascribed as the ammonical form of nitrogenous fertilizers is known to stimulate phosphorus uptake as reported by (Tisdale and Nelson, 1966) they reported that phosphorus become more available to the plant when supplied with nitrogen (Nayyar and Sawarkar 1980; Mathur *et al.*, 1978). Singh and Banerjee (1999) reported similar finding for fertilizers N, P and K response to *Albizia procera* in skeletal soil. The maximum height (63.0 cm), collar diameter (1.53 cm) was obtained when N-150, P₂O₅-50 and K₂O-50 kg ha⁻¹ in combined farm applied in the field. These results are in confirmation with the results obtained in present investigation.

Interaction of N x P on growth attributes of *Jatropha curcas* is presented in Table 4.6. The data revealed that there was no significant effect of N x P observed interaction during 120 DAT in root, shoot and collar diameter, however, leaves showed significant result. The reverse trend was observed during 30 to 90 DAT in root, shoot and collar diameter it was almost at par with the significant, while for leaves it was non significant during 60 and 90 DAT.

The above trend is in confirmation with the results obtained by the Prasad and Rawat (1994). They reported that application of K₂O had no significant effect on height growth of FRI-4 and FRI-5 clones of *Eucalyptus*

species. When factorial combination of N, P and K was applied maximum height growth after six month in FRI-4 was noticed.

Interaction of P x K on growth attributes are presented in Table 4.7. The data reveals that root did not gave any significant result in 30 and 120 DAT. Simultaneously it gave significant values during 60 and 90 DAT. Collar diameter, shoot length and number of leaves showed significant interaction of P and K. This may be ascribed as root may not require much K and P during early and later age. Seedling growth however collar diameter, shoot length and number of leaves significantly increased with the higher level of P and K combinations. This may be ascribed that these nutrients play a great role in sturdiness, root length and increase in number of leaves significantly increased with the higher level of P and K combinations.

Prasad and Rawat (1991) reported the similar observation in *Acacia nilotica* seedlings when 100 ppm N applied. Significant increase of fresh weight from 45 g/pot (no nitrogen) to 198 g/pot with 100 ppm P_2O_5 application, fresh weight increased with 75 g/pot (no P_2O_5) to only 78 g/pot (100 ppm P_2O_5). The highest 145 g/pot was observed in $N_{100} P_{100} K_{50}$ treatment as compared to $N_0P_0K_0$ treatment. Similar trend were recorded inn dry biomass $N_{100}P_{100}K_{50}$ (54.92 g/plot) followed by $N_{100}P_0K_0$ (45.45 g/pot), $N_{100}P_0K_{50}$ (42.06 g/pot) and $N_{100}P_{100}K_0$ (41.49g/pot). These results are in confirmation with the results obtained by present investigation that P x K interaction are in conformation with the results obtained by present investigation that P x K interaction play a significant role in the growth of the seedlings.

The interaction of N x P x K are presented in Table 4.8. The results revealed that balanced use of fertilizer enhance the growth of the seedling during early stage. The data revealed that the growth of seedling i.e. roots, shoot, collar diameter and number of leaves were increased with the age and higher level of fertilizer application. The interaction of N x P x K are statistically significant in the present investigation. This may be because plants require balance dose of these major nutrients during early growth of seedling.

Singh and Banerjee (1999) reported similar findings in response to the interaction of N, P and K on *Albizia procera*. They reported that combination of N, P and K was found to be more effective in boosting height of *A. procera*. The most effective combination of N, P and K was N₁₅₀P₅₀ and K₅₀ followed by N₇₅P₅₀K₁₀₀ (56.3 cm). However, the height in last two treatments were not significantly different ($P < 0.05$). These results are similar with the present investigation.

Prasad and Rawat (1994) also reported that when factorial combination of N, P and K was applied in *E. tereticornis* seedling different parameters viz, leaf number, average leaf area, total leaf area, relative chlorophyll content, fresh biomass and dry biomass were directly related to N, P and K fertilizer use.

5.2 Effect of organic manure and inorganic fertilizers on biomass accumulation of *Jatropha curcas* seedlings

The perusal of data on biomass accumulation in *Jatropha curcas* seedling are presented in Table 4.9 the data revealed that biomass accumulation rate of above and below ground biomass was significantly higher in poultry manure as compared to FYM while it was lowest in control. The trend of

biomass accumulation increased with the higher level of manure application. It is interesting to note that the below ground biomass increment was less as compared to above ground biomass. However, the control showed minimum above and below ground biomass as compared with poultry manure and FYM. The poultry manure showed maximum above and below ground biomass (63.23 and 9.40 g/seedling) followed by FYM it was recorded (47.58 and 8.43 g/seedling) respectively. While in control it was recorded minimum (28.24 and 6.33g/ seedling) above and below ground biomass respectively. This may be ascribed as higher amount of N, P and K is available in poultry manure as compared with FYM.

Various workers reported similar findings. Vashishta *et al.* (1997) reported that higher levels of organic matter significantly increased fresh and dry weight in *Gmelina arborea*, *Dendrocalamus strictus* and *Dalbergia sissoo*. This may be attributed to higher amount of available nutrient as composting improves the physical properties viz., porosity, CEC, water holding capacity and maintain C and N ratio balance.

Gopikumar *et al.* (2002) also reported that potting mixtures of soil and cowdung with two weeks or four weeks decomposed garbage showed maximum biomass of Teak (10.69 g/seedling), *Ailanthus* (9.41 g/seedling), *Albizia* (7.56 g/seedling) and *Terminalia* (9.97 g/seedling). Banerjee *et al.* also reported the similar finding that higher biomass production may be attributed to the ameliorative characters and is high nutrient content in *Dalbergia sissoo* seedlings. It was recorded 240 per cent more over the control for root, 481.1 per

cent more over control for stem and 509.1 per cent more over control for leaves. The above findings are in conformation with the present investigation.

Application of fertilizer at seedling stage in the nursery helps in production of healthy stock with higher biomass and sturdy root system. The healthy seeding plays very important role in survival and fast growth of the plantations. The effect of nitrogen, phosphorus and potassium on above and below ground biomass of *Jatropha* seedlings are presented in Table 4.10. The data showed that the higher level of N, P and K significantly increases the above and below ground biomass. Effect of nitrogen on above and below ground biomass showed maximum (50.44 and 15.95 g/seedling) in N₃ treatment respectively. The response of phosphorus also reveals the maximum value for above and below ground biomass (53.12 and 15.60 g/seedling) for P₃ treatment. The above trend shows that in this species potassium gave maximum value followed by phosphorus and nitrogen for above ground biomass, while below ground biomass was higher for nitrogen followed by phosphorus and minimum for potash. Singh and Banerjee (1999) also reported that response of N, P and K on biomass of *Albizia lebbeck* was observed that higher level of these nutrients showed significant increase in the biomass. They reported that nitrogen and phosphorus alone and in combination exhibited significant effect on height growth of *A. procera*. However, the increase was limited to 25 kg/ha⁻¹ P₂O₅ and 150 kg ha⁻¹ N. Application of N above this level exhibited detrimental effect on height of the plant. Application of N and K alone and in combination, exhibited significant effect on height growth of seedling. However, the increase was limited to 150 kg ha⁻¹ N and 50 kg ha⁻¹ K₂O. It was also found that weight

increment upto 100 kg ha⁻¹ K₂O responded well. The above results are in conformation with the present findings.

Similar findings were also reported by Vashishta *et al.* (1997) in his experiment where 20 ppm N, 10 ppm P and 20 ppm K was applied. The emergence count was recorded from 5th to 15th day after sowing. Seedling shoot length, root length, fresh weight and dry weight were observed at 15 and 75 DAS. They find that the fresh weight and dry weight was more during 15, 75 DAS as compared with control.

Interaction of nitrogen and phosphorus revealed that the higher level of N x P application showed significant increase in the above and below ground biomass. The maximum above and below ground biomass was observed (50.48 and 15.68 g/seedling) in N₃P₃ treatment. While minimum value (43.02, 12.79 g/seedling) above and below ground biomass was recorded for N₁P₁ treatment. Similar results for the interaction of N x K was also obtained. The maximum above ground biomass (49.79 g/seedling) was observed in N₃K₃ and minimum (42.32 g/seedling) in N₁K₁ treatment respectively this reveals that increment is significant with the higher levels of N x K. However, in below ground biomass it was statistically non significant.

The interaction of phosphorus and potash on above and below ground biomass also showed similar trend that biomass significantly increased with the higher concentrations. The maximum above and below ground biomass was recorded (48.30 and 14.33 g/seedling) in P₃K₂ and P₃K₃ treatments respectively, However, it was minimum (43.53 and 12.82 g/seedling in P₁K₁ and P₂K₃ treatment, respectively. This ascribed as shoot and leaves require more

phosphorus and potassium, while root did not responded to phosphorus and potash concentration for biomass accumulation.

Prasad and Rawat (1987) reported similar findings on interaction of N x P, N x K and K x P fertilizer use efficiency. They reported that when N was applied (14.2 mg/mg N) or alongwith P (10.4 mg/mg N) or K (9.8 mg/mg N) height was increased 74 per cent due to combined application of N, P and K. Similarly, primary fertilizer use efficiency was negative when K was applied alone or in combination with P and positive when applied alongwith N or N + P. This finding is in conformation with the present study.

The combined effect of N x P x K on above and below ground biomass presented in Table 4.14. The data reveals that above and below ground biomass increased with the higher concentration of these nutrients upto certain level than it showed negative effect on biomass. The best interaction of higher above ground biomass was recorded (53.61 g/seedling) in $N_3P_3K_2$ treatment and minimum (42.23 g/seedling) in $N_2P_2K_1$ treatment. Similar trend were recorded in below ground biomass it was recorded maximum (15.97 g/seedling) in $N_1P_1K_2$ treatment and minimum (12.17 g/seedling) in $N_3P_1K_3$ treatment.

Similar findings were reported on *Ulmus villosa* by Chauhan and Sharma (1995) that application of different doses of nitrogen showed a significant and quadratic effect on the growth characters but beyond 80 kg ha⁻¹ showed a negative but non significant effect except seedling height. Nitrogen and phosphorus interaction significantly affected the seedling dry weight. Prasad and Rawat (1987) also reported similar trend in *Acacia nilotica* seedlings when grown in new forest soils and it required important primary

nutrient. This was confirmed by the fertilizer use efficiency of N, P and K. They observed that beyond 100 ppm N when applied with 100 ppm P_2O_5 and 50 ppm K_2O may prove unbalanced causing reduction in biomass. The above findings are in conformation with the present investigation.

5.3 Nutrient uptake as influenced by organic manure and inorganic fertilizer

Nutrient uptake usually varies in response to nutrient availability. Different species have a specific pattern of nutrient uptake and accumulation pattern in different plant parts. The nutrient uptake from FYM and poultry manure by *Jatropha curcas* is presented in Table 4.15 to 4.17. It is evident from the data analysed that the uptake of N, P and K is generally higher in poultry manure as compared with FYM. However, it was found lowest in control. The higher nutrient uptake trend in poultry manure may be due to high concentration of N, P and K and easily available form of nutrient as compared with the FYM.

The values obtained for poultry manure revealed that nitrogen uptake by root was recorded maximum (0.071 g/seedling) in OPT₃ treatment, while in FYM it was recorded maximum (0.054 g/seedling) in OFT₃ and minimum values were recorded in OPT₁ and OFT₁. N uptake by stem revealed the maximum (0.405 g/seedling) and (0.39 g/seedling) OPT₃ and OFT₃ treatments respectively. However, the minimum values were recorded in OFT₁ and OPT₁. Similar trend was observed in leaves, the maximum N uptake was (0.392 g/seedling) in OPT₂ and (0.328 g/seedling) in OFT₃. While the minimum values were recorded in OPT₁ and OFT₁, respectively. However for control all

the values were lowest. The trend of N concentration uptake was observed as leaves > stem > root.

Shrivastava and Behl (2002) reported similar findings in their studies on nutrient uptake in *Terminalia arjuna* seedlings. They reported that FYM was not found to be critical in early stage of seedling growth. *T. arjuna* seedling showed a high nitrogen use efficiency even in medium soil and poor nutrient availability exhibiting a higher porosity. These results are contradictory with the present investigation. This may be that the nutrient uptake varies in response to nutrient availability, although species may have a specific pattern. Kannan and Paliwal (1992) found significant variations in nutrient uptake in two species *Peltophorum ferrugineum* and *Albizia lebbeck*. These findings are in confirmation with the present investigation.

Generally, phosphorus plays an important role in a very large number of enzyme reactions that depends on phosphorylation (Greulach, 1973). This influences shoot growth parameter such as height leaf area, collar girth etc. by acting as a structural component of all constituents and other metabolically active compounds (Agarwala and Sharma, 1976).

Phosphorus uptake from different organic manure revealed that phosphorus also showed the similar trend as it was in nitrogen uptake. The phosphorus uptake increased significantly with the higher level. The general pattern of phosphorus concentration is summarized as stem > leaves > root in *Jatropha curcus*. The data presented in Table 4.16 reveals that phosphorus uptake was more in poultry manure over FYM and control. Phosphorus uptake by root showed the non significant results during 30, 60 and 120 DAT, while it

was significant during 90 DAT. Phosphorus uptake was recorded maximum (0.64 g/seedling) in OPT₃ and (0.41 g/seedling) in OFT₃ treatment respectively. However, it was recorded minimum in OPT₁ and OFT₁ respectively. The phosphorus uptake values were minimum in control over poultry manure and FYM.

The uptake of phosphorus in stem was recorded maximum (0.548 g) in OPT₃ and (0.535 g/seedling) in OFT₃ treatments, while minimum was (0.197 g/seedling) in OPT₁ and (0.320 g/seedling) in OFT₁. The lowest concentration of phosphorus was found in control. The similar findings were observed in leaves. The maximum values was recorded (0.315 g/seedling) in OPT₃ and (0.197 g/seedling) in OFT₃, while minimum was (0.166 g/seedling) in OFT₁ and (0.235 g/seedling) in OPT₁.

Banerjee *et al.* (1999) also reported that the uptake of phosphorus in root declined inspite of increase of compost upto 1:1 level after that there was an increase in 1:2 combination. They reported that stem also showed the same trend. Compost did not affect the concentration of phosphorus (0.05 to 0.054%). However in leaves concentration of phosphorus showed the same trend the differences between control and 1:0:5 as well as 1:1 and 1:2 combination were non significant.

The above findings are contradictory with the result obtained by present investigation only it was same as uptake of phosphorus by root showed. The stem and leaves showed significant uptake of phosphorus by *Jatropha curcas* seedling this might be due to the difference in nutrient requirement by different

species. Kannan and Paliwal (1992) also reports significant variation in nutrient uptake between two species (*P. Ferrugineum* and *A. lebbbeck*).

Potassium has several physiological and biochemical roles in protein synthesis (Wild, 1988). It is required in large concentration to activate many enzymes and to neutralize anions. The potassium uptake from organic manure is presented in Table 4.17. The data revealed that poultry manure showed maximum uptake over FYM and control, respectively. The potassium uptake by root was recorded maximum (0.099 g/seedling) in OPT₃ and (0.086 g/seedling) in OFT₃ while the minimum value was recorded (0.084 g/seedling in OPT₁ and (0.082 g/seedling) in OFT₁. Stem also showed the similar trend. The concentration of potassium in stem was recorded maximum (0.078 g/seedling) in OPT₃ and (0.074) in OFT₃. While it was minimum (0.68 and 0.066 g/seedling) in OPT₁ and OFT₁, treatments respectively. The potassium uptake in leaves was recorded maximum (0.0371 and 0.270 g/seedling) in OPT₃ and OFT₃ treatments, respectively. The minimum value was recorded (0.270 and 0.213) in OPT₁ and OFT₁ treatments respectively.

Banerjee *et al.* (1999) reported that alternate increase and decrease were noted in potassium concentration of roots with the increase of the proportion of compost. In stem the potassium concentration differ significantly with the different treatment. However, it was significantly higher with the treatment receiving 1:1 and 1:2 combination in case of leaves concentration. Shrivastava *et al.* (2002) also reported in *T. arjuna* that the differences in P, K and Zn concentration between treatments were insignificant. Uptake of P and K was

different from N irrespective of the nature of potting mixture and availability of nutrient in it.

The present investigation reveals that the potassium concentration was non significant only in root i.e. at 90 DAT. However, it was found significant with the higher level of organic manure application. This may be the uptake pattern of potassium may differ with species to species. The similar findings are conformation with the Kannan and Paliwal (1992) found significant variation in nutrient uptake in different species.

Effect of inorganic fertilizer on uptake of nutrient content in different plant parts of *Jatropha curcas* seedlings is presented in table 4.18.

Different sources of nitrogen exhibited different effect on nutrient concentration in plant parts. In the present study urea was used as source of nitrogen. The data on nitrogen uptake revealed that nitrogen concentration of different plant parts significantly increases with the higher levels. Nitrogen uptake was in root was recorded (0.083, 0.080 g/seedling) in N₃ and N₂ treatment. However, leaves showed maximum (0.40 and 0.09) maximum and minimum values for N₃ and N₂ treatment respectively. On the basis of data it is clear that concentration of N in roots is almost at par while in stem it was higher with higher levels and lower levels. However leaf showed maximum uptake of nitrogen as compared with stem and root. Statistically in all parts of the plant nitrogen concentration was found significant. Thus the general trend of the N concentration summarized as leaves > stem > root.

Similar findings were observed by (Banerjee et al., 1999) they reported that from urea nitrogen uptake was recorded maximum as compared to other fertilizers and it was (4.98 %) in leaves followed by stem (2.82%) and minimum in root (0.82%). Prasad and Rawat (1987) also reported the similar trend in *Acacia nilotica*. The above findings are in conformation with the present investigation.

The result of phosphorus concentration also showed the similar trend as it was found in nitrogen. The maximum value for phosphorus uptake was recorded (0.041 g/seedling) in P_3 and minimum (0.032 g/seedling) in P_2 treatment. Concentration of phosphorus in stem also showed the similar trend. The maximum value was recorded (0.36 g/seedling) in P_3 and minimum (0.08 g/seedling) in P_2 treatment. Concentration in leaves showed reverse trend of phosphorus uptake. Statistically the concentration of phosphorus was found significant.

The similar trend of phosphorus uptake by different plant parts was reported by (Banerjee et al., 2002). The above findings are in conformation with that of the present study except in leaves, the uptake was found higher in middle level of dose as compared with higher level and lower level.

The result of potassium concentration in different plant parts revealed that the uptake was increased with higher level of application. In root maximum (0.051 g/seedling) in K_2 and minimum (0.034 g/seedling) in K_1 treatment respectively. The uptake value in stem was recorded maximum (0.10 g/seedling) in K_3 and minimum (0.057 g/seedling) in K_1 treatments, respectively. In leaves it was recorded maximum (0.034 g/seedling) in K_2 and

minimum (0.032 g/seedling) in K₁ treatment respectively. Therefore, the potassium concentration in leaves were summarized as stem > leaves > roots. Statistically potassium concentration in all parts of *Jatropha curcas* was found significant.

Similar findings were obtained by Shrivastava and Behl, (2002) they reported that the concentration of potassium in *Terminalia arjuna* was summarized as stem > leaves > root. They have also reported the concentration of potassium increased with the higher levels of potassium application. Therefore, the findings of present experiment are in conformation with the findings of above workers.

The effect of Nitrogen x Phosphorus interaction on uptake of nutrient by different plant parts is presented in table 4.21. The interaction of N x P on uptake by root was found non-significant except on 60 DAT. During this period maximum value was recorded (0.04 g/seedling) in N₃P₃, N₃P₁, N₂P₂, and N₁P₃ combination respectively, while minimum uptake was recorded (0.03 g/seedling) in N₃P₂, N₂P₃ treatments. The interaction of N x P was found significant. In stem the uptake increased with the higher level of fertilizer application. The maximum uptake value was recorded (0.22 g/seedling) for N₃P₃, N₃P₂ and minimum (0.19 g/seedling) for N₁P₁, N₂P₁, N₂P₂ treatments, respectively. Stem showed non-significant result on 90 DAT. The leaves also showed similar trend as it was in stem. The maximum value was recorded (0.11g/seedling) for N₃P₃ and minimum (0.06g/seedling) in N₁P₁ combination respectively. The overall interaction of N and P was not observed positive. The

uptake pattern in N x P interaction on *Jatropha curcas* was summarized as stem> leaves>root.

The effect of Nitrogen x Potassium on nutrient uptake by different plant parts is presented in table 4.22. The results on interaction of N x K revealed that increase in uptake of nutrients with higher levels of fertilizers were found significant, except in root it was non significant during 120 DAT. The nutrient uptake in stem and leaves were positive, it may be that these nutrients play important role in development of vegetative part but roots required low amount of these nutrients during seedling stage. The maximum value was recorded in stem (0.21g/seedling) for N₃K₃, N₃K₂ and minimum (0.18 g/seedling) in N₂K₁ treatment respectively. In leaves the maximum uptake was recorded (0.11) and minimum (0.05 g/seedling) in N₃K₃ and N₁K₁ treatment respectively. The uptake trend on nutrient was summarized as stem> leaves > root.

The similar findings were reported by Singh and Banerjee (1999) in *Albizia procera* height and biomass production and radial growth. Shrivastava and Behl also reported the similar observations in *Terminalia arjuna* seedlings he stated that leaves of seedlings grown in FYM amended medium had highest chlorophyll and protein content. In *Jatropha curcas* also the similar results were obtained with organic manure and fertilizer application. The above findings are conformation of present investigation

Effect of phosphorus and potassium on nutrient uptake by different plant parts of *Jatropha curcus* is presented in Table 4.23. The data revealed that the interaction of P x K was found non significant in all parts of the seedling. This may be that the combination of P and K give adverse effect on the seedling

growth. Without nitrogen the effect was almost nil 60 to 90 DAT in root and leaf. However, during 30 and 120 DAT it was significant. Therefore, it can be concluded that uptake of these nutrients is closely related with the presence of nitrogen, which enhances the uptake of P, and K. In the absence of nitrogen the uptake of these nutrients is very negligible.

Shrivastava and Behl (2002) also reported in *T. arjuna* showed the differences in P, K and Zn concentration between treatment were insignificant. This finding is in confirmation of present findings.

Effect of nitrogen, phosphorus and potassium on nutrient uptake of different plant part is presented in Table 24. The interaction of N x P x K was statistically significant. It was increased with the higher level of nutrient upto certain extent. Sometimes it was decreased with the higher level during different stages. The maximum root uptake was recorded (0.12 g/seedling) in $N_3P_3K_3$ and minimum (0.06 g/seedling) in $N_1P_3K_1$ treatment respectively. The stem showed the maximum (0.21 g/seedling) in $N_3P_3K_3$ and minimum (0.15 g/seedling) in $N_1P_3K_1$ treatment respectively. Leaves showed the maximum (0.15 g/seedling) in $N_3P_3K_2$ and minimum (0.05 g/seedling) in $N_1P_1K_1$. The best combination for uptake it was $N_3P_3K_3$ in case of root and stem, while in leaves $N_3P_3K_2$ was found best combination.

Singh and Banerjee (1999) also reported similar findings with *A. procera* regarding interaction of N, P and K. They reported that combinations of all three nutrients exhibits better results than the individual nutrients and combination of two nutrients. Banerjee *et al.* (1999) also reported in his experiment on *D. sissoo* a nodulating and nitrogen fixing tree species requires

higher status of N, P, K and Ca in the soil for their uptake and production of higher photosynthetic biomass. These findings are similar as find out in present investigation of *Jatropha curcas* seedlings. As reported by other workers in different species.

CHAPTER-VI

SUMMARY, CONCLUSION AND SUGGESTIONS

FOR FUTURE RESEARCH WORK

The genus *Jatropha* is a morphologically diverse genus comprising 160-175 species of shrubs, rhizomatous, sub-shrubs and herbs. In addition to their use as ornamental, medicinal and energy crops. In last few years the potential of the drought resistant tropical tree *Jatropha curcas* for the production of oil and industrial lubricants has been assessed. Newly developed biotechnological process related to the exploitation of *J. curcas* include the genetic improvement of the plant, biological pest control, enzyme supported oil extraction, anaerobic fermentation of the press cake and the isolation of anti-inflammatory substances and wound-healing enzymes were worked out. It can be grown over a wide range of arid and semi-arid climatic conditions, well adapted to harsh conditions of soil and climate of our country as well as other parts of the world.

As it is well known that to establish a quality plantation of any species superior, vigorous planting stock play a significant role. The experiment to estimate the nutrient requirement of *Jatropha curcas* seedling in nursery were designed in which organic manure and inorganic fertilizers are applied in different doses and combination to see the effect on seedling. The results obtained under present investigation are summarized in this chapter.

The vegetative parameters viz., plant height, collar diameter, number of leaves and root length were recorded at 30,60,90,120 DAT. Similarly, the

observations for biomass accumulation, nutrient uptake were recorded at monthly intervals. The results obtained are summarized into following points.

1. Growth parameters viz., root length, shoot length, collar diameter and number of leaves were found maximum for poultry manure followed by FYM and control showed minimum values in all parameters. The maximum growth was recorded @ 100 g PM/seedling. This treatment gave maximum shoot length (56.67cm). Similar results were obtained for root length, number of leaves and collar diameter (35.33cm), (52.33) and (35.25 mm) respectively.
2. For, inorganic fertilizer combinations it was observed that the growth attributes of *Jatropha curcas* seedlings increases with the higher levels of fertilizer doses upto certain extent afterward it gives adverse effect on the growth of the seedlings. The N3P3K3 treatment showed the superior growth rate of the seedlings. The individual or two nutrient combinations showed significant results but were relatively lower than the N, P and K combinations. The comparison of organic verses inorganic reveals that @ 100 g poultry manure/ seedling is better as compared to inorganic fertilizer.
3. The above and below ground biomass also revealed that poultry manure @ 100 g / seedling gave maximum above ground biomass (63.23g/ seedling) and (9.40g/ seedling) for below ground biomass followed by FYM (47.58 g/seedling) above ground biomass, (8.43 g/ seedling) below ground biomass in OFT₃ treatment.

4. Inorganic fertilizer showed the maximum AGB (53.61 g/ seedling) in $N_3P_3K_2$ combination. While, maximum BGB was recorded (17.74 g/ seedling) in $N_2P_2K_1$ treatment. Factorial combinations reveal that individual doses showed significant results. Except N x K interaction showed non-significant effect on BGB. The individual doses and two nutrient combinations were at par while, combination of N, P and K gave significant results with higher level of nutrient application and increased biomass accumulation in the seedlings.
5. Nutrient uptake from organic manure revealed that uptake of nutrient was observed maximum in poultry manure @ 100 g/ seedling. Except for N in case of leaves, maximum value was observed (0.39 g/ seedling) @ 50 g/ seedling. The nutrient uptake was summarized as stem > leaves > root. While, nutrient uptake showed following trend $N > K > P$ respectively.
6. Nutrient uptake from inorganic fertilizers was comparatively less as compared to organic manure. Individual doses showed significant uptake, when N was applied as alone, maximum values (0.083 g/ seedling), (0.30 g/ seedling) and (0.40 g/ seedling) by roots, stem and leaves for N_3 treatment followed by N_1 treatment respectively.
7. When P was applied as single dose with different levels. Close competition was observed between the treatments. Maximum uptake was recorded (0.041 g/seedling) and (0.36 g/seedling) in P_3 by root and stem. For leaves maximum uptake (0.056 g/seedling) was recorded for P_2 treatment.

8. For K uptake the maximum value was recorded (0.48 g/seedling), (0.10 g/seedling), (0.034 g/ seedling) in K_2 treatment by roots, stem and leaves respectively.
9. No significant effect was observed on nutrient uptake by roots except at 60 DAT in factorial combination of N x P. Maximum value was observed (0.40 g/seedling) for N_3P_3 , N_3P_1 , N_1P_3 treatments. Uptake by stem was maximum (0.22 g/seedling) for N_3P_2 and N_3P_3 treatments. The uptake by leaves was recorded (0.11 g/seedling) for N_3P_3 treatment. Most of the treatments were found almost at par to each other.
10. Interaction of N x K on nutrient uptake was statistically significant. Maximum uptake was recorded (0.07 g/seedling) in N_3K_3 at 90 DAT, for stem, it was recorded (0.21 g/ seedling) for N_3K_3 , N_3K_2 and N_2K_3 treatments. Maximum value was recorded (0.11 g/ seedling) for N_3K_2 treatment in leaves.
11. Overall, interaction of P x K on nutrient uptake was statistically non significant . It was found significant only at 90 DAT. Maximum uptake by leaves were observed (0.07 g/seedling) for P_3K_3 at 90 DAT. For stem, it was (0.12 g/ seedling) in P_3K_2 and P_3K_3 at 90 DAT. In leaves, uptake was significant at 90 DAT recording (0.06 g/seedling) for P_3K_2 and P_3K_3 .
12. Factorial effect of N x P x K was found to be superior to the individual doses and combination of two nutrients. The root showed maximum uptake (0.08 g/seedling) for $N_3P_3K_2$ and $N_3P_2K_3$ treatment. The uptake by stem was maximum (0.21 g/seedling) for $N_3P_3K_3$ and (0.15 g/ seedling) for $N_3P_3K_2$ by leaves.

Conclusion:

The present study has been conducted for four months of short period. Hence, definite conclusion could not be drawn. However, the following conclusions can be drawn from the results.

1. Highest dose of poultry manure showed higher root, shoot length, collar diameter and number of leaves by 68.8, 70.9, 75.8 and 74.5 per cent over the control. Similar trend was also found in FYM.
2. Combination of different inorganic fertilizers showed that balance dose of N, P and K resulted in better growth rate. The growth rate was higher as compared with individual and two nutrient combinations however, higher level of these fertilizers showed some significant increase in growth and biomass but upto certain limit.
3. Above ground biomass was observed maximum 63.23g/seedling, in 100g poultry manure per seedling. It was followed by 47.58 g/seedling in FYM. However, below ground biomass was observed 9.40 g/seedling in 100g poultry manure per plant and 8.43 g/seedling when FYM @ 100 g/plant was applied, respectively.
4. Interaction of NPK combinations, showed that $N_3P_3K_2$ combination resulted maximum above ground biomass of 53.61g/seedling and below ground biomass 17.74 g/seedling in $N_2P_2K_1$ over, individual and interaction of two nutrient combinations.
5. Poultry manure showed maximum nutrient uptake by roots and stem for OPT_3 treatment while, in leaves it was maximum for OPT_2 treatment followed by FYM and it was least in control.

6. The uptake of nutrient with various doses revealed the maximum uptake was observed in $N_3P_3K_3$ and $N_3P_3K_2$ combination over individual and two nutrient combinations.
7. The result obtained from the experiment, it can be concluded that poultry manure application is better as compared to FYM and inorganic fertilizers in *Jatropha curcas* seedlings in nursery.

Suggestions for future research work

1. The result of present investigation was carried out only for four months. Therefore, it is difficult to reach any definite conclusion and recommendations. It needs further repetition for at least two successive years.
2. Investigations are also important to screen the fertilizer requirements of *Jatropha curcas* with other high oil yielding species.
3. The effect of micronutrients and growth hormones should be worked out for vigorous growth of the seedlings.
4. The seedling raised from seed and cuttings should be compared for their nutrient requirement in nursery.

“Effect of organic and inorganic fertilizer on growth performance of tree borne oil seedling *Jatropha curcas* in nursery”

By

R. Koulini Sri

ABSTRACT

The present investigation entitled “Effect of organic and inorganic fertilizers on growth performance of tree borne oil seedling *Jatropha curcas* in nursery” was carried out to evaluate the optimum requirement of nutrient. To see the effect of organic manure *i.e.* Poultry Manure and FYM on growth performance, biomass accumulation and nutrient uptake pattern in the seedlings. Similar observations were also studied with 27 factorial combinations of N, P and K. The trial was laid out in Completely Randomized Design (CRD). The study was carried out at Research Farm, Department of Forestry, IGAU, Raipur (C.G.) during March 2003 to July 2003.

The growth and biomass as well as nutrient uptake were observed significantly higher in Poultry Manure treatment @ 100 g/seedling followed by FYM, over control. An increase in growth attributes with the increased dose of Poultry Manure was prominent. The growth rate of root, shoot, collar diameter and number of leaves varied from 35.33cm, 56.67cm, 35.25mm and 52.33 respectively under higher level. The above and below ground biomass of *Jatropha curcas* seedlings were recorded to be significantly higher in poultry manure followed by FYM over control. The above ground biomass varied from 33.42, 40.52, 63.23 g/seedling for Poultry Manure treatment @ 25, 50, 100 g/seedling respectively. The below ground biomass varied from 8.16, 8.30, 9.40 g/seedling for Poultry Manure treatment @ 25, 50, 100 g/seedling, respectively. The nutrient uptake also showed similar trend in different stages and it was increasing with the higher level of organic manure application. The Poultry Manure showed maximum uptake varied from 0.095, 0.40, 0.32 g/seedling for roots, stem and leaves in Poultry Manure treatment @ 100 g/seedling followed by FYM, over control.

The effect of inorganic fertilizers as individual, two nutrient combinations revealed that the balanced dose of N, P and K was found statistically significant.

The growth performance, biomass production and nutrient uptake was observed to be significantly higher in N, P and K combination. The highest root length, Collar diameter, shoot length and number of leaves were recorded for treatments N@ 6.9g/seedling, P@ 4.8g/seedling and K@ 1.6g/seedling respectively when applied individually. In N x P combination, higher and medium levels proved to be better for growth attributes. Over all performance of N x K combination did not effect significantly on growth attributes. Higher levels of P x K combinations showed better growth performance. The factorial combination of N, P and K showed that balanced dose of higher levels proved to be superior. Similar trend was observed for biomass accumulation and nutrient uptake, except interaction of N x K for Below ground biomass and interaction of P x K for the uptake of nutrients which was observed to be non significant.

Over all, it can be stated that the higher levels of organic and inorganic fertilizers help in boosting up the growth performance of *Jatropha curcas* during nursery stage.

Place: Raipur
Date:

(Dr. R.K. Prajapati)
Chairman
Advisory committee

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Table 4.1 : Effect of organic manure on growth attributes of *Jatropha curcas* seedlings

Treatment	Root length (cm)				Collar diameter (mm)				Shoot length (cm)				Number of leaves			
Organic manure	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T ₀	6.67	15.00	21.33	24.33	5.55	10.46	18.00	25.00	11.00	26.54	36.33	43.00	8.00	16.67	31.00	39.00
OFT ₁	8.21	19.15	25.34	28.45	6.44	11.54	20.47	28.63	13.67	29.67	40.67	46.33	10.67	20.00	34.00	43.67
OFT ₂	10.48	23.56	26.76	30.74	6.47	13.61	22.44	29.26	15.00	33.33	44.33	47.67	11.00	20.67	35.33	44.67
OFT ₃	11.37	24.17	28.03	34.60	7.02	13.93	24.99	31.75	15.33	34.00	46.67	51.00	13.33	22.33	36.33	47.76
OPT ₁	12.90	24.26	28.43	30.44	7.16	14.71	26.01	28.24	14.00	35.00	43.33	52.67	11.33	24.67	34.00	46.00
OPT ₂	13.94	24.45	30.25	34.24	7.24	16.27	27.00	34.19	16.33	36.33	47.76	55.30	13.00	25.00	36.67	47.86
OPT ₃	14.08	27.41	32.86	35.33	8.18	17.54	28.52	35.25	18.33	37.67	50.16	56.67	14.00	28.33	38.00	52.33
CD at 5%	2.55	3.37	3.32	2.93	NS	2.97	2.46	4.24	1.83	3.80	3.91	4.34	1.92	4.13	NS	4.24

T₀ : Control, OFT₁ : 25gFYM, OFT₂ : 50 g FYM, OFT₃ – 100 g FYM,
OPT₁ – 25g Poultry manure, OPT₂ – 50g Poultry manure, OPT₃ –100g Poultry manure
DAT= Days after transplanting

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Table 4.2 : Influence of Nitrogen on growth attributes of *Jatropha curcas* seedlings

Treatments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁	7.02	12.03	14.40	17.33	5.81	10.75	15.63	20.56	10.37	22.14	35.11	40.33	9.03	15.16	23.10	33.11
N ₂	9.10	13.30	15.65	18.13	6.01	9.82	14.03	22.77	12.33	24.10	40.2	42.3	10.11	17.20	27.27	35.07
N ₃	10.11	15.16	17.37	17.31	6.22	11.57	15.55	25.32	13.14	27.02	45.3	47.50	11.23	18.12	30.13	40.14
CD at 5%	0.03	0.07	0.23	NS	NS	0.01	NS	0.32	NS	0.47	0.43	1.02	0.02	0.19	0.29	0.42

Table 4.3 : Influence of Phosphorus on growth attributes of *Jatropha curcas* seedlings

Treatments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
P ₁	8.10	10.01	12.18	16.17	6.01	11.70	16.17	21.10	10.75	23.91	35.42	41.77	10.54	17.44	25.11	35.17
P ₂	10.14	11.66	13.56	17.23	7.04	12.18	15.10	23.34	12.01	25.60	38.72	44.22	11.10	18.03	30.03	37.99
P ₃	10.75	12.92	15.21	19.16	7.17	13.03	16.23	27.07	14.50	29.13	40.03	47.14	11.17	18.12	31.59	41.04
CD at 5%	0.02	0.27	0.39	0.44	NS	0.230	0.39	0.42	0.02	0.20	0.42	0.58	NS	NS	0.60	0.68

Table 4.4 : Influence of Potassium on growth attributes of *Jatropha curcas* seedlings

Treatments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
K ₁	7.71	11.13	14.41	17.73	7.03	13.36	15.53	23.11	11.23	22.13	36.05	42.08	11.10	15.66	27.98	35.01
K ₂	9.56	12.61	14.08	18.10	8.18	13.58	17.90	25.06	12.13	24.10	38.11	45.55	12.16	18.81	31.03	38.91
K ₃	10.33	12.33	16.21	19.33	8.13	15.10	18.51	28.88	13.17	27.31	43.91	48.68	13.02	18.91	33.51	42.13
CD at 5%	0.01	0.04	0.23	1.02	NS	1.07	0.25	0.30	NS	0.29	0.32	0.49	NS	0.28	0.37	0.43

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

DAT= Days after transplanting

Table 4.5 : Influence of Nitrogen and Phosphorus (N x P) interaction on growth attributes of *Jatropha curcas* seedlings

Treatments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁ P ₁	9.13	11.36	15.77	17.18	8.19	10.11	14.76	20.18	13.01	17.05	23.15	35.17	12.73	19.32	24.17	28.13
N ₁ P ₂	10.11	11.17	15.81	17.58	8.11	11.73	15.25	22.00	14.03	18.03	24.05	35.40	13.00	19.31	23.02	30.11
N ₁ P ₃	11.13	13.56	16.88	18.01	9.13	10.11	13.76	20.17	14.15	18.19	25.16	36.71	13.15	20.56	23.13	31.14
N ₂ P ₁	10.50	13.17	15.41	18.59	10.11	12.09	16.73	23.17	13.04	19.03	25.18	37.12	14.05	20.91	25.07	33.01
N ₂ P ₂	11.37	12.03	17.31	17.38	10.75	13.18	17.03	24.05	15.19	20.17	26.37	35.07	13.05	21.37	25.14	34.15
N ₂ P ₃	11.38	13.18	16.81	17.08	9.13	12.17	17.05	23.17	16.07	21.13	27.55	38.12	15.19	22.09	26.15	32.15
N ₃ P ₁	12.01	14.01	17.03	18.11	11.71	13.98	18.17	25.00	16.03	21.33	27.15	40.17	16.31	22.59	25.17	35.16
N ₃ P ₂	11.58	13.19	17.03	18.95	11.98	14.01	19.53	24.17	17.11	22.14	28.11	42.23	16.32	23.14	26.37	35.37
N ₃ P ₃	12.55	13.07	16.91	17.09	12.23	15.63	19.07	25.11	18.91	22.45	29.30	43.41	17.19	24.01	26.15	35.88
CD at 5%	0.31	1.04	NS	NS	0.27	0.40	0.03	0.39	1.30	1.43	1.13	1.84	0.57	2.80	NS	1.12

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm

DAT= Days after transplanting

Table 4.6 : Influence of Nitrogen and Potassium (N x K) interaction on growth attributes of *Jatropha curcas* seedlings

Treatments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁ K ₁	9.24	12.07	16.99	18.96	8.29	10.24	14.00	21.00	12.93	16.86	23.01	32.30	12.39	18.88	23.86	28.00
N ₁ K ₂	10.27	12.58	17.06	19.03	8.30	10.56	14.36	21.87	14.22	17.08	24.79	34.00	12.98	19.29	23.09	30.82
N ₁ K ₃	11.50	13.49	18.32	19.97	9.03	11.66	15.49	22.66	14.31	18.03	26.04	34.04	13.24	20.03	23.20	30.92
N ₂ K ₁	10.81	12.48	17.00	19.00	9.56	11.78	15.99	22.93	14.00	18.90	25.18	36.76	14.06	20.86	23.37	31.19
N ₂ K ₂	11.39	13.04	18.03	19.90	10.07	13.03	17.04	23.02	15.50	21.05	26.00	36.06	14.47	22.03	26.01	35.02
N ₂ K ₃	12.08	14.03	18.96	19.97	10.75	13.34	17.76	23.89	16.17	22.08	26.93	37.93	15.06	21.97	26.89	31.79
N ₃ K ₁	12.58	14.49	19.03	20.00	11.05	13.89	18.00	25.00	16.83	22.19	27.04	38.02	15.91	22.03	25.08	34.94
N ₃ K ₂	12.03	14.01	18.00	19.42	11.89	14.03	19.39	25.04	17.44	22.46	28.01	38.97	16.04	24.00	26.73	34.89
N ₃ K ₃	12.56	14.77	18.73	19.48	12.24	15.86	20.86	26.37	19.00	23.42	29.06	44.07	17.29	24.37	27.02	35.03
CD at 5%	0.41	0.83	0.56	NS	NS	0.24	0.39	NS	0.03	0.17	1.03	NS	0.20	NS	NS	1.05

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm
 DAT= Days after transplanting.

Table 4.7 : Influence of Phosphorus and Potassium (P x K) interaction on growth attributes of *Jatropha curcas* seedlings

Treat- ments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
P ₁ K ₁	9.33	10.83	15.96	17.89	8.40	10.31	14.00	21.23	12.78	15.64	23.67	32.33	11.98	18.00	23.39	23.23
P ₁ K ₂	9.49	11.32	16.03	17.93	8.73	10.84	15.03	21.78	13.98	16.98	24.09	33.94	12.68	18.74	23.78	24.23
P ₁ K ₃	10.04	11.78	16.38	18.02	8.86	10.97	15.63	22.77	14.04	17.99	25.00	34.79	13.93	19.02	24.26	24.99
P ₂ K ₁	10.78	12.24	16.79	18.34	9.39	11.04	15.89	22.99	14.87	18.48	26.08	34.86	14.38	19.96	24.78	25.00
P ₂ K ₂	11.32	12.83	17.04	18.76	10.04	11.97	16.03	23.03	15.83	19.07	27.00	35.83	15.06	20.07	25.04	25.39
P ₂ K ₃	11.76	13.04	17.93	18.94	10.39	12.03	16.53	23.83	16.00	21.02	27.49	36.00	16.77	20.96	26.03	26.02
P ₃ K ₁	11.94	13.09	18.24	19.04	11.12	13.04	17.97	24.18	16.59	21.83	27.93	37.04	17.00	21.32	26.93	27.00
P ₃ K ₂	12.22	13.76	18.93	19.24	12.04	13.83	18.94	26.31	17.44	22.09	28.33	39.33	17.83	22.24	27.00	27.36
P ₃ K ₃	12.68	14.26	19.01	19.76	13.01	13.94	19.92	25.13	19.39	23.42	28.74	42.48	18.04	23.46	27.46	28.09
CD at 5%	NS	0.15	0.78	NS	NS	0.28	0.39	1.04	0.05	0.15	1.03	1.12	0.18	0.38	0.69	1.07

P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ - 4.8 gm, K₁ – 0.8 gm, K₂ –1.6 gm, K₃ – 2.4 gm

DAT= Days after transplanting.

Table 4.8 : Influence of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on growth attributes of *Jatropha curcas* seedlings

Treatments	Root length(cm)				Collar diameter(mm)				Shoot length(cm)				Number of leaves			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁ P ₁ K ₁	13.04	16.00	20.11	22.19	13.01	15.12	19.03	26.11	15.04	19.12	26.02	35.77	14.98	20.11	25.01	31.06
N ₁ P ₁ K ₂	13.44	16.15	20.15	22.67	13.15	15.39	19.67	26.98	15.34	19.73	26.68	35.98	15.08	20.45	25.42	31.73
N ₁ P ₁ K ₃	13.78	16.98	21.66	23.00	13.78	16.18	19.98	27.00	15.49	19.94	26.94	36.18	15.76	20.76	25.99	31.94
N ₁ P ₂ K ₁	13.98	17.00	20.17	22.98	13.96	15.98	20.00	27.78	15.92	20.00	27.08	36.77	15.80	21.00	26.00	32.08
N ₁ P ₂ K ₂	14.02	17.14	21.98	23.66	14.00	16.04	20.44	27.99	16.12	20.13	27.37	37.42	16.04	21.73	26.29	32.67
N ₁ P ₂ K ₃	14.78	17.58	20.66	22.97	14.15	16.77	20.68	28.05	16.38	20.68	28.00	37.98	16.23	21.96	26.76	32.89
N ₁ P ₃ K ₁	14.99	17.16	19.99	23.12	13.98	16.98	20.97	28.35	16.74	20.77	28.15	38.00	16.44	22.04	26.94	33.00
N ₁ P ₃ K ₂	15.01	18.18	20.00	23.14	14.16	17.00	21.00	28.95	17.00	21.03	28.79	38.26	16.68	22.34	27.04	33.12
N ₁ P ₃ K ₃	15.72	18.19	21.66	22.56	14.77	17.15	21.58	29.11	17.14	21.49	28.99	38.76	16.88	22.48	27.20	33.66
N ₂ P ₁ K ₁	15.93	18.58	22.74	22.47	14.15	17.86	21.87	29.23	17.23	22.03	29.13	39.02	17.00	22.93	27.78	33.86
N ₂ P ₁ K ₂	16.00	18.78	22.66	23.00	15.10	17.99	22.04	29.47	17.68	22.14	29.45	39.38	17.17	23.44	27.99	34.45
N ₂ P ₁ K ₃	16.13	19.48	21.99	23.11	15.66	18.17	22.48	29.88	17.94	22.73	29.77	39.96	17.34	23.59	28.12	34.96
N ₂ P ₂ K ₁	16.73	19.12	21.93	22.99	15.98	18.29	22.58	30.12	18.09	22.94	29.89	40.12	17.96	23.83	28.52	35.05
N ₂ P ₂ K ₂	16.94	19.78	22.06	22.47	15.67	18.66	23.44	30.47	18.19	23.13	30.01	40.87	18.04	24.04	28.74	35.14
N ₂ P ₂ K ₃	17.00	18.76	23.00	23.18	14.98	19.00	23.86	30.97	18.36	23.29	30.24	41.33	18.36	24.73	29.17	35.46
N ₂ P ₃ K ₁	17.18	19.20	22.86	24.56	15.01	19.23	24.14	31.00	18.84	23.73	30.68	41.97	18.81	24.99	29.77	36.14
N ₂ P ₃ K ₂	17.38	17.96	23.14	24.56	15.00	19.76	24.77	31.47	19.12	24.00	30.87	42.44	18.92	25.14	29.89	36.67
N ₂ P ₃ K ₃	17.69	18.17	22.71	23.97	15.98	19.89	24.98	31.99	19.42	24.09	31.13	43.04	19.06	25.27	30.02	36.98
N ₃ P ₁ K ₁	17.94	19.03	23.45	24.00	16.00	20.00	25.00	32.00	19.73	24.23	31.51	43.76	19.00	25.43	30.39	37.00
N ₃ P ₁ K ₂	18.01	18.66	21.15	23.94	16.28	20.11	25.12	32.98	20.04	24.83	31.78	44.03	19.86	25.78	30.78	37.89
N ₃ P ₁ K ₃	18.19	19.78	22.16	25.00	15.91	20.23	25.52	32.45	20.21	25.12	31.89	44.68	19.93	25.89	30.99	38.08
N ₃ P ₂ K ₁	18.39	18.11	22.98	24.18	16.11	20.56	25.99	32.66	20.76	25.47	32.00	45.01	20.00	26.00	31.04	38.58
N ₃ P ₂ K ₂	18.57	17.56	20.99	23.97	16.22	20.99	26.13	33.09	20.93	25.96	32.09	45.93	20.11	26.11	31.78	38.97
N ₃ P ₂ K ₃	18.94	20.11	23.66	24.28	16.23	21.19	26.77	32.98	21.24	26.01	32.19	46.09	20.23	26.21	31.94	39.01
N ₃ P ₃ K ₁	19.00	20.18	24.17	25.11	17.11	21.98	27.03	33.66	22.39	26.32	32.48	46.89	20.44	26.39	32.19	39.32
N ₃ P ₃ K ₂	19.24	19.17	24.54	24.98	17.17	22.67	27.88	33.89	22.94	27.17	32.97	47.09	20.96	26.89	32.46	39.48
N ₃ P ₃ K ₃	19.47	20.16	24.54	25.78	18.00	22.99	27.04	34.00	23.01	27.38	33.03	47.88	21.01	27.01	32.76	40.05
CD at 5%	0.20	0.30	0.29	0.38	0.25	0.40	0.68	1.02	0.40	0.78	1.20	1.35	0.30	0.42	0.97	1.39

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm; DAT= Days after transplanting.

Table 4.10 : Influence of Nitrogen, Phosphorus and Potassium on above and below ground biomass in *Jatropha* seedlings

	Nitrogen				Phosphorus				Potassium			
	N ₁	N ₂	N ₃	CD at 5%	P ₁	P ₂	P ₃	CD at 5%	K ₁	K ₂	K ₃	CD at 5%
Total AGB g/ seedlings	43.59	45.07	50.44	0.73	45.0	48.98	53.12	0.86	45.94	48.36	55.80	0.10
Total BGB g/ seedlings	13.38	14.58	15.95	0.82	13.14	14.70	15.60	0.95	13.31	14.78	15.85	0.05

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

AGB = above ground biomass, BGB = below ground biomass

Table 4.15 : Effect of FYM and Poultry Manure on nutrient uptake by different plant parts of *Jatropha curcas* seedlings (on dry wt basis)

Treatment Organic Manure	Nitrogen uptake (g/seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T ₀	0.015 (0.43)	0.021 (0.50)	0.030 (0.55)	0.049 (0.78)	0.107 (0.45)	0.163 (0.56)	0.146 (0.62)	0.116 (0.73)	0.037 (0.47)	0.062 (0.52)	0.053 (0.62)	0.098 (0.83)
OFT ₁	0.026 (0.52)	0.032 (0.53)	0.040 (0.56)	0.078 (0.97)	0.143 (0.56)	0.208 (0.70)	0.205 (0.83)	0.238 (1.02)	0.065 (0.58)	0.088 (0.69)	0.112 (1.33)	0.228 (1.40)
OFT ₂	0.027 (0.54)	0.033 (0.54)	0.052 (0.73)	0.080 (0.98)	0.177 (0.58)	0.242 (0.78)	0.232 (0.83)	0.254 (1.04)	0.073 (0.65)	0.095 (0.78)	0.113 (1.34)	0.306 (1.63)
OFT ₃	0.033 (0.54)	0.034 (0.55)	0.054 (0.74)	0.083 (0.99)	0.098 (0.65)	0.258 (0.79)	0.306 (0.84)	0.393 (1.05)	0.081 (0.69)	0.105 (0.78)	0.130 (1.35)	0.328 (1.63)
OPT ₁	0.029 (0.55)	0.035 (0.57)	0.041 (0.77)	0.082 (1.01)	0.216 (0.68)	0.218 (0.80)	0.280 (0.94)	0.145 (1.05)	0.079 (0.71)	0.098 (0.80)	0.135 (1.35)	0.319 (1.63)
OPT ₂	0.032 (0.56)	0.035 (0.58)	0.063 (0.86)	0.084 (1.02)	0.201 (0.75)	0.243 (0.81)	0.289 (0.96)	0.186 (1.07)	0.101 (0.76)	0.120 (0.87)	0.166 (1.36)	0.392 (1.70)
OPT ₃	0.036 (0.58)	0.039 (0.62)	0.071 (0.86)	0.095 (1.02)	0.279 (0.78)	0.288 (0.82)	0.355 (0.97)	0.405 (1.08)	0.117 (0.78)	0.144 (0.98)	0.188 (1.37)	0.324 (1.73)
CD at 5%	0.01	0.00	0.03	0.03	0.02	0.01	0.04	0.01	0.03	0.01	NS	1.80

N.B.: Figures in parentheses indicates % value.

T₀ – Control, OFT₁ – 25g FYM, OFT₂ – 50 g FYM, OFT₃ – 100 g FYM OPT₁ – 25g Poultry manure, OPT₂ – 50g Poultry manure,

OPT₃ –100g Poultry manure

DAT= Days after transplanting

Table 4.16 : Effect of FYM and Poultry Manure on nutrient uptake by different plant parts of *Jatropha curcas* seedlings (on dry wt basis)

Treatment Organic Manure	Phosphorus uptake (g/seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T ₀	0.003 (0.10)	0.007 (0.23)	0.017 (0.33)	0.035 (0.42)	0.047 (0.20)	0.087 (0.30)	0.101 (0.43)	0.079 (0.50)	0.012 (0.15)	0.027 (0.23)	0.029 (0.35)	0.061 (0.50)
OFT ₁	0.001 (0.02)	0.026 (0.43)	0.036 (0.51)	0.051 (0.57)	0.110 (0.43)	0.175 (0.59)	0.248 (1.00)	0.320 (1.37)	0.025 (0.23)	0.070 (0.55)	0.064 (0.77)	0.166 (1.02)
OFT ₂	0.005 (0.03)	0.031 (0.50)	0.038 (0.53)	0.070 (0.77)	0.161 (0.53)	0.186 (0.60)	0.293 (1.05)	0.347 (1.42)	0.024 (0.22)	0.069 (0.57)	0.066 (0.75)	0.193 (1.03)
OFT ₃	0.005 (0.04)	0.032 (0.50)	0.041 (0.56)	0.080 (0.79)	0.191 (0.60)	0.199 (0.61)	0.386 (1.06)	0.535 (1.43)	0.027 (0.23)	0.076 (0.57)	0.071 (0.74)	0.197 (1.05)
OPT ₁	0.003 (0.04)	0.030 (0.50)	0.040 (0.56)	0.076 (0.85)	0.267 (0.77)	0.171 (0.63)	0.363 (1.22)	0.197 (1.43)	0.028 (0.25)	0.083 (0.68)	0.082 (0.85)	0.235 (1.20)
OPT ₂	0.003 (0.04)	0.037 (0.60)	0.045 (0.62)	0.081 (0.86)	0.261 (0.80)	0.222 (0.74)	0.377 (1.25)	0.251 (1.44)	0.030 (0.26)	0.103 (0.75)	0.093 (0.93)	0.279 (1.21)
OPT ₃	0.005 (0.04)	0.044 (0.77)	0.064 (0.78)	0.099 (0.96)	0.322 (0.90)	0.267 (0.76)	0.457 (1.25)	0.548 (1.46)	0.032 (0.27)	0.115 (0.78)	0.126 (0.92)	0.315 (1.23)
CD at 5%	NS	NS	0.03	NS	0.07	0.01	0.02	0.03	0.01	0.02	0.02	0.02

N.B.: Figures in parentheses indicates % value

T₀ – Control, OFT₁ – 25g FYM, OFT₂ – 50 g FYM, OFT₃ – 100 g FYM

OPT₁ – 25g Poultry manure, OPT₂ – 50g Poultry manure, OPT₃ – 100g Poultry manure.

DAT= Days after transplanting

Table 4.17 : Effect of FYM and Poultry Manure on nutrient uptake by different plant parts of *Jatropha curcas* seedlings (on dry wt basis)

Treatment Organic Manure	Potassium uptake (g/seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
T ₀	0.012 (0.30)	0.010 (0.33)	0.021 (0.38)	0.028 (0.45)	0.013 (0.45)	0.10 (0.62)	0.16 (0.70)	0.13 (0.82)	0.047 (0.35)	0.028 (0.42)	0.045 (0.53)	0.076 (0.62)
OFT ₁	0.019 (0.32)	0.016 (0.46)	0.053 (0.74)	0.082 (1.01)	0.040 (0.57)	0.14 (0.87)	0.25 (1.04)	0.28 (1.23)	0.066 (0.52)	0.058 (0.65)	0.073 (0.87)	0.213 (1.31)
OFT ₂	0.020 (0.32)	0.016 (0.47)	0.054 (0.74)	0.085 (1.03)	0.040 (0.57)	0.17 (0.98)	0.29 (1.06)	0.30 (1.25)	0.066 (0.54)	0.061 (0.68)	0.077 (0.88)	0.275 (1.35)
OFT ₃	0.021 (0.34)	0.021 (0.48)	0.055 (0.76)	0.086 (1.03)	0.041 (0.58)	0.18 (1.01)	0.39 (1.07)	0.47 (1.26)	0.074 (0.55)	0.065 (0.69)	0.090 (0.93)	0.270 (1.37)
OPT ₁	0.020 (0.34)	0.018 (0.51)	0.054 (0.76)	0.084 (1.03)	0.041 (0.59)	0.15 (1.01)	0.32 (1.08)	0.174 (1.26)	0.068 (0.56)	0.062 (0.70)	0.096 (0.96)	0.270 (1.38)
OPT ₂	0.022 (0.35)	0.020 (0.56)	0.055 (0.76)	0.086 (1.04)	0.043 (0.60)	0.19 (1.02)	0.33 (1.08)	0.219 (1.26)	0.078 (0.57)	0.066 (0.71)	0.117 (0.97)	0.325 (1.41)
OPT ₃	0.023 (0.36)	0.022 (0.58)	0.063 (0.76)	0.099 (1.06)	0.044 (0.61)	0.21 (1.03)	0.39 (1.09)	0.488 (1.30)	0.078 (0.58)	0.069 (0.72)	0.134 (0.98)	0.371 (1.45)
CD at 5%	0.02	0.01	NS	0.02	0.01	0.02	0.03	0.04	0.01	0.00	0.04	0.05

N.B.: Figures in parentheses indicates % value

T₀ – Control, OFT₁ – 25g FYM, OFT₂ – 50 g FYM, OFT₃ – 100 g FYM

OPT₁ – 25g Poultry manure, OPT₂ – 50g Poultry manure, OPT₃ – 100g Poultry manure

DAT= Days after transplanting

Table 4.18 : Influence of Nitrogen on nutrient uptake by different plant parts of *Jatropha curcas* seedlings

Treat-ments	Nutrient uptake (g/seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁	0.012 (0.18)	0.022 (0.22)	0.029 (0.22)	0.082 (0.45)	0.033 (0.20)	0.060 (0.28)	0.12 (0.43)	0.17 (0.55)	0.019 (0.22)	0.033 (0.37)	0.040 (0.45)	0.051 (0.58)
N ₂	0.015 (0.23)	0.027 (0.25)	0.060 (0.47)	0.080 (0.47)	0.043 (0.26)	0.48 (0.29)	0.96 (0.58)	0.13 (0.83)	0.023 (0.26)	0.035 (0.38)	0.072 (0.78)	0.095 (1.03)
N ₃	0.19 (0.25)	0.026 (0.25)	0.082 (0.60)	0.083 (0.86)	0.052 (0.26)	0.78 (0.33)	0.21 (0.73)	0.30 (0.92)	0.031 (0.29)	0.039 (0.42)	0.025 (0.86)	0.40 (1.23)
CD at 5%	0.025	0.045	0.35	0.34	0.024	0.020	0.034	0.021	0.032	0.026	0.034	0.034

N.B.: Figures in parentheses indicates % value.

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm

DAT= Days after transplanting

Table 4.19 : Influence of Phosphorus on nutrient uptake by different plant parts of *Jatropha curcas* seedlings

Treatments	Nutrient uptake (g/seedling).											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
P ₁	0.010 (0.18)	0.019 (0.20)	0.025 (0.20)	0.032 (0.23)	0.045 (0.25)	0.063 (0.28)	0.094 (0.36)	0.13 (0.40)	0.018 (0.20)	0.015 (0.24)	0.022 (0.24)	0.037 (0.30)
P ₂	0.015 (0.23)	0.022 (0.22)	0.029 (0.23)	0.032 (0.25)	0.053 (0.30)	0.079 (0.35)	0.21 (0.76)	0.35 (1.08)	0.023 (0.23)	0.017 (0.27)	0.029 (0.30)	0.056 (0.43)
P ₃	0.016 (0.24)	0.027 (0.25)	0.038 (0.27)	0.041 (0.30)	0.068 (0.37)	0.10 (0.45)	0.24 (0.86)	0.36 (1.10)	0.024 (0.26)	0.017 (0.26)	0.037 (0.35)	0.021 (0.37)
CD at 5%	0.34	0.45	0.35	0.37	0.34	0.24	0.26	0.34	0.21	0.34	0.32	0.45

N.B.: Figures in parentheses indicates % value.

P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ - 4.8 gm

DAT= Days after transplanting

Table 4.20 : Influence of Potassium on nutrient uptake by different plant parts of *Jatropha curcas* seedlings

Treat- ments	Nutrient uptake (g/ seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
K ₁	0.011 (0.17)	0.022 (0.23)	0.034 (0.27)	0.40 (0.29)	0.018 (0.11)	0.033 (0.15)	0.036 (0.16)	0.057 (0.18)	0.013 (0.13)	0.016 (0.12)	0.017 (0.18)	0.024 (0.18)
K ₂	0.015 (0.23)	0.029 (0.27)	0.039 (0.30)	0.48 (0.37)	0.027 (0.15)	0.046 (0.20)	0.069 (0.30)	0.10 (0.33)	0.016 (0.17)	0.020 (0.21)	0.022 (0.23)	0.034 (0.25)
K ₃	0.017 (0.30)	0.037 (0.37)	0.051 (0.39)	0.053 (0.39)	0.051 (0.17)	0.067 (0.30)	0.023 (0.32)	0.10 (0.32)	0.019 (0.22)	0.021 (0.25)	0.027 (0.27)	0.032 (0.27)
CD at 5%	0.32	0.33	0.54	0.32	1.02	1.12	0.65	0.42	0.24	0.22	0.21	0.30

N.B.: Figures in parentheses indicates % value.

K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

DAT= Days after transplanting

Table 4.21 : Influence of Nitrogen and Phosphorus (N x P) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings.

Treat- ment	Nutrient uptake (g/ seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁ P ₁	0.01 (0.21)	0.03 (0.27)	0.03 (0.30)	0.05 (0.30)	0.04 (0.31)	0.09 (0.44)	0.10 (0.48)	0.19 (0.59)	0.02 (0.30)	0.02 (0.37)	0.04 (0.42)	0.06 (0.53)
N ₁ P ₂	0.02 (0.23)	0.03 (0.29)	0.04 (0.33)	0.04 (0.32)	0.06 (0.32)	0.10 (0.48)	0.11 (0.47)	0.20 (0.60)	0.03 (0.33)	0.02 (0.38)	0.04 (0.43)	0.06 (0.55)
N ₁ P ₃	0.01 (0.24)	0.04 (0.30)	0.05 (0.34)	0.04 (0.33)	0.07 (0.34)	0.11 (0.49)	0.11 (0.48)	0.21 (0.63)	0.03 (0.37)	0.03 (0.40)	0.05 (0.45)	0.07 (0.59)
N ₂ P ₁	0.01 (0.22)	0.03 (0.29)	0.04 (0.36)	0.04 (0.30)	0.06 (0.37)	0.12 (0.50)	0.11 (0.51)	0.19 (0.60)	0.04 (0.41)	0.03 (0.38)	0.03 (0.49)	0.05 (0.54)
N ₂ P ₂	0.01 (0.21)	0.04 (0.29)	0.05 (0.40)	0.05 (0.35)	0.06 (0.40)	0.12 (0.48)	0.12 (0.53)	0.19 (0.59)	0.04 (0.39)	0.04 (0.42)	0.04 (0.48)	0.07 (0.57)
N ₂ P ₃	0.02 (0.25)	0.03 (0.28)	0.06 (0.39)	0.05 (0.33)	0.08 (0.42)	0.12 (0.51)	0.12 (0.49)	0.21 (0.62)	0.03 (0.37)	0.03 (0.44)	0.05 (0.50)	0.09 (0.60)
N ₃ P ₁	0.02 (0.24)	0.04 (0.31)	0.05 (0.36)	0.04 (0.32)	0.06 (0.39)	0.11 (0.49)	0.12 (0.50)	0.21 (0.65)	0.05 (0.44)	0.03 (0.41)	0.05 (0.47)	0.09 (0.59)
N ₃ P ₂	0.02 (0.26)	0.03 (0.33)	0.05 (0.40)	0.04 (0.35)	0.08 (0.42)	0.12 (0.52)	0.12 (0.53)	0.22 (0.65)	0.05 (0.48)	0.04 (0.47)	0.05 (0.50)	0.10 (0.61)
N ₃ P ₃	0.02 (0.30)	0.04 (0.35)	0.06 (0.42)	0.05 (0.37)	0.07 (0.44)	0.12 (0.54)	0.13 (0.55)	0.22 (0.66)	0.06 (0.52)	0.06 (0.55)	0.06 (0.54)	0.11 (0.63)
CD at 5%	NS	0.023	NS	NS	0.30	0.022	NS	0.029	0.012	NS	NS	0.035

N.B.: Figures in parentheses indicates % value.

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm

DAT= Days after transplanting

Table 4.22 : Influence of Nitrogen and Potassium (N x K) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings.

Treat-ments	Nutrient uptake (g/ seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁ K ₁	0.01 (0.22)	0.03 (0.27)	0.04 (0.31)	0.05 (0.33)	0.07 (0.32)	0.10 (0.46)	0.11 (0.48)	0.19 (0.58)	0.03 (0.31)	0.02 (0.38)	0.04 (0.42)	0.05 (0.51)
N ₁ K ₂	0.02 (0.24)	0.03 (0.29)	0.04 (0.33)	0.05 (0.34)	0.07 (0.34)	0.10 (0.45)	0.11 (0.49)	0.19 (0.59)	0.03 (0.33)	0.02 (0.38)	0.04 (0.43)	0.06 (0.53)
N ₂ K ₃	0.01 (0.23)	0.03 (0.29)	0.04 (0.35)	0.05 (0.36)	0.07 (0.37)	0.10 (0.44)	0.11 (0.49)	0.19 (0.57)	0.02 (0.32)	0.02 (0.40)	0.04 (0.45)	0.07 (0.55)
N ₂ K ₁	0.02 (0.25)	0.03 (0.30)	0.04 (0.35)	0.05 (0.34)	0.06 (0.40)	0.11 (0.46)	0.11 (0.49)	0.18 (0.58)	0.03 (0.31)	0.02 (0.45)	0.04 (0.47)	0.06 (0.55)
N ₂ K ₂	0.02 (0.30)	0.04 (0.32)	0.05 (0.37)	0.05 (0.35)	0.07 (0.39)	0.12 (0.50)	0.12 (0.50)	0.19 (0.60)	0.03 (0.34)	0.02 (0.41)	0.04 (0.49)	0.07 (0.58)
N ₂ K ₃	0.02 (0.31)	0.04 (0.35)	0.05 (0.40)	0.04 (0.35)	0.06 (0.40)	0.12 (0.49)	0.12 (0.53)	0.21 (0.61)	0.03 (0.37)	0.03 (0.44)	0.04 (0.48)	0.08 (0.60)
N ₃ K ₁	0.02 (0.32)	0.04 (0.38)	0.06 (0.42)	0.05 (0.40)	0.06 (0.38)	0.11 (0.48)	0.11 (0.48)	0.20 (0.61)	0.04 (0.40)	0.03 (0.45)	0.06 (0.50)	0.09 (0.59)
N ₃ K ₂	0.03 (0.35)	0.05 (0.40)	0.06 (0.44)	0.05 (0.40)	0.07 (0.44)	0.12 (0.52)	0.12 (0.52)	0.21 (0.62)	0.04 (0.42)	0.04 (0.47)	0.06 (0.52)	0.11 (0.62)
N ₃ K ₃	0.02 (0.38)	0.05 (0.42)	0.07 (0.48)	0.06 (0.42)	0.07 (0.43)	0.13 (0.54)	0.13 (0.54)	0.21 (0.63)	0.05 (0.44)	0.03 (0.50)	0.07 (0.55)	0.10 (0.63)
CD at 5%	0.053	0.054	0.041	NS	0.025	NS	0.056	0.041	NS	0.032	0.025	0.024

N.B.: Figures in parentheses indicates % value.

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

DAT = Days after transplanting

Table 4.23 : Influence of Phosphorus and Potassium (P x K) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings.

Treat-ments	Nutrient uptake (g/ seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
P ₁ K ₁	0.03 (0.29)	0.02 (0.32)	0.04 (0.41)	0.05 (0.44)	0.06 (0.32)	0.09 (0.39)	0.10 (0.44)	0.016 (0.49)	0.02 (0.34)	0.04 (0.37)	0.05 (0.41)	0.07 (0.48)
P ₁ K ₂	0.03 (0.29)	0.02 (0.34)	0.04 (0.43)	0.06 (0.46)	0.07 (0.35)	0.09 (0.39)	0.11 (0.46)	0.15 (0.46)	0.02 (0.35)	0.05 (0.39)	0.06 (0.44)	0.07 (0.50)
P ₂ K ₃	0.02 (0.32)	0.02 (0.35)	0.05 (0.45)	0.06 (0.48)	0.06 (0.34)	0.09 (0.40)	0.10 (0.45)	0.17 (0.48)	0.02 (0.34)	0.04 (0.37)	0.05 (0.43)	0.07 (0.52)
P ₂ K ₁	0.04 (0.34)	0.02 (0.38)	0.04 (0.44)	0.06 (0.46)	0.05 (0.32)	0.09 (0.40)	0.11 (0.48)	0.16 (0.49)	0.02 (0.35)	0.04 (0.39)	0.05 (0.44)	0.07 (0.51)
P ₂ K ₂	0.03 (0.32)	0.03 (0.37)	0.04 (0.44)	0.06 (0.46)	0.06 (0.32)	0.08 (0.38)	0.11 (0.48)	0.17 (0.51)	0.03 (0.39)	0.05 (0.39)	0.05 (0.42)	0.06 (0.53)
P ₂ K ₃	0.04 (0.36)	0.03 (0.38)	0.05 (0.48)	0.07 (0.52)	0.06 (0.33)	0.10 (0.42)	0.11 (0.46)	0.16 (0.50)	0.03 (0.40)	0.05 (0.42)	0.06 (0.43)	0.06 (0.50)
P ₃ K ₁	0.04 (0.39)	0.02 (0.42)	0.05 (0.47)	0.07 (0.53)	0.07 (0.36)	0.10 (0.41)	0.11 (0.50)	0.17 (0.52)	0.03 (0.38)	0.05 (0.44)	0.06 (0.44)	0.07 (0.55)
P ₃ K ₂	0.04 (0.39)	0.03 (0.44)	0.06 (0.52)	0.08 (0.52)	0.07 (0.40)	0.10 (0.44)	0.12 (0.52)	0.17 (0.53)	0.03 (0.40)	0.06 (0.45)	0.06 (0.45)	0.07 (0.54)
P ₃ K ₃	0.04 (0.42)	0.03 (0.44)	0.06 (0.54)	0.08 (0.55)	0.06 (0.38)	0.11 (0.44)	0.12 (0.51)	0.18 (0.53)	0.02 (0.41)	0.06 (0.47)	0.07 (0.47)	0.08 (0.55)
CD at 5%	NS	0.041	0.025	NS	0.046	0.056	0.012	NS	NS	0.016	0.032	NS

N.B.: Figures in parentheses indicates % value.

P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

DAT = Days after transplanting

Table 4.24 : Influence of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings.

Treatment	Nutrient uptake(g/seedling)											
	Root				Stem				Leaf			
	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT	30 DAT	60 DAT	90 DAT	120 DAT
N ₁ P ₁ K ₁	0.02 (0.37)	0.04 (0.41)	0.06 (0.45)	0.07 (0.49)	0.09 (0.35)	0.08 (0.42)	0.10 (0.46)	0.17 (0.52)	0.031 (0.32)	0.02 (0.35)	0.03 (0.47)	0.05 (0.50)
N ₁ P ₁ K ₂	0.03 (0.39)	0.04 (0.42)	0.05 (0.46)	0.08 (0.50)	0.08 (0.36)	0.09 (0.43)	0.10 (0.47)	0.17 (0.53)	0.042 (0.37)	0.02 (0.38)	0.04 (0.48)	0.06 (0.52)
N ₁ P ₁ K ₃	0.02 (0.39)	0.04 (0.40)	0.05 (0.46)	0.08 (0.50)	0.08 (0.36)	0.10 (0.44)	0.10 (0.46)	0.18 (0.52)	0.013 (0.40)	0.03 (0.44)	0.05 (0.46)	0.07 (0.52)
N ₁ P ₂ K ₁	0.02 (0.40)	0.04 (0.41)	0.06 (0.45)	0.07 (0.51)	0.06 (0.37)	0.09 (0.43)	0.10 (0.45)	0.17 (0.51)	0.051 (0.44)	0.02 (0.46)	0.06 (0.48)	0.06 (0.51)
N ₁ P ₂ K ₂	0.04 (0.42)	0.05 (0.42)	0.06 (0.47)	0.07 (0.52)	0.07 (0.38)	0.10 (0.43)	0.10 (0.45)	0.16 (0.50)	0.033 (0.47)	0.03 (0.49)	0.04 (0.50)	0.06 (0.51)
N ₁ P ₂ K ₃	0.03 (0.44)	0.05 (0.43)	0.06 (0.44)	0.07 (0.48)	0.06 (0.36)	0.09 (0.44)	0.10 (0.44)	0.16 (0.49)	0.054 (0.48)	0.02 (0.49)	0.05 (0.51)	0.07 (0.52)
N ₁ P ₃ K ₁	0.03 (0.46)	0.06 (0.47)	0.06 (0.48)	0.06 (0.49)	0.07 (0.37)	0.10 (0.45)	0.10 (0.46)	0.15 (0.48)	0.04 (0.47)	0.03 (0.49)	0.05 (0.50)	0.05 (0.51)
N ₁ P ₃ K ₂	0.03 (0.44)	0.04 (0.45)	0.06 (0.46)	0.06 (0.48)	0.07 (0.37)	0.11 (0.46)	0.12 (0.47)	0.16 (0.49)	0.05 (0.49)	0.04 (0.52)	0.07 (0.55)	0.06 (0.56)
N ₁ P ₃ K ₃	0.03 (0.45)	0.05 (0.46)	0.07 (0.47)	0.07 (0.49)	0.07 (0.38)	0.10 (0.45)	0.10 (0.48)	0.17 (0.50)	0.05 (0.49)	0.04 (0.50)	0.04 (0.52)	0.06 (0.54)
N ₂ P ₁ K ₁	0.03 (0.47)	0.06 (0.49)	0.06 (0.50)	0.06 (0.51)	0.06 (0.39)	0.11 (0.47)	0.11 (0.48)	0.16 (0.50)	1.00 (0.50)	0.04 (0.53)	0.05 (0.55)	0.05 (0.57)
N ₂ P ₁ K ₂	0.02 (0.49)	0.05 (0.50)	0.07 (0.52)	0.06 (0.53)	0.08 (0.42)	0.11 (0.48)	0.11 (0.50)	0.15 (0.52)	0.05 (0.52)	0.04 (0.53)	0.06 (0.54)	0.06 (0.55)
N ₂ P ₁ K ₃	0.03 (0.48)	0.06 (0.49)	0.06 (0.50)	0.07 (0.51)	0.07 (0.40)	0.11 (0.49)	0.10 (0.50)	0.18 (0.52)	0.04 (0.54)	0.03 (0.55)	0.04 (0.54)	0.06 (0.55)
N ₂ P ₂ K ₁	0.02 (0.47)	0.06 (0.48)	0.05 (0.50)	0.08 (0.52)	0.05 (0.43)	0.11 (0.49)	0.12 (0.51)	0.15 (0.51)	0.05 (0.54)	0.02 (0.56)	0.04 (0.58)	0.07 (0.59)
N ₂ P ₂ K ₂	0.03 (0.48)	0.06 (0.49)	0.06 (0.50)	0.06 (0.51)	0.07 (0.45)	0.12 (0.47)	0.11 (0.50)	0.16 (0.50)	0.06 (0.57)	0.03 (0.59)	0.03 (0.60)	0.07 (0.62)
N ₂ P ₂ K ₃	0.03 (0.49)	0.06 (0.50)	0.06 (0.52)	0.07 (0.53)	0.07 (0.43)	0.12 (0.48)	0.12 (0.49)	0.16 (0.49)	0.05 (0.55)	0.03 (0.57)	0.05 (0.59)	0.07 (0.60)
N ₂ P ₃ K ₁	0.04 (0.49)	0.06 (0.50)	0.08 (0.53)	0.07 (0.54)	0.09 (0.44)	0.12 (0.48)	0.12 (0.48)	0.18 (0.53)	0.06 (0.56)	0.05 (0.58)	0.05 (0.59)	0.08 (0.61)
N ₂ P ₃ K ₂	0.04 (0.50)	0.06 (0.52)	0.08 (0.53)	0.08 (0.54)	0.09 (0.47)	0.11 (0.49)	0.13 (0.52)	0.18 (0.55)	0.04 (0.57)	0.04 (0.60)	0.07 (0.62)	0.10 (0.64)
N ₂ P ₃ K ₃	0.03 (0.52)	0.07 (0.54)	0.08 (0.55)	0.09 (0.56)	0.07 (0.49)	0.12 (0.51)	0.13 (0.53)	0.19 (0.55)	0.04 (0.56)	0.06 (0.58)	0.07 (0.61)	0.10 (0.62)
N ₃ P ₁ K ₁	0.04 (0.50)	0.06 (0.52)	0.08 (0.54)	0.07 (0.55)	0.07 (0.50)	0.12 (0.52)	0.13 (0.54)	0.18 (0.57)	0.05 (0.62)	0.04 (0.63)	0.07 (0.65)	0.10 (0.67)
N ₃ P ₁ K ₂	0.04 (0.53)	0.05 (0.55)	0.08 (0.56)	0.07 (0.58)	0.09 (0.52)	0.12 (0.54)	0.14 (0.55)	0.20 (0.59)	0.08 (0.60)	0.05 (0.62)	0.06 (0.64)	0.12 (0.66)
N ₃ P ₁ K ₃	0.02 (0.55)	0.07 (0.55)	0.08 (0.56)	0.07 (0.58)	0.08 (0.54)	0.13 (0.55)	0.13 (0.57)	0.21 (0.60)	0.07 (0.66)	0.04 (0.68)	0.09 (0.70)	0.10 (0.71)
N ₃ P ₂ K ₁	0.03 (0.53)	0.05 (0.54)	0.07 (0.55)	0.07 (0.57)	0.09 (0.55)	0.13 (0.57)	0.14 (0.59)	0.19 (0.59)	0.09 (0.67)	0.05 (0.69)	0.09 (0.70)	0.10 (0.72)
N ₃ P ₂ K ₂	0.05 (0.54)	0.07 (0.54)	0.07 (0.55)	0.07 (0.57)	0.10 (0.53)	0.14 (0.55)	0.14 (0.57)	0.20 (0.59)	0.05 (0.65)	0.08 (0.67)	0.08 (0.68)	0.11 (0.70)
N ₃ P ₂ K ₃	0.04 (0.53)	0.07 (0.55)	0.08 (0.56)	0.09 (0.58)	0.12 (0.55)	0.11 (0.56)	0.14 (0.58)	0.20 (0.61)	0.08 (0.65)	0.09 (0.67)	0.08 (0.69)	0.13 (0.71)
N ₃ P ₃ K ₁	0.04 (0.53)	0.06 (0.55)	0.08 (0.56)	0.08 (0.57)	0.11 (0.57)	0.15 (0.58)	0.14 (0.59)	0.20 (0.62)	0.07 (0.66)	0.05 (0.68)	0.08 (0.69)	0.10 (0.71)
N ₃ P ₃ K ₂	0.04 (0.55)	0.07 (0.56)	0.08 (0.57)	0.08 (0.57)	0.08 (0.58)	0.12 (0.59)	0.14 (0.60)	0.20 (0.61)	0.07 (0.68)	0.07 (0.70)	0.08 (0.72)	0.15 (0.73)
N ₃ P ₃ K ₃	0.08 (0.68)	0.07 (0.72)	0.08 (0.73)	0.12 (0.73)	0.09 (0.57)	0.14 (0.60)	0.14 (0.60)	0.21 (0.62)	0.05 (0.68)	0.06 (0.72)	0.07 (0.73)	0.08 (0.73)
CD at 5%	0.032	0.034	0.025	0.025	0.036	0.047	0.028	0.059	0.054	0.046	0.067	0.026

N.B.: Figures in parentheses indicates % value.

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm
 DAT= Days after transplanting

Table 4.9: Effect of FYM and Poultry Manure on above and below ground biomass of *Jatropha curcas* seedlings.

Treatment	Total AGB (g/seedling)	Total BGB (g/seedling)
T ₀	28.24	6.33
OFT ₁	39.70	8.12
OFT ₂	43.31	8.26
OFT ₃	47.58	8.43
OPT ₁	33.42	8.16
OPT ₂	40.52	8.30
OPT ₃	63.23	9.40
CD at 1%	0.12	0.10

T₀– Control

OFT₁ – 25g FYM, OFT₂ – 50 g FYM, OFT₃ – 100 g FYM

OPT₁ – 25g Poultry manure, OPT₂ – 50g Poultry manure,

OPT₃ –100g Poultry manure

AGB = above ground biomass

BGB = below ground biomass

Table 4.11: Influence of nitrogen and phosphorus (N x P) interaction on above and below ground biomass in *Jatropha curcas* seedling

Treatment	Total AGB g/seedling	Total BGB g/seedling
N ₁ P ₁	43.02	12.79
N ₁ P ₂	44.08	13.37
N ₁ P ₃	45.34	12.80
N ₂ P ₁	41.66	13.49
N ₂ P ₂	43.54	13.85
N ₂ P ₃	48.41	13.83
N ₃ P ₁	48.75	12.57
N ₃ P ₂	49.09	14.46
N ₃ P ₃	50.48	15.68
CD at 1%	0.04	0.85

Table 4.12: Effect of Nitrogen and Potassium (N x K) interaction on above and below ground biomass in *Jatropha curcas* seedlings

Treatment	Total AGB g/seedling	Total BGB g/seedling
N ₁ K ₁	42.32	13.68
N ₁ K ₂	44.08	13.79
N ₁ K ₃	45.99	14.37
N ₂ K ₁	43.23	13.49
N ₂ K ₂	43.96	13.69
N ₂ K ₃	46.42	13.96
N ₃ K ₁	47.21	14.39
N ₃ K ₂	51.33	14.44
N ₃ K ₃	49.79	13.02
CD at 5%	0.88	NS

Table 4.13 : Influence of Phosphorus and Potassium (P x K) interaction on above and below ground biomass *Jatropha curcas* seedlings

Treatment	Total AGB g/seedling	Total BGB g/seedling
P ₁ K ₁	43.53	14.33
P ₁ K ₂	45.02	13.78
P ₁ K ₃	47.41	14.20
P ₂ K ₁	44.31	13.63
P ₂ K ₂	46.06	12.98
P ₂ K ₃	46.65	12.82
P ₃ K ₁	44.92	13.61
P ₃ K ₂	48.30	14.16
P ₃ K ₃	48.10	14.33
CD at 5%	0.72	0.63

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm, K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

AGB = above ground biomass, BGB = below ground biomass

NS -Non Significant

Table 4.14 : Influence of nitrogen, phosphorus and potassium (N x P x K) interaction on above and below ground biomass in *Jatropha curcas* seedlings

Treatment	Total AGB g/seedling	Total BGB g/seedling
N ₁ P ₁ K ₁	42.57	14.80
N ₁ P ₁ K ₂	44.99	15.97
N ₁ P ₁ K ₃	47.41	16.27
N ₁ P ₂ K ₁	43.51	12.91
N ₁ P ₂ K ₂	44.21	13.18
N ₁ P ₂ K ₃	45.47	14.02
N ₁ P ₃ K ₁	40.59	12.23
N ₁ P ₃ K ₂	43.07	12.48
N ₁ P ₃ K ₃	45.10	13.66
N ₂ P ₁ K ₁	40.42	12.36
N ₂ P ₁ K ₂	39.41	11.88
N ₂ P ₁ K ₃	45.14	14.15
N ₂ P ₂ K ₁	42.23	17.74
N ₂ P ₂ K ₂	44.25	12.31
N ₂ P ₂ K ₃	44.13	13.42
N ₂ P ₃ K ₁	47.07	13.37
N ₂ P ₃ K ₂	48.22	12.77
N ₂ P ₃ K ₃	49.99	15.42
N ₃ P ₁ K ₁	47.59	15.82
N ₃ P ₁ K ₂	50.65	13.50
N ₃ P ₁ K ₃	49.71	12.17
N ₃ P ₂ K ₁	47.20	12.13
N ₃ P ₂ K ₂	49.71	12.60
N ₃ P ₂ K ₃	50.35	12.98
N ₃ P ₃ K ₁	46.82	15.23
N ₃ P ₃ K ₂	53.61	14.23
N ₃ P ₃ K ₃	49.32	13.92
CD at 5%	0.89	0.85

N₁ – 4.6 gm, N₂ – 6.9 gm, N₃ – 9.2 gm, P₁ – 3.2 gm, P₂ – 4.0 gm, P₃ – 4.8 gm,
K₁ – 0.8 gm, K₂ – 1.6 gm, K₃ – 2.4 gm

AGB = above ground biomass

BGB = below ground biomass

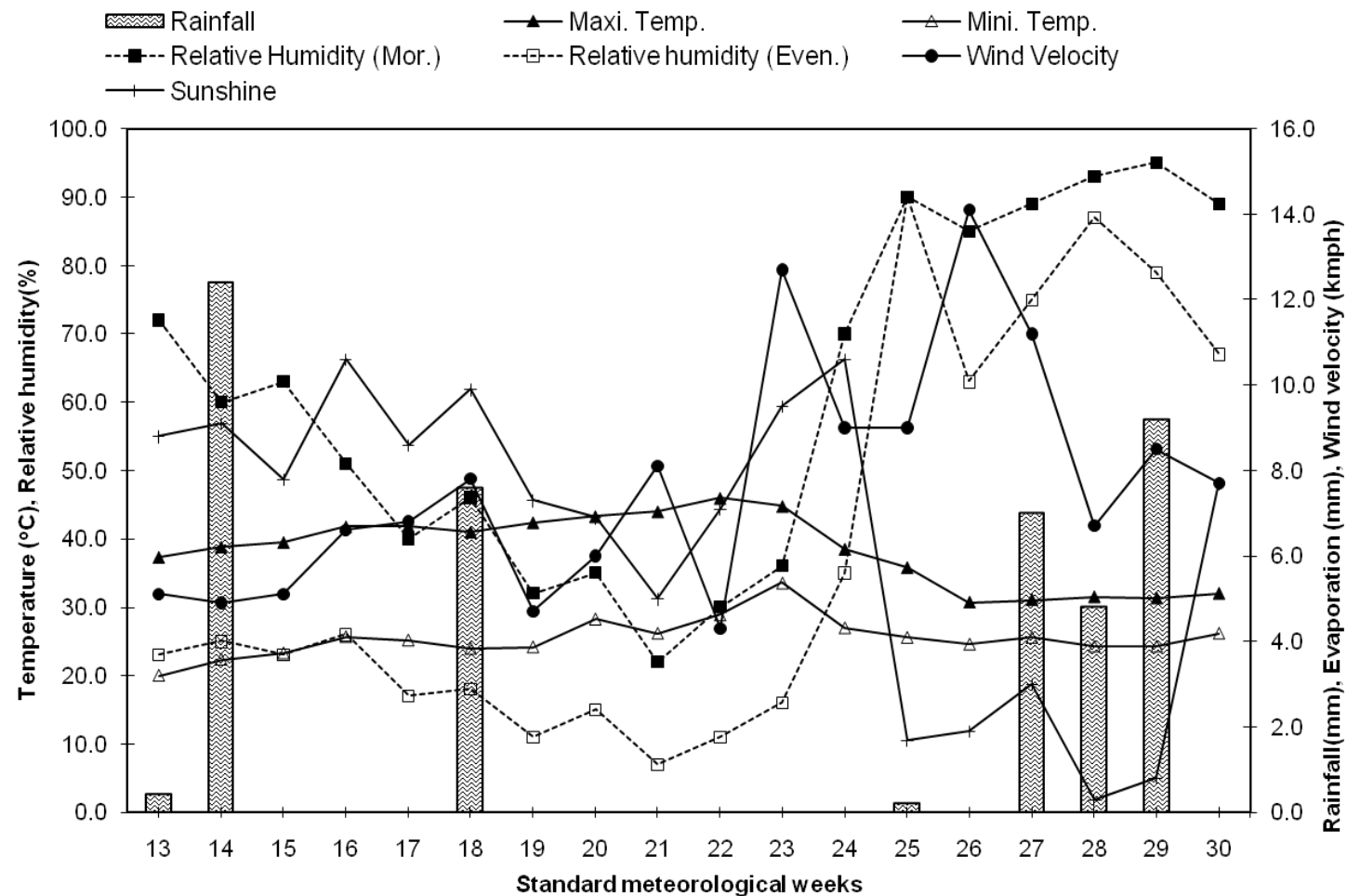


Fig. 3.1 : Weekly pattern of meteorological parameters during the growth period (April to July, 2003)

	Maxi. Temp.	Mini. Temp.	Rainfall	Relative Humidity (Mor.)	Relative humidity (Even.)	Wind Velocity	Sunshine
13	37.3	20.0	0.4	72	23	5.1	8.8
14	38.8	22.4	12.4	60	25	4.9	9.1
15	39.5	23.3	0.0	63	23	5.1	7.8
16	41.8	25.7	0.0	51	26	6.6	10.6
17	41.9	25.2	0.0	40	17	6.8	8.6
18	41.0	24.0	7.6	46	18	7.8	9.9
19	42.4	24.2	0.0	32	11	4.7	7.3
20	43.3	28.3	0.0	35	15	6	6.9
21	44.0	26.2	0.0	22	7	8.1	5
22	46.0	28.9	0.0	30	11	4.3	7.1
23	44.8	33.6	0.0	36	16	12.7	9.5
24	38.5	27.0	0.0	70	35	9	10.6
25	35.8	25.6	0.2	90	90	9	1.7
26	30.7	24.6	0.0	85	63	14.1	1.9
27	31.1	25.6	7.0	89	75	11.2	3
28	31.5	24.3	4.8	93	87	6.7	0.3
29	31.3	24.3	9.2	95	79	8.5	0.8
30	32.0	26.2	0.0	89	67	7.7	7.7

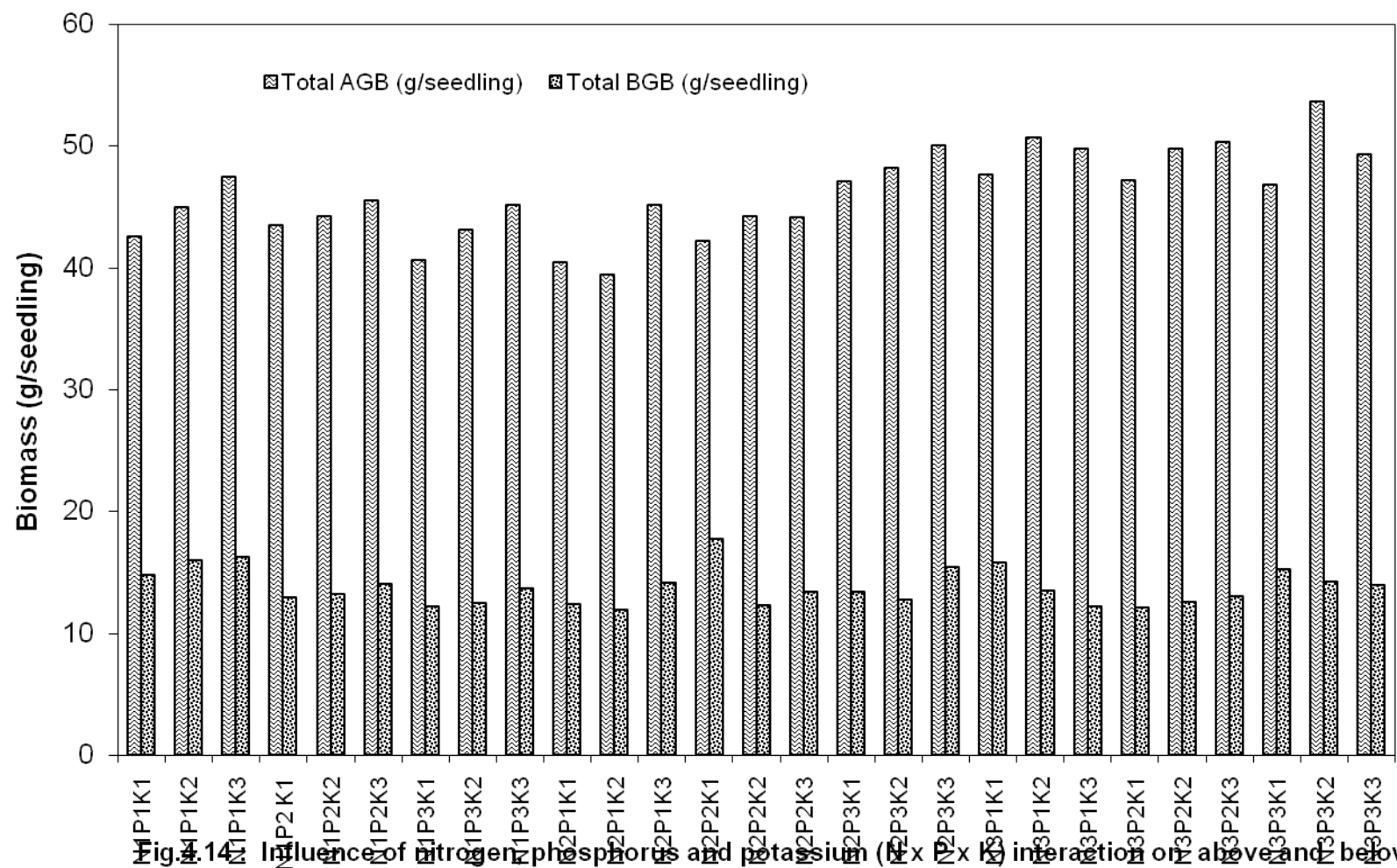
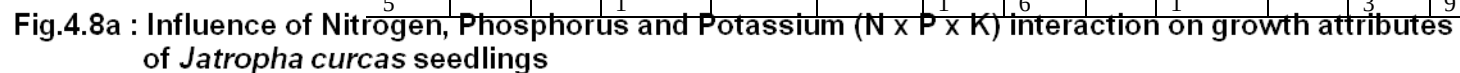


Fig. 4.14 Influence of nitrogen phosphorus and potassium (N x P x K) interaction on above and below ground biomass in *Jatropha curcas* seedlings



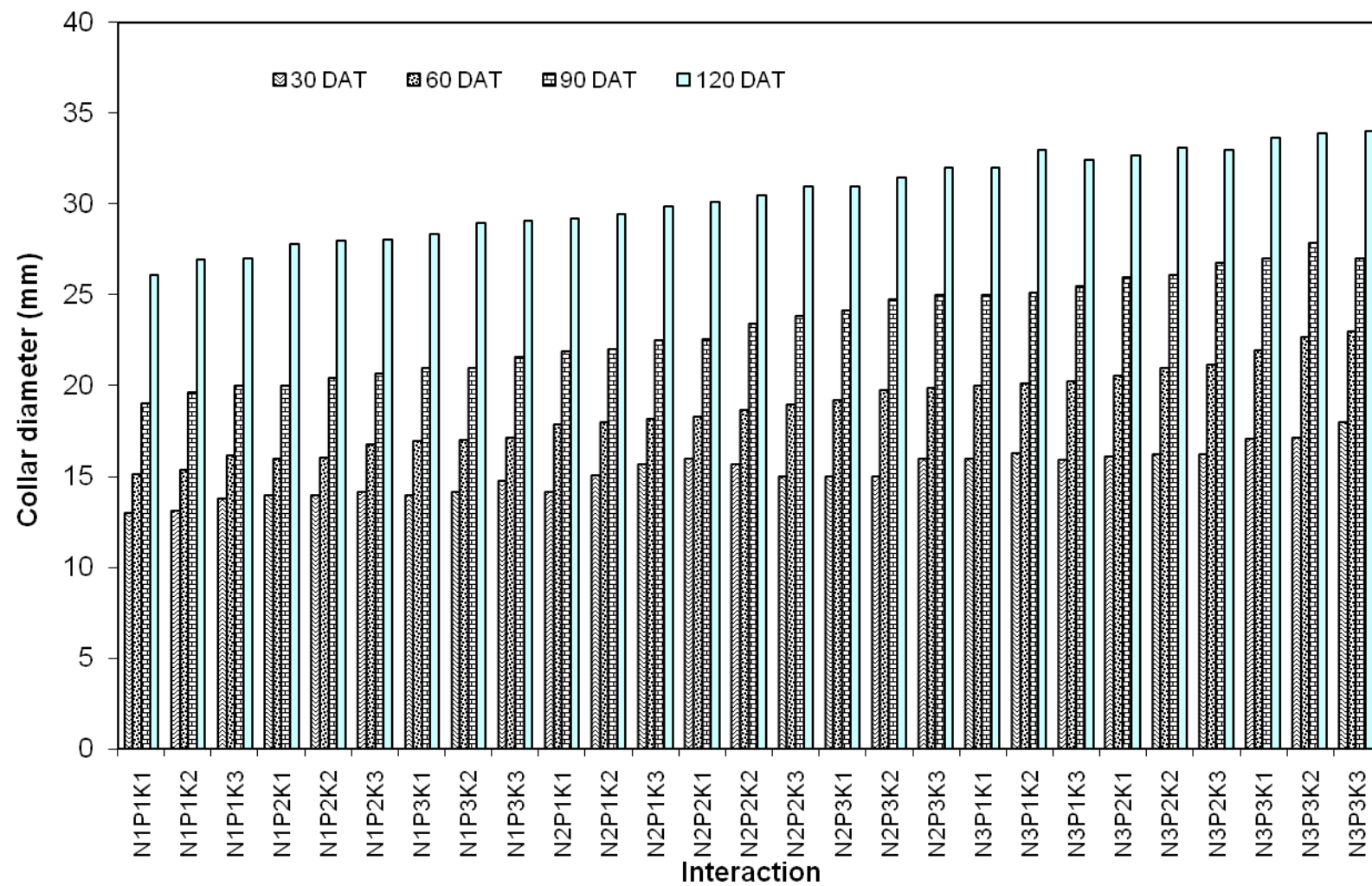


Fig.4.8b : Influence of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on growth attributes of *Jatropha curcas* seedlings

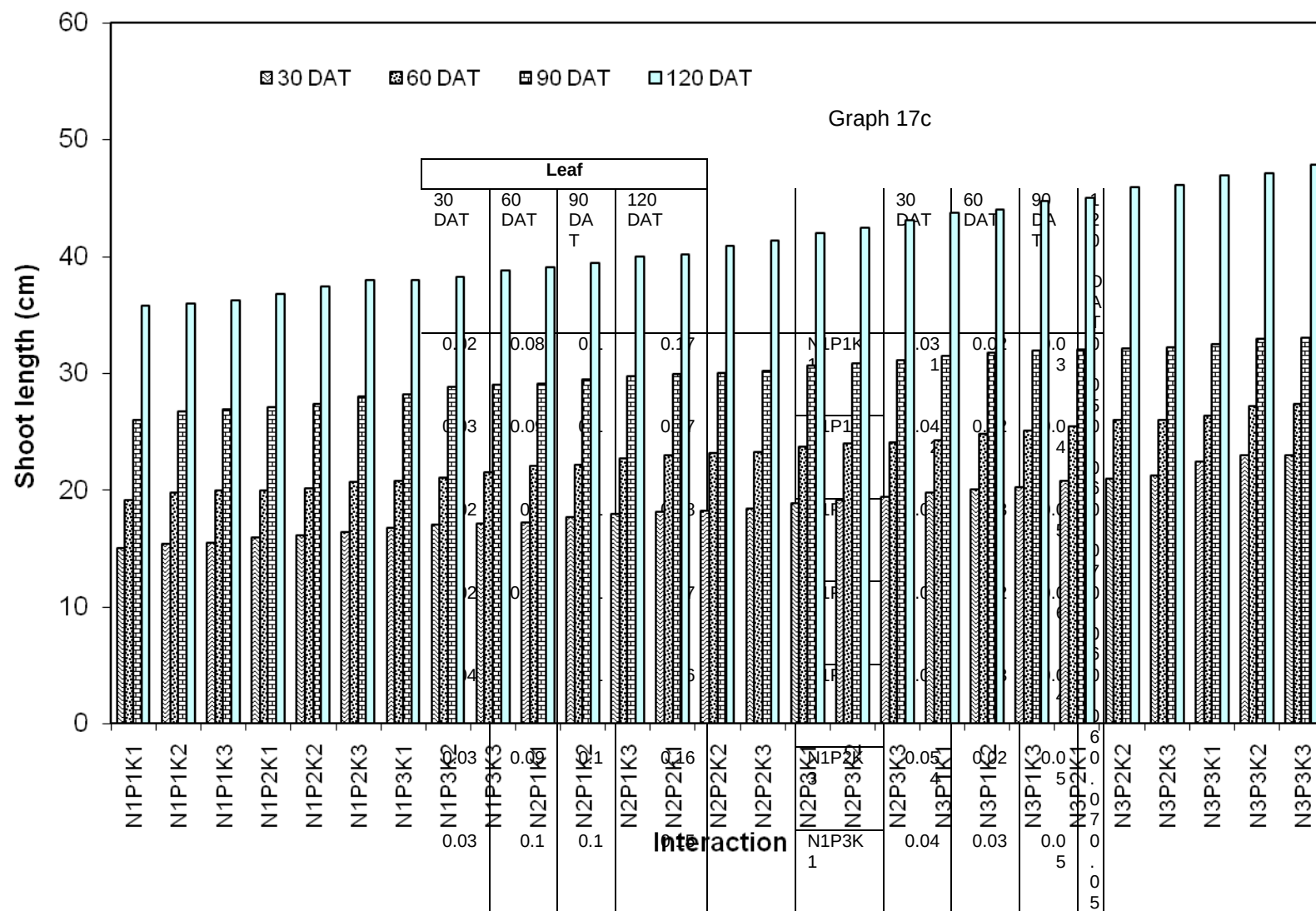
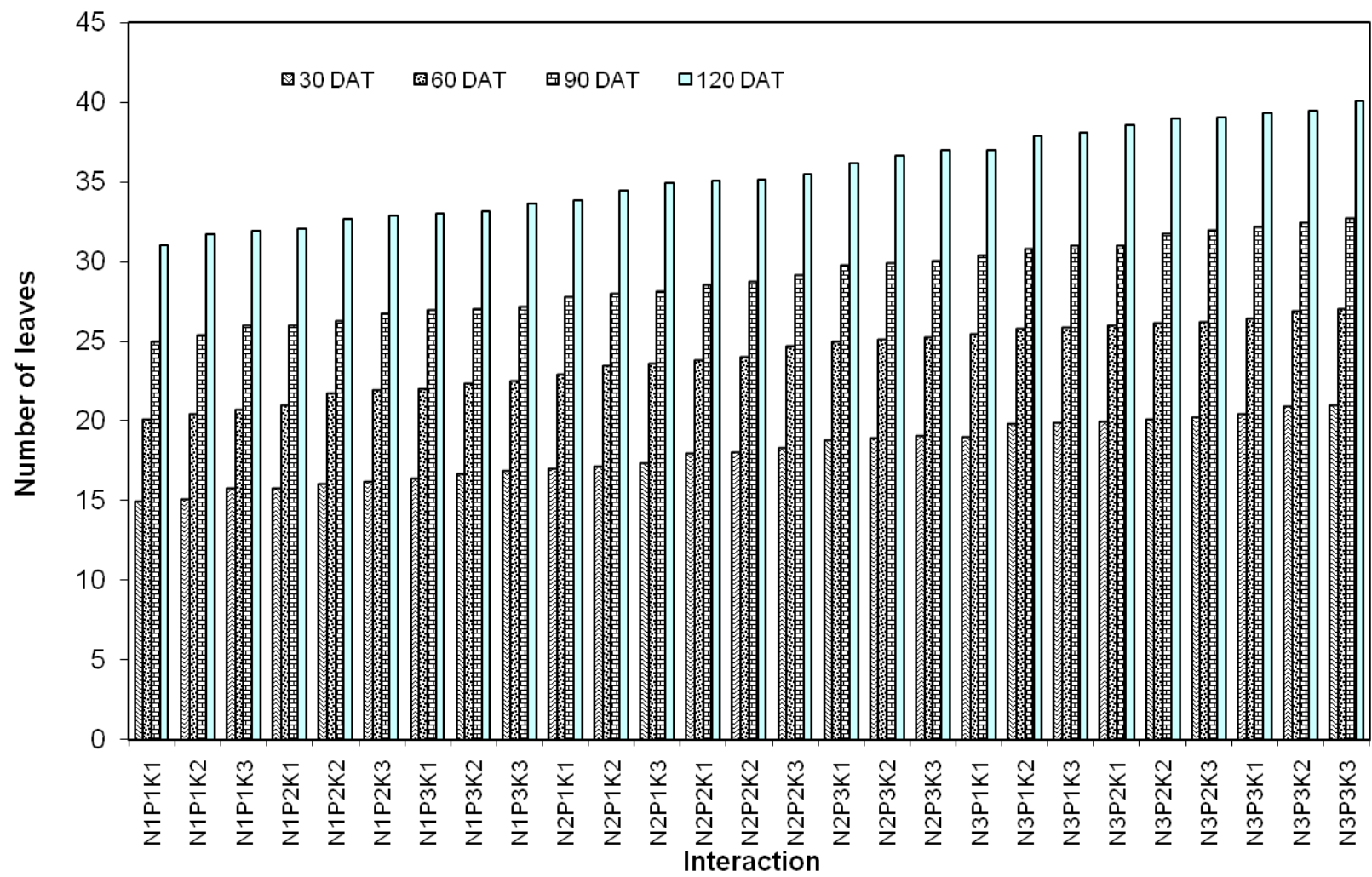


Fig.4.8c : Influence of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on growth attributes of *Jatropha curcas* seedlings



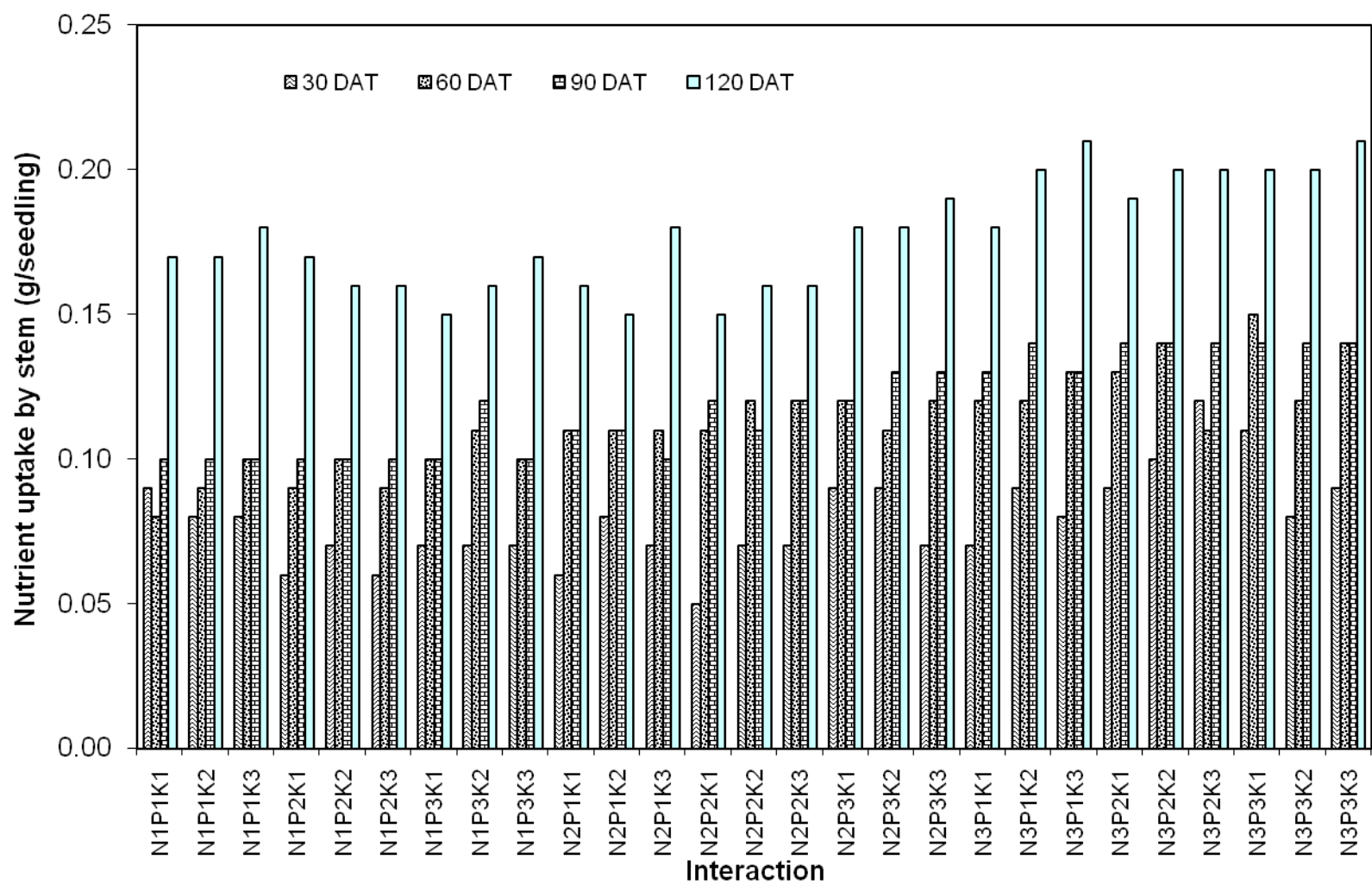


Fig.4.24b : Influence of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings

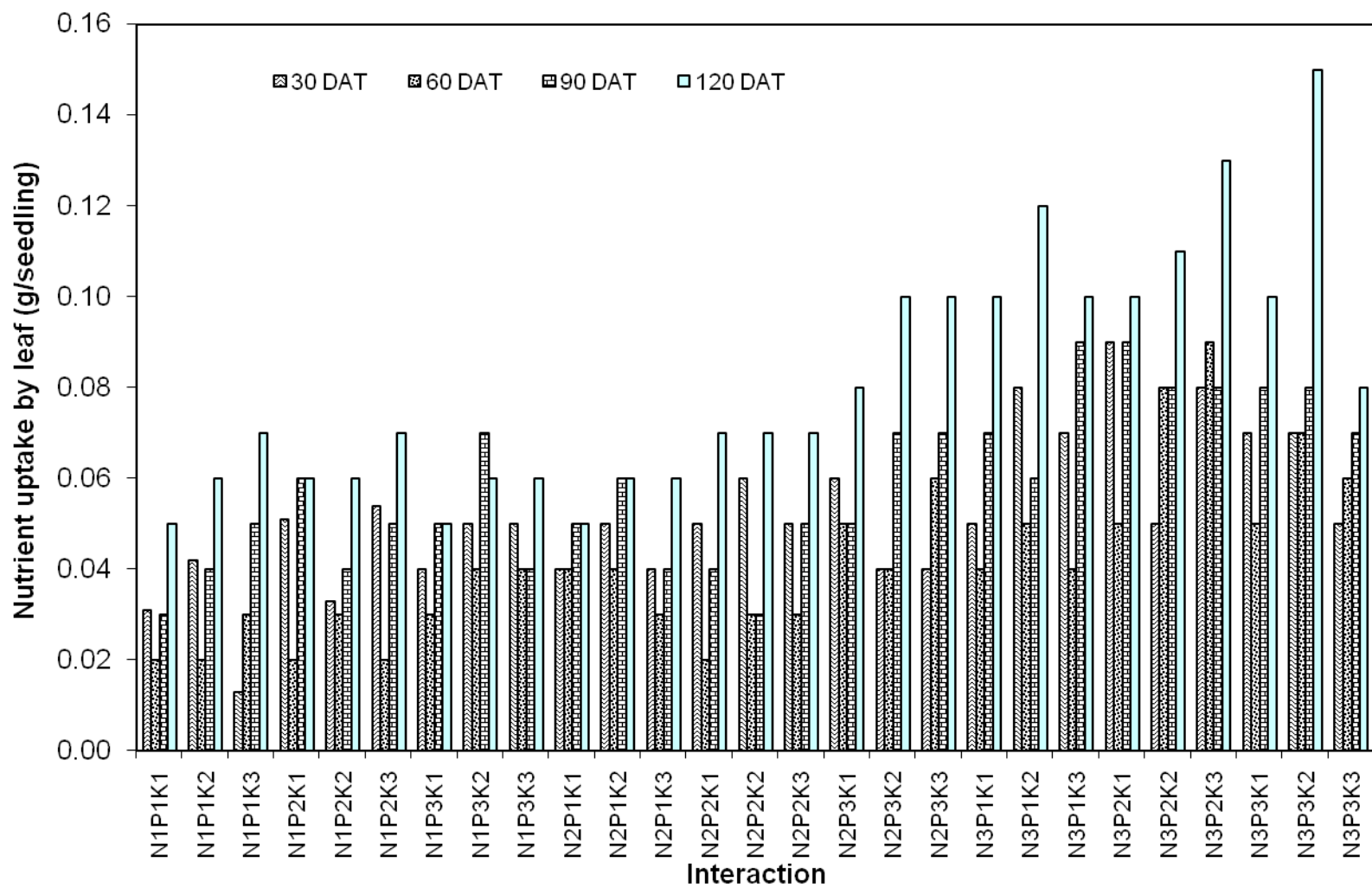


Fig.4.24c : Influence of Nitrogen, Phosphorus and Potassium (N x P x K) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings

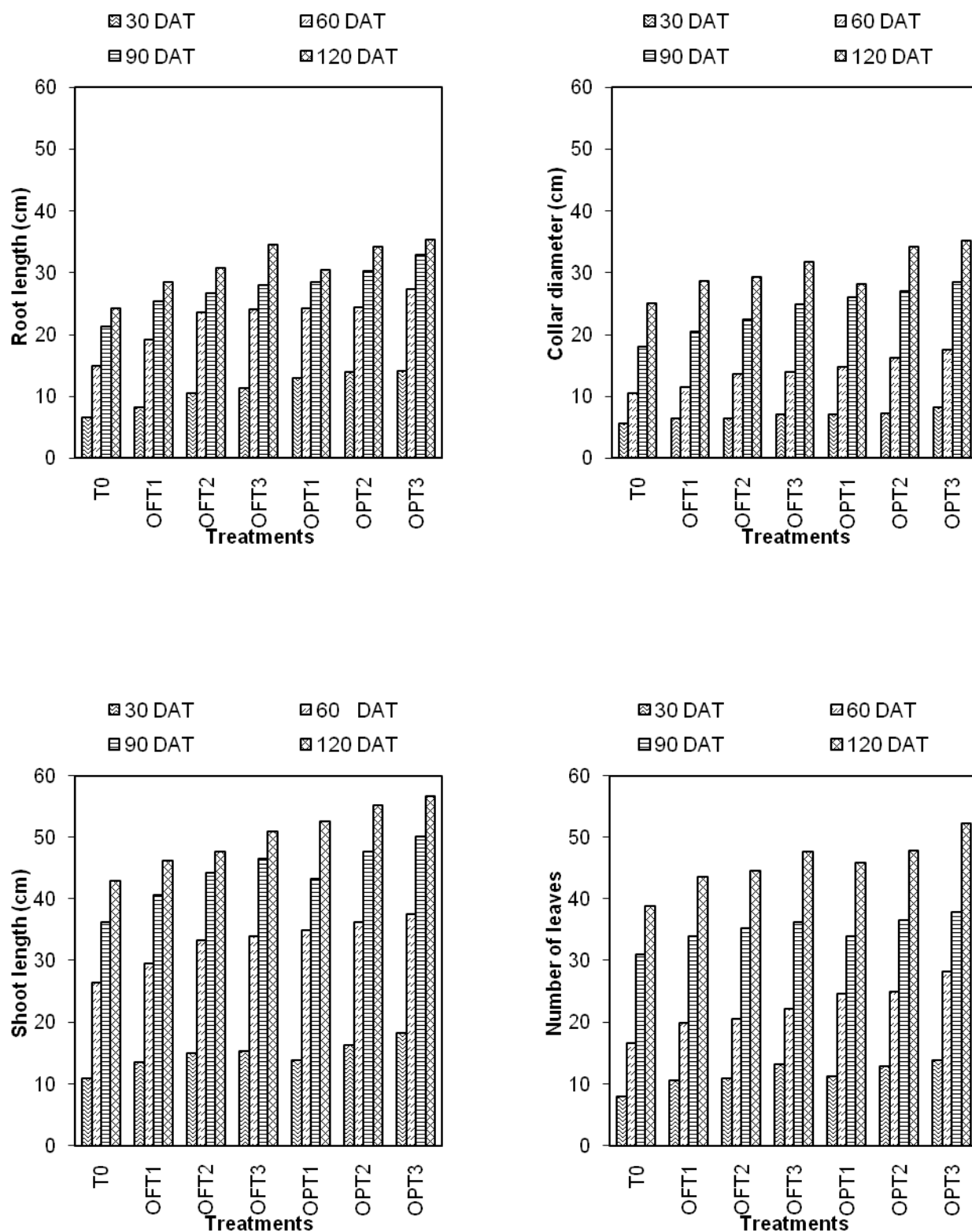


Fig.4.1 : Effect of organic manure on growth attributes of *Jatropha curcas* seedlings

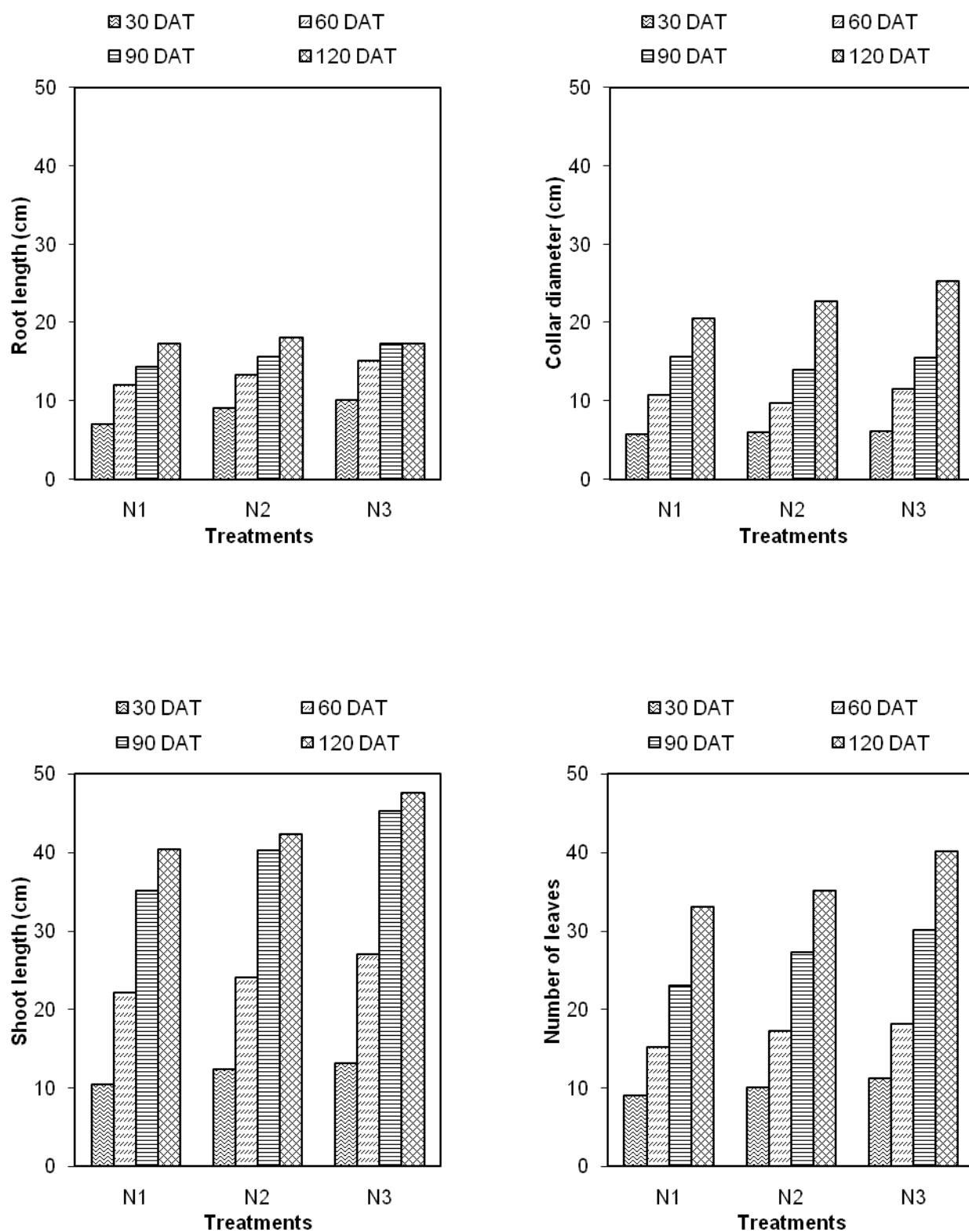


Fig.4.2 : Influence of Nitrogen on growth attributes of *Jatropha curcas* seedlings

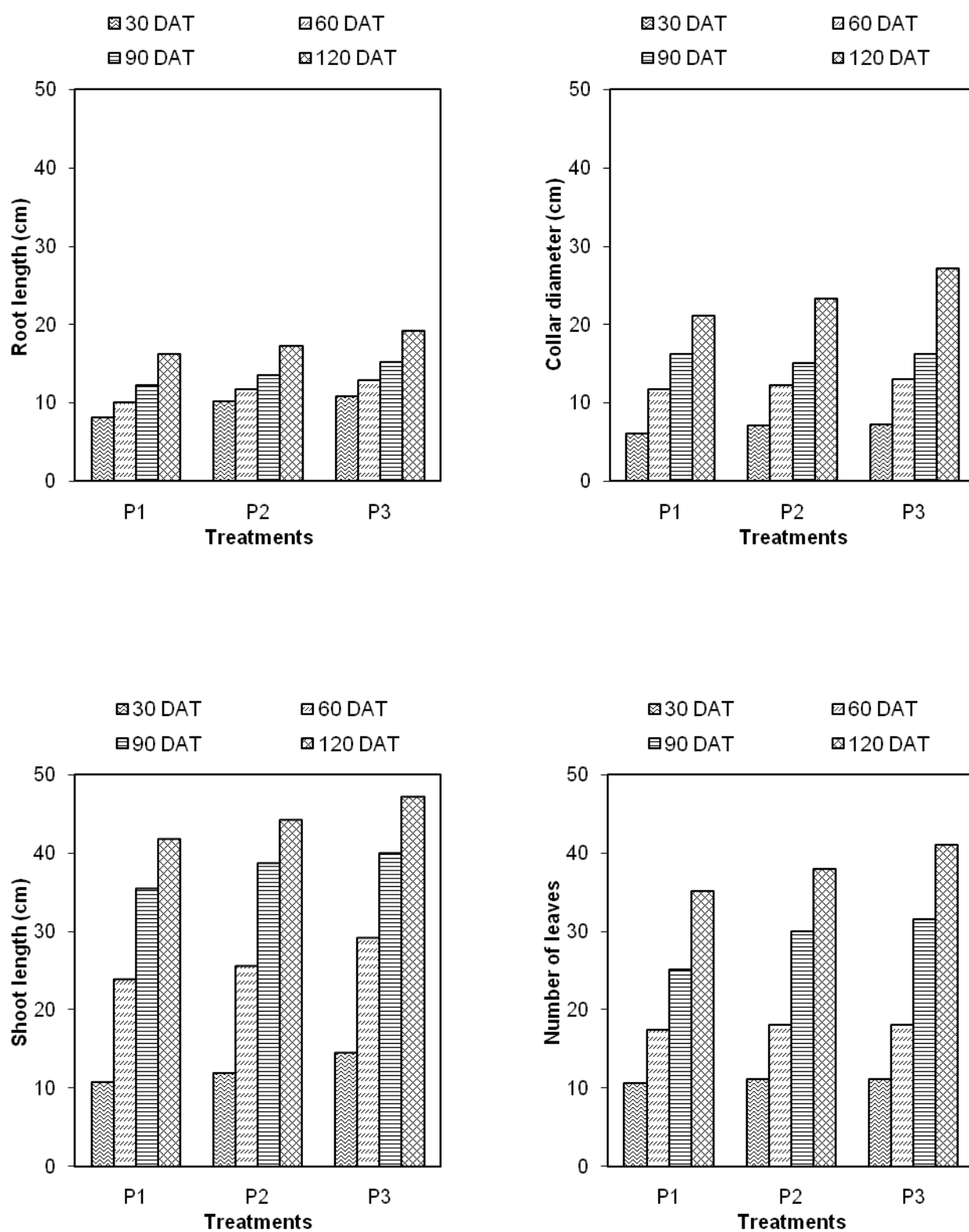


Fig.4.3 : Influence of Phosphorus on growth attributes of *Jatropha curcas* seedlings

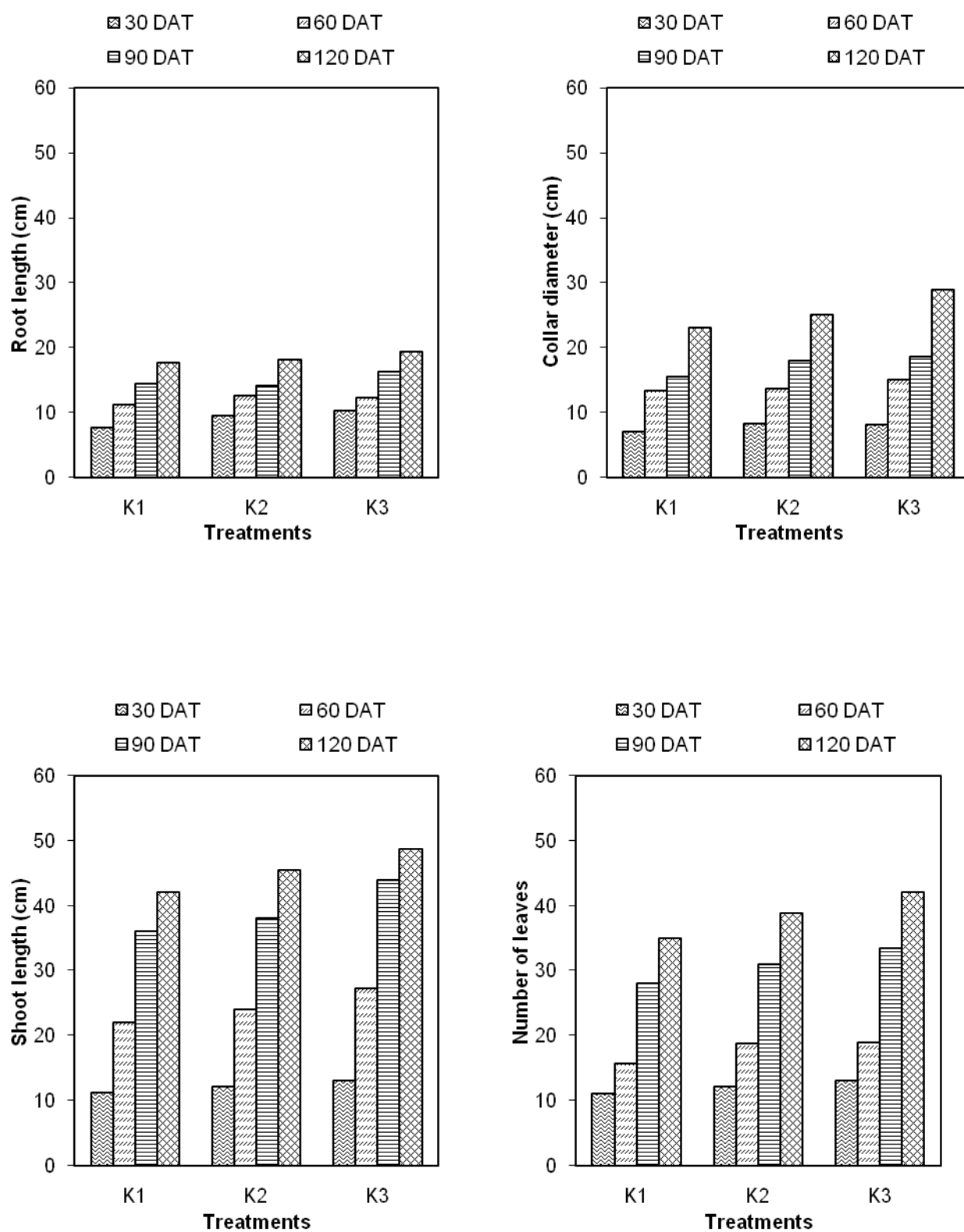


Fig.4.4 : Influence of Potassium on growth attributes of *Jatropha curcas* seedlings

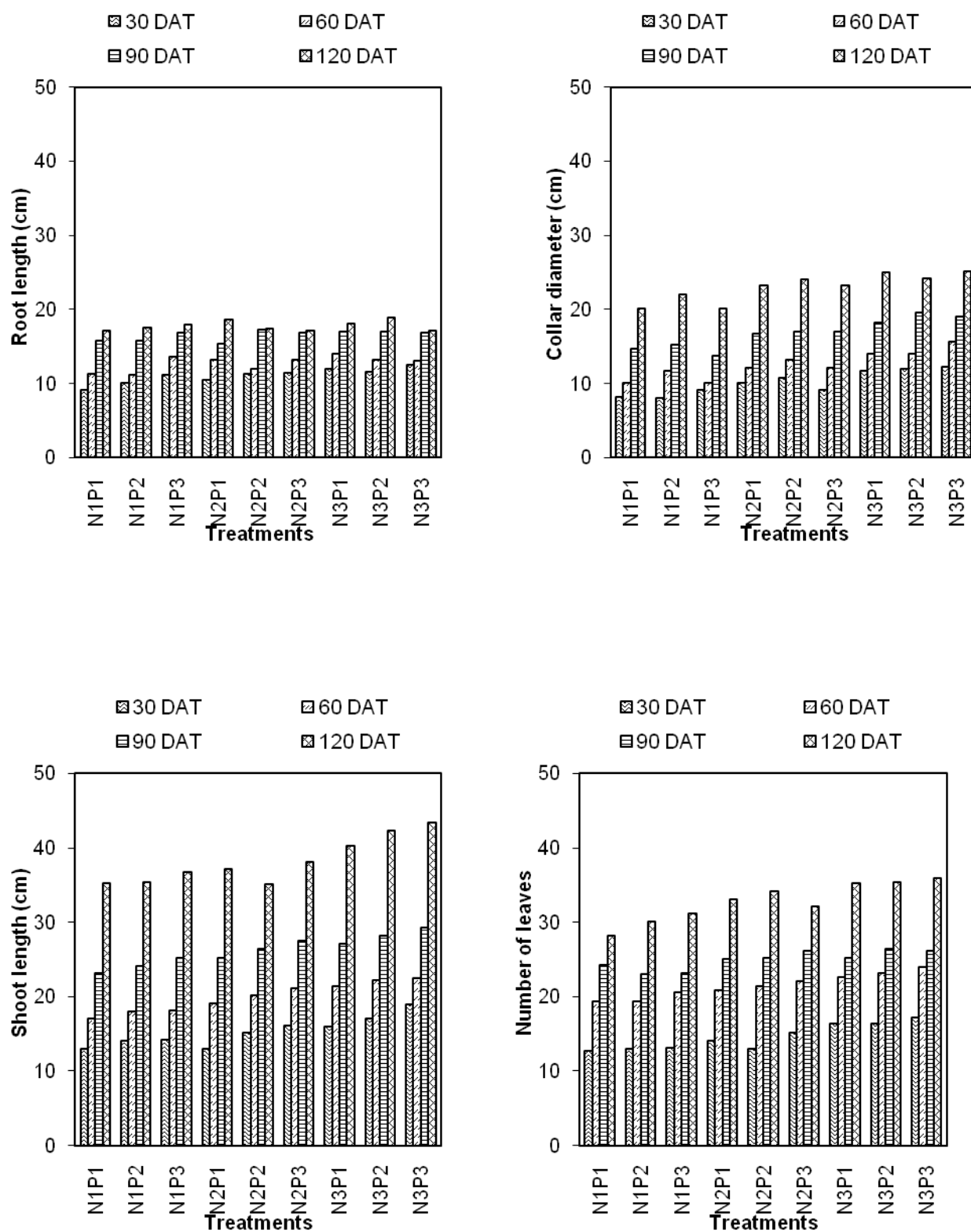


Fig.4.5 : Influence of Nitrogen and Phosphorus (N x P) interaction on growth attributes of *Jatropha curcas* seedlings

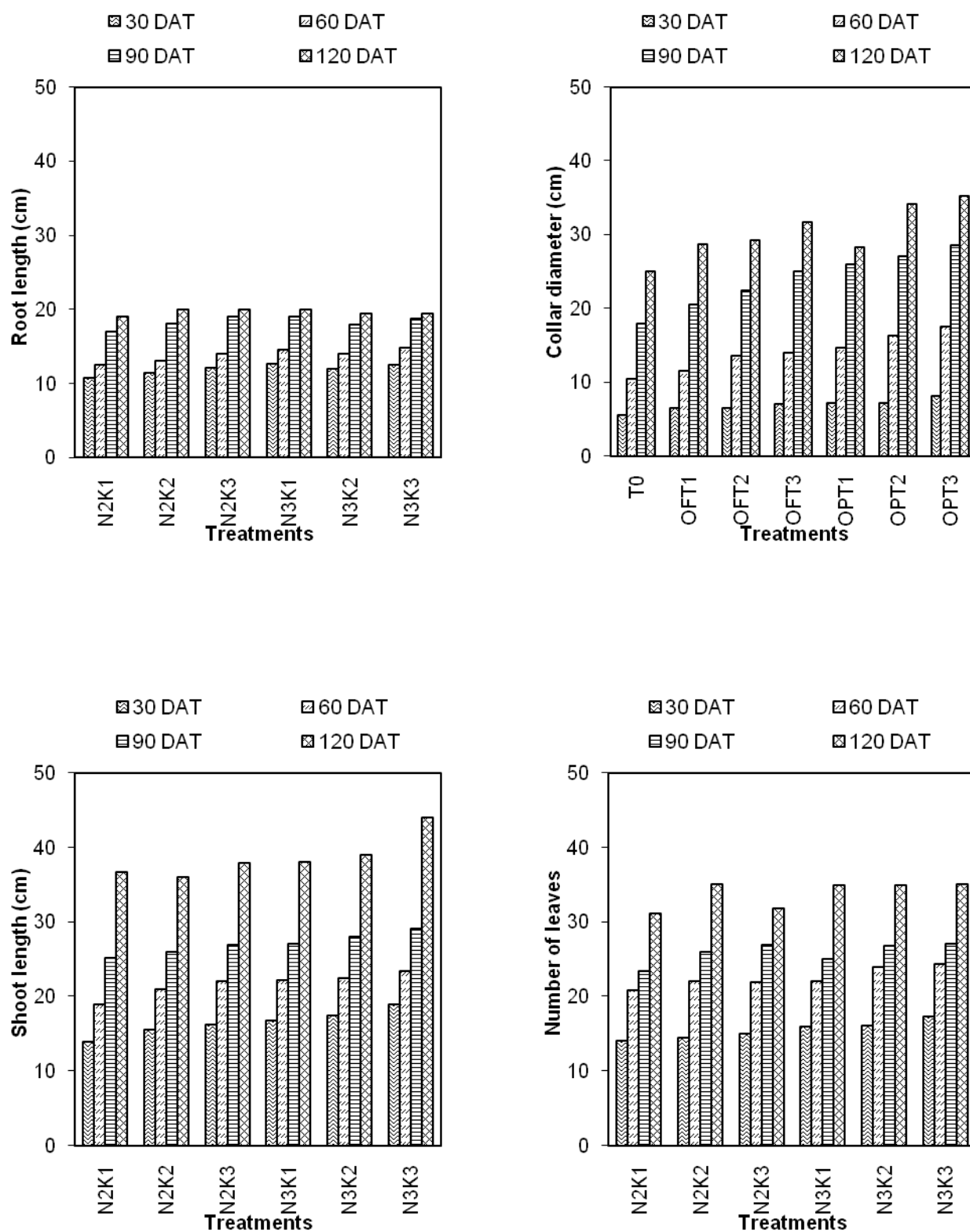


Fig.4.6 : Influence of Nitrogen and Potassium (N x K) interaction on growth attributes of *Jatropa curcas* seedlings

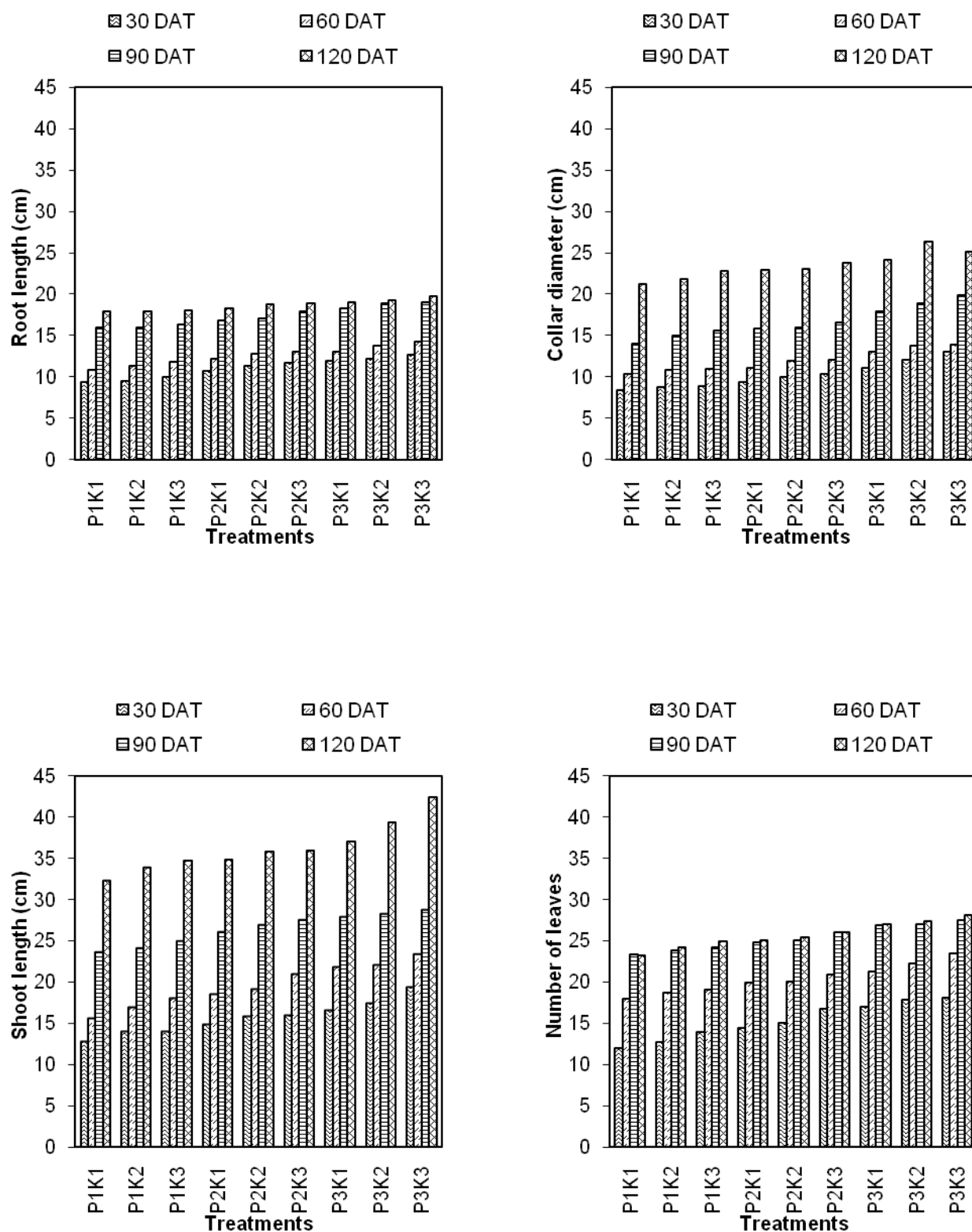


Fig.4.7 : Influence of Phosphorus and Potassium (P x K) interaction on growth attributes of *Jatropha curcas* seedlings

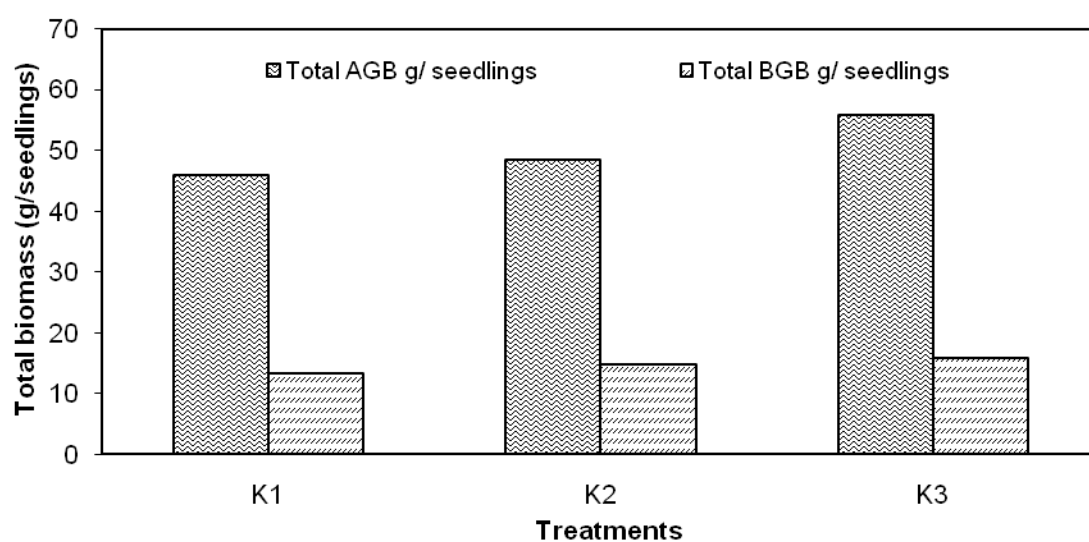
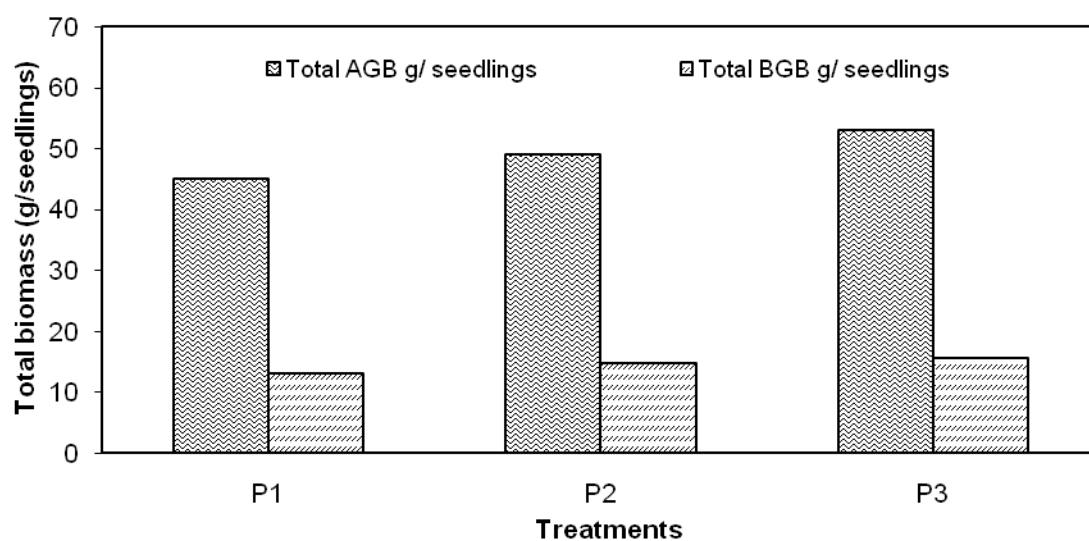
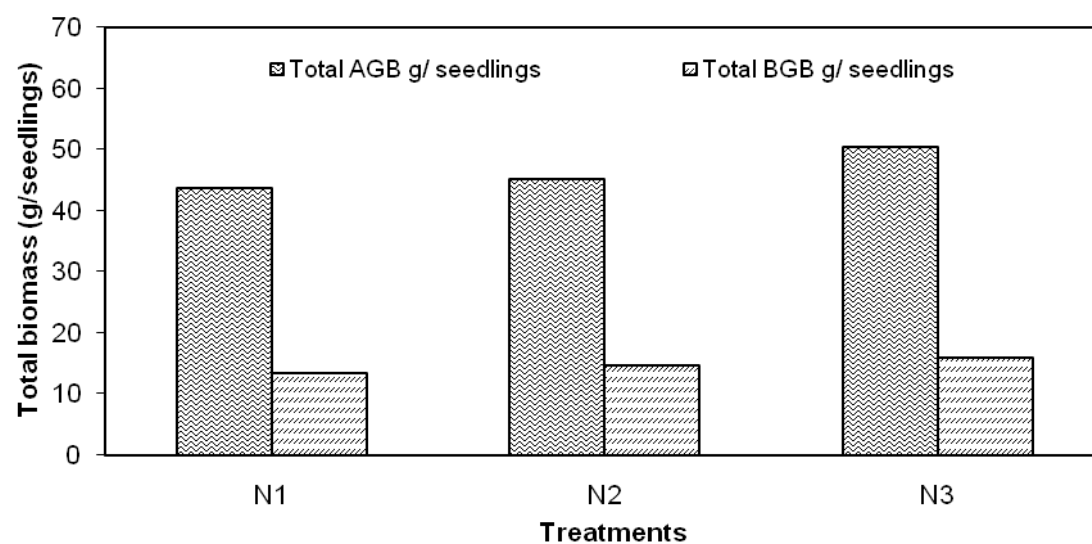


Fig.4.10 : Influence of Nitrogen, Phosphorus and Potassium on above and below ground biomass in *Jatropha* seedlings

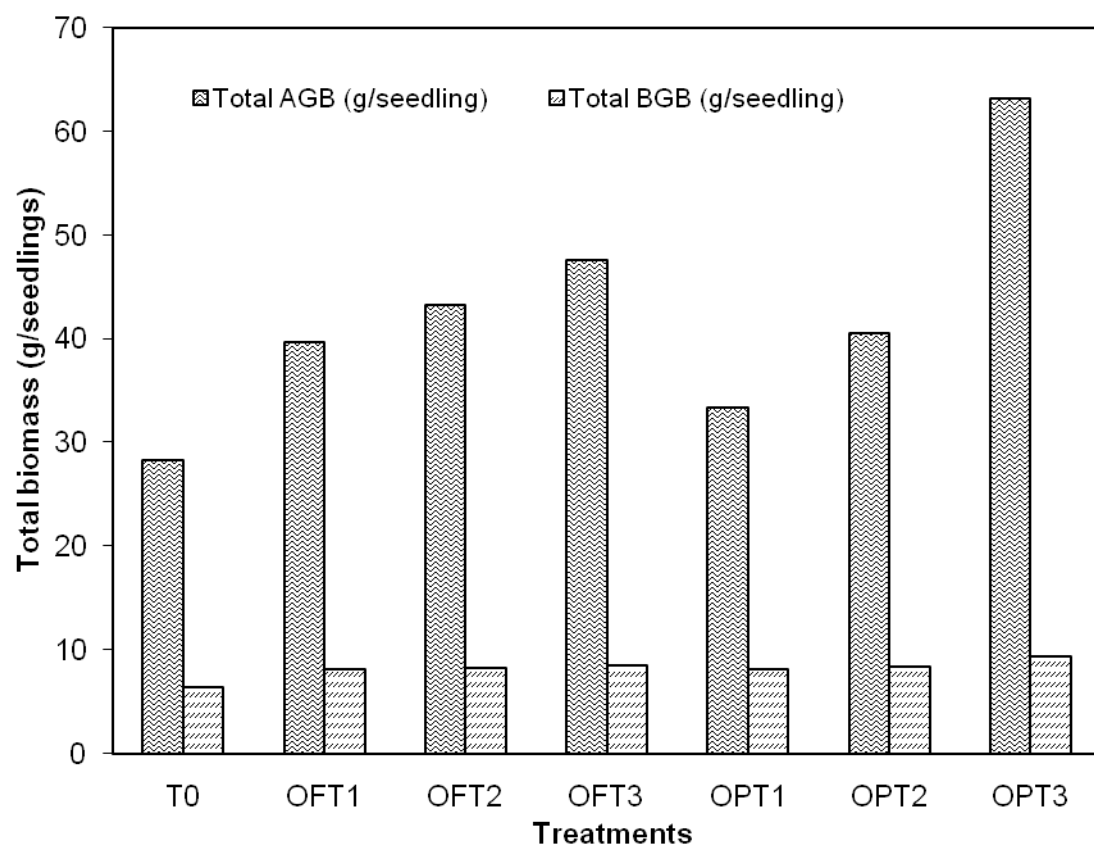


Fig.4.9 : Effect of organic manure on growth attributes of *Jatropha curcas* seedlings

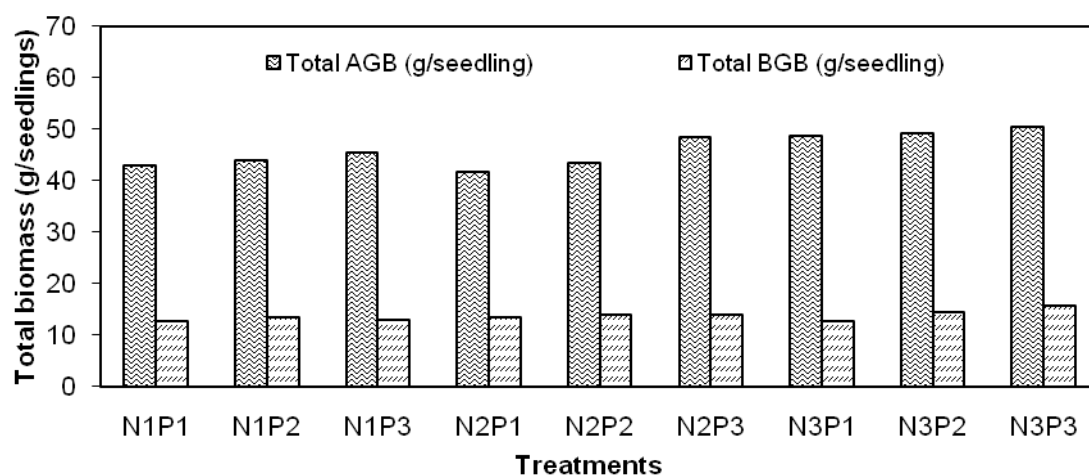


Fig.4.11 : Influence of Nitrogen and Phosphorus (N x P) interaction on above and below ground biomass in *Jatropha curcas* seedling

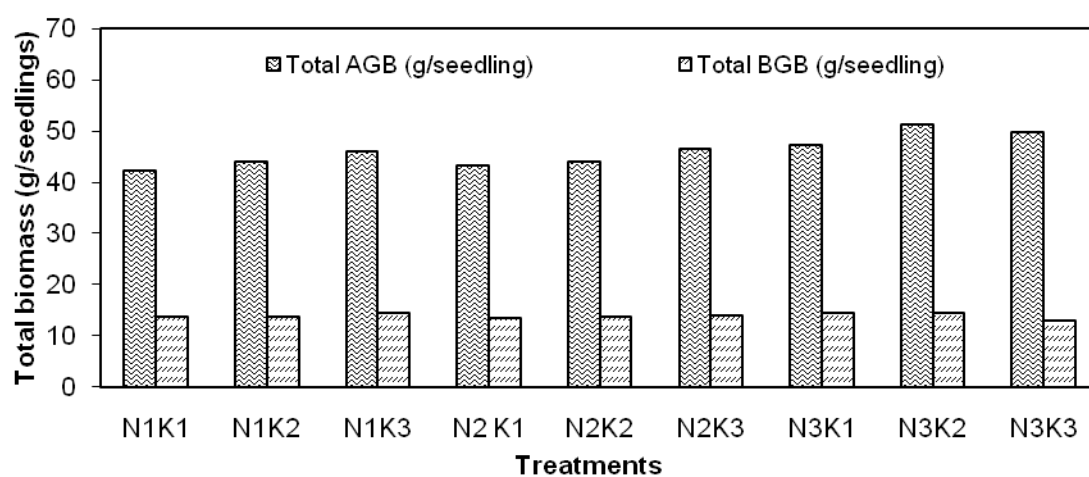


Fig.4.12 : Influence of Nitrogen and Potassium (N x K) interaction on above and below ground biomass in *Jatropha curcas* seedling

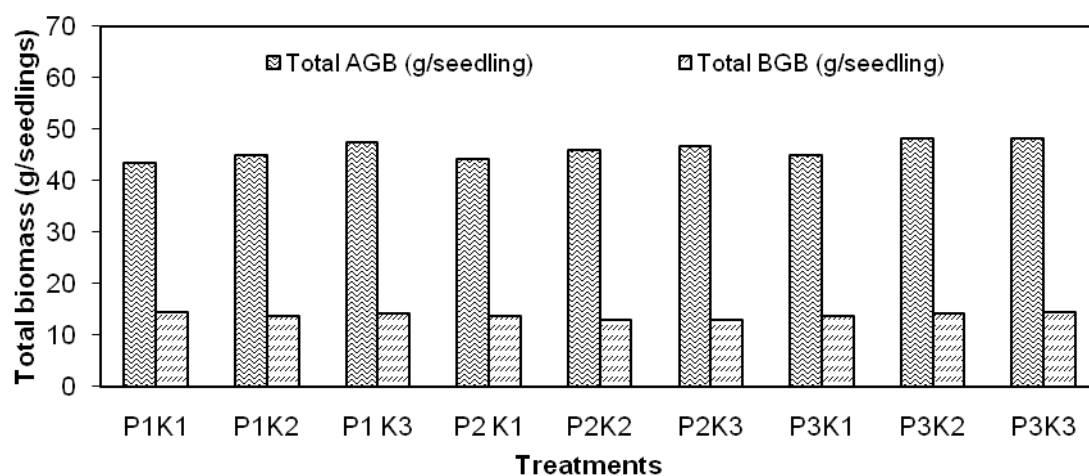


Fig.4.13 : Influence of Phosphorus and Potassium (P x K) interaction on above and below ground biomass in *Jatropha curcas* seedling

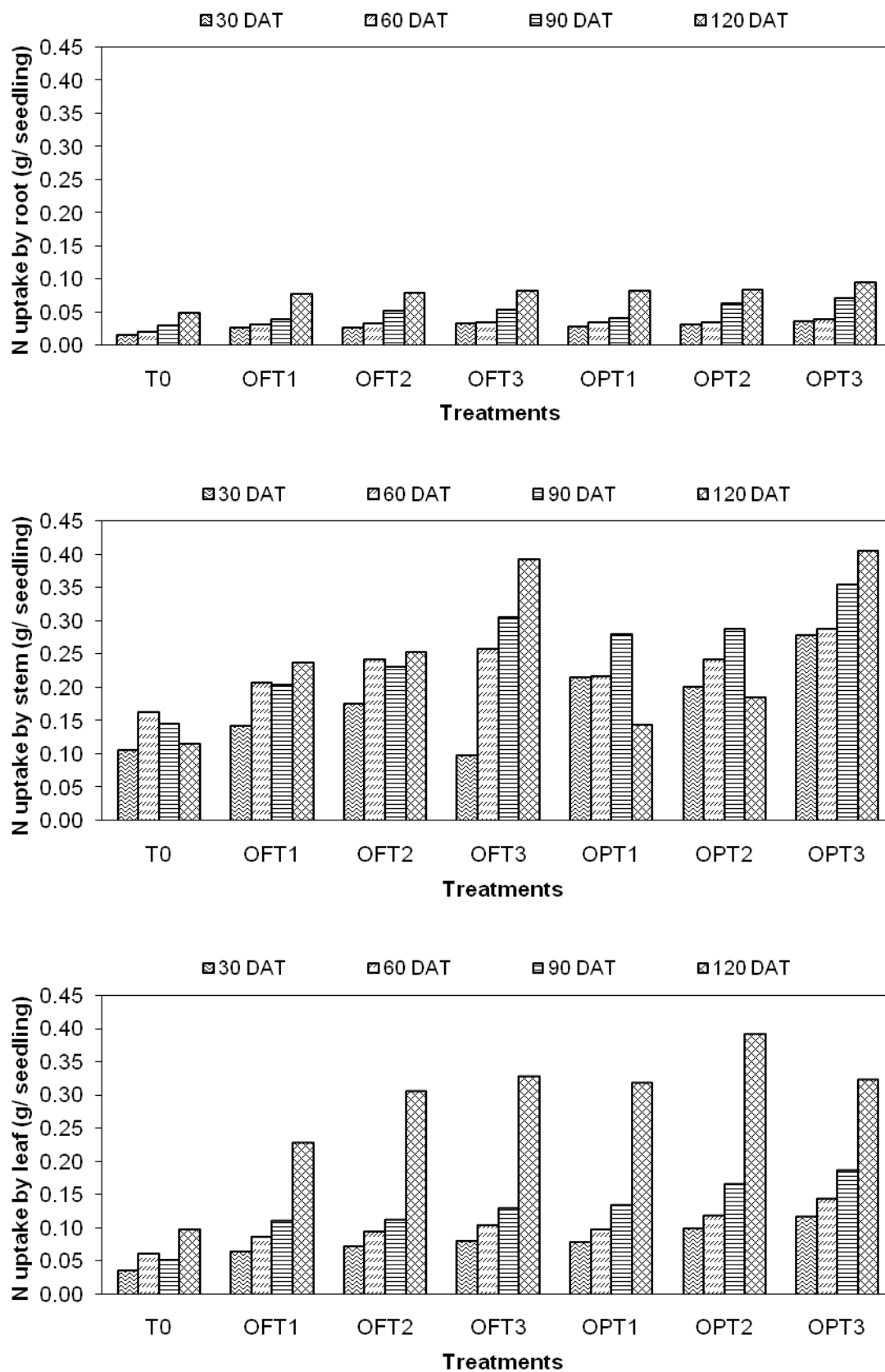


Fig.4.15 : Effect of FYM and Poultry Manure on nutrient uptake by different plant parts of *Jatropha curcas* seedlings (on dry wt basis)

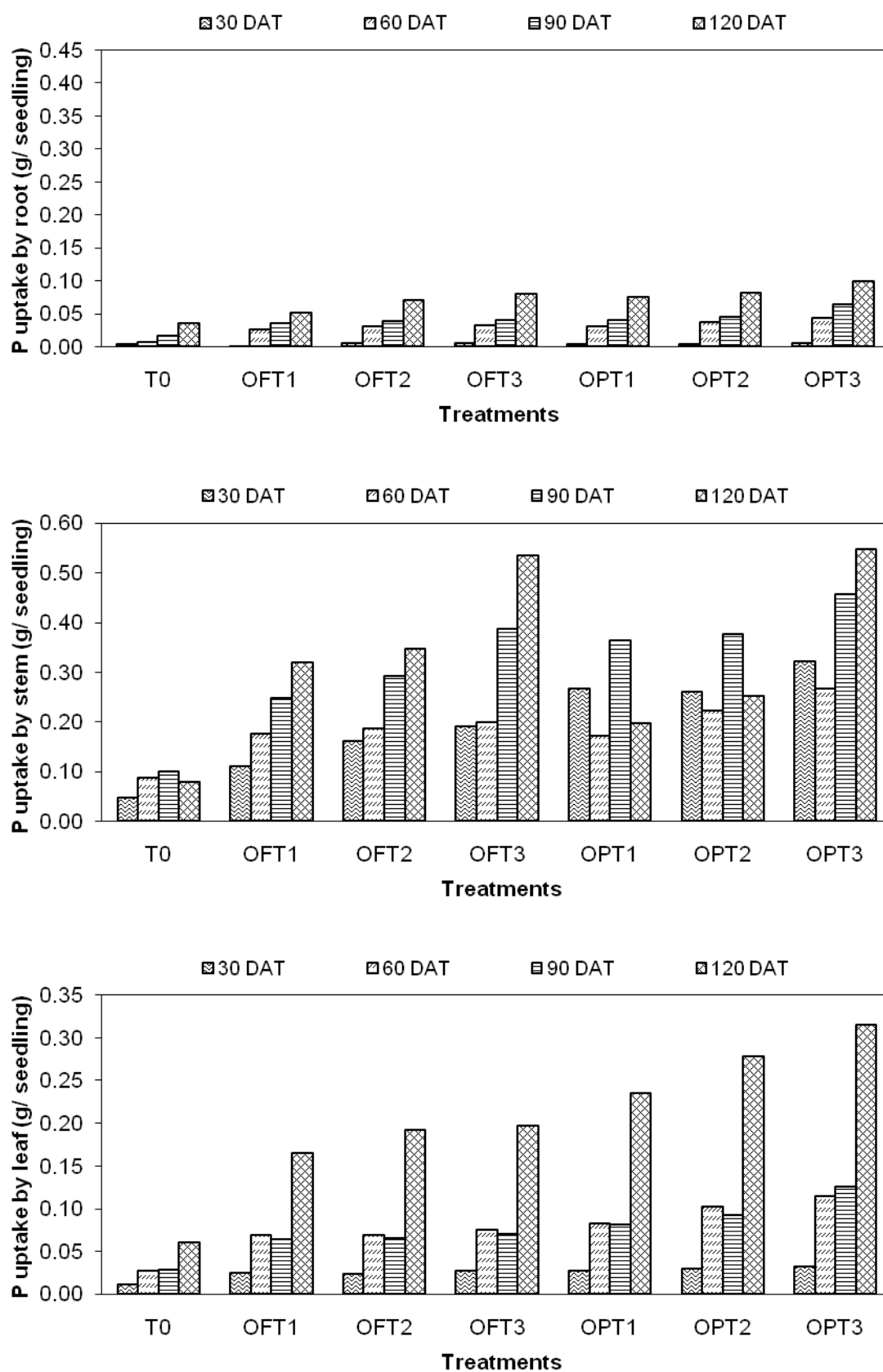


Fig.4.16 : Effect of FYM and Poultry Manure on nutrient uptake by different plant parts of *Jatropha curcas* seedlings (on dry wt basis)

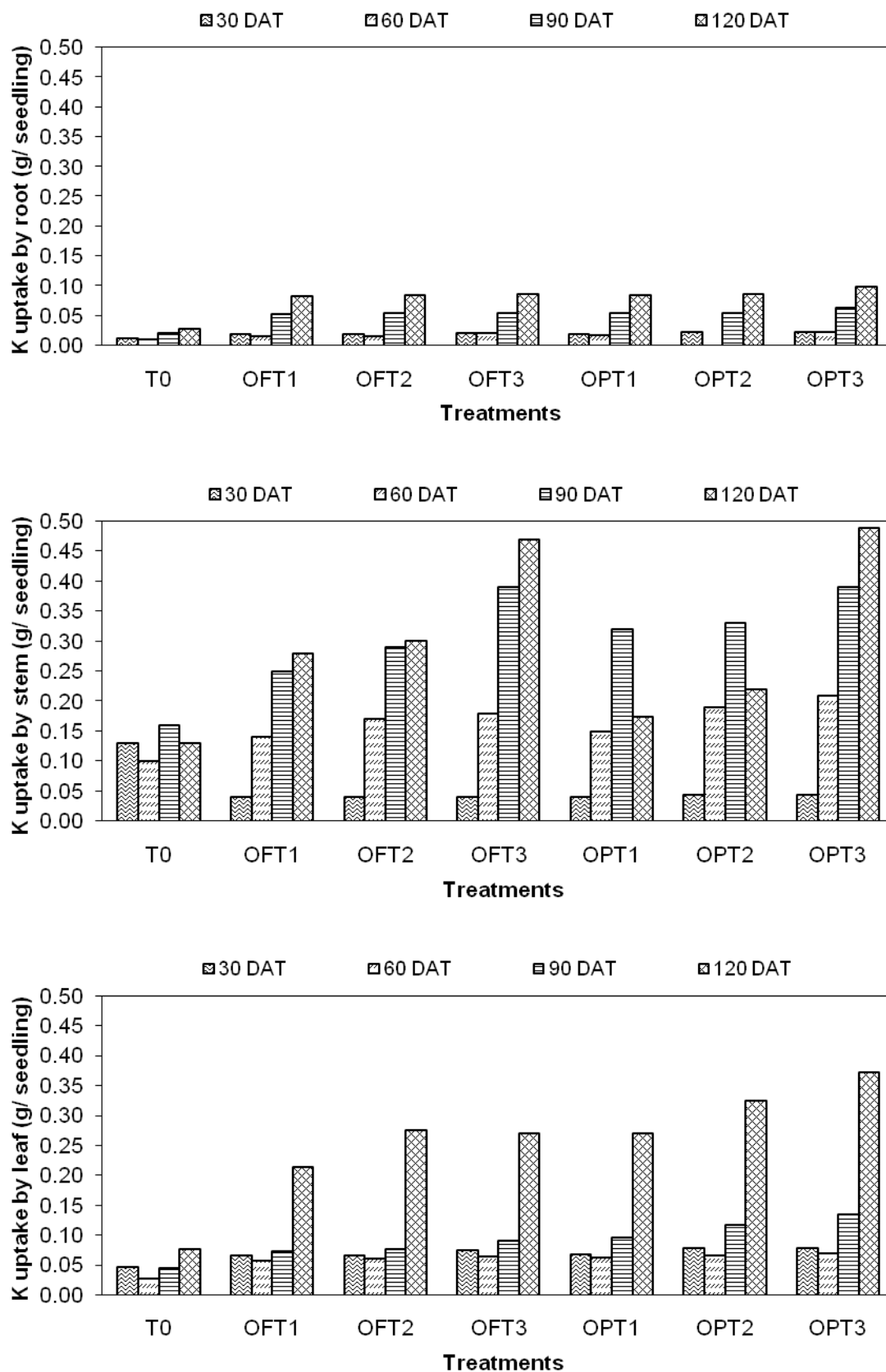


Fig.4.17 : Effect of FYM and Poultry Manure on nutrient uptake by different plant parts of *Jatropha curcas* seedlings (on dry wt basis)

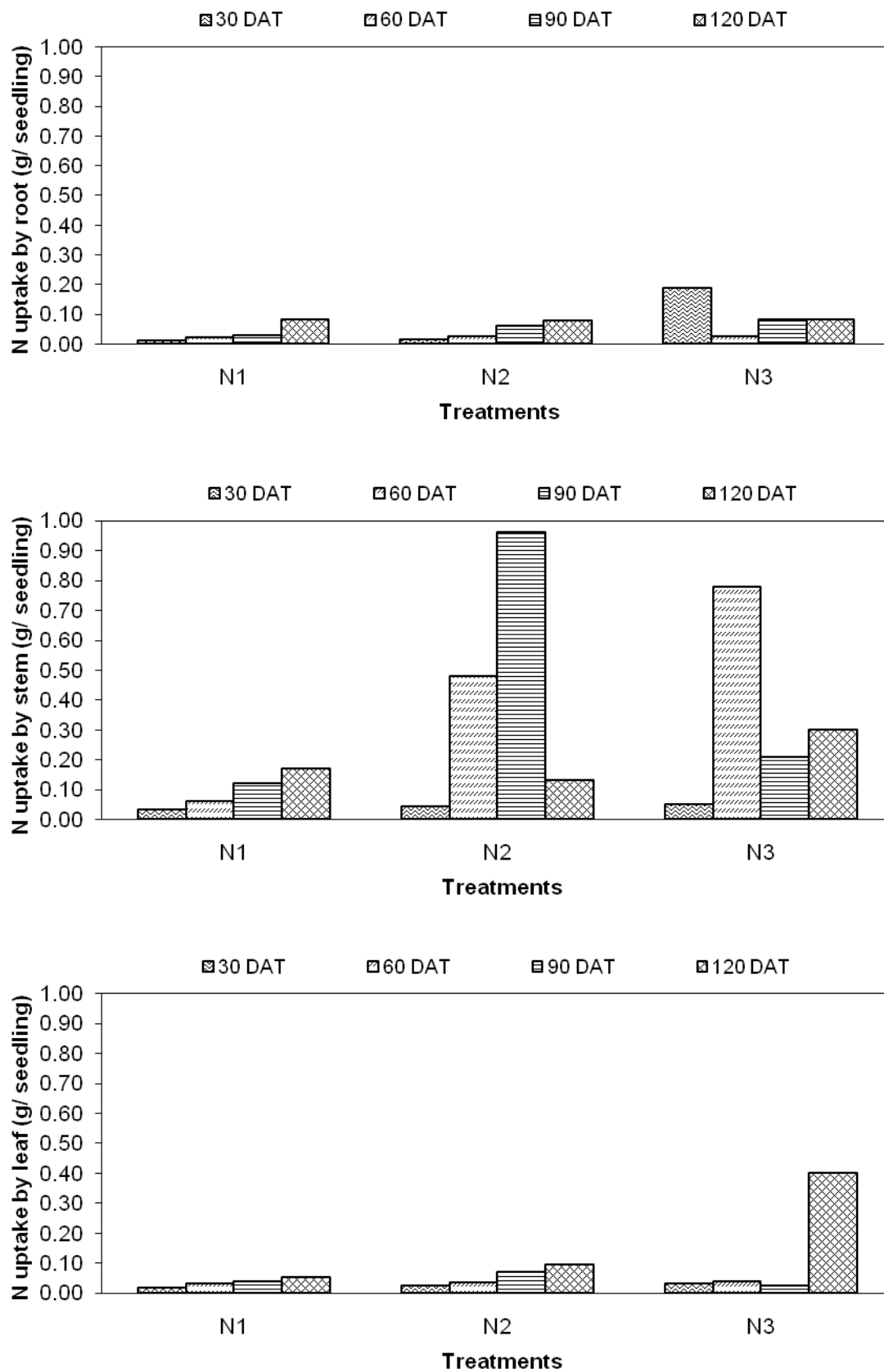


Fig.4.18 : Influence of Nitrogen on nutrient uptake by different plant parts of *Jatropha curcas* seedlings

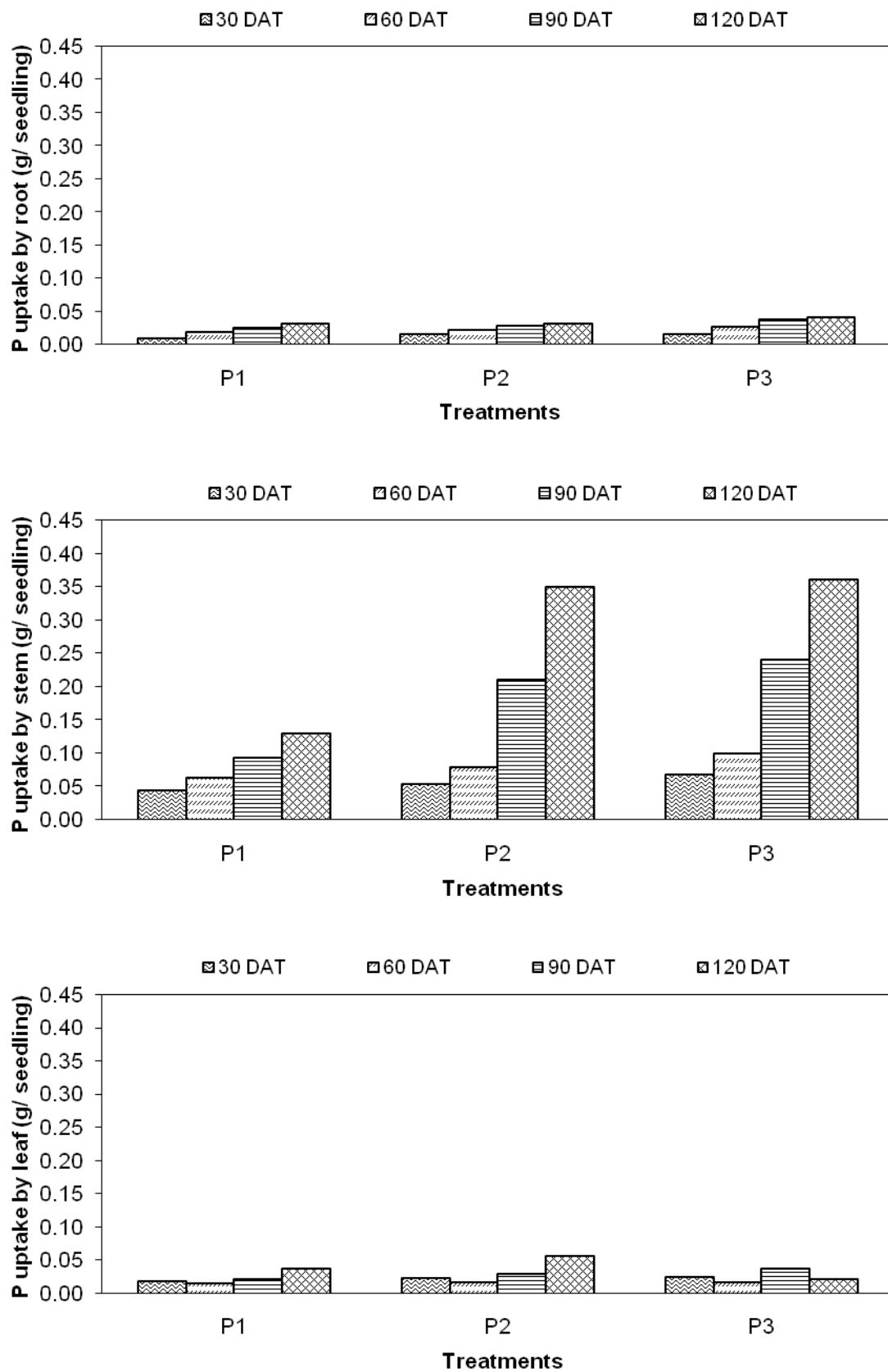


Fig.4.19 : Influence of Phosphorus on nutrient uptake by different plant parts of *Jatropha curcas* seedlings

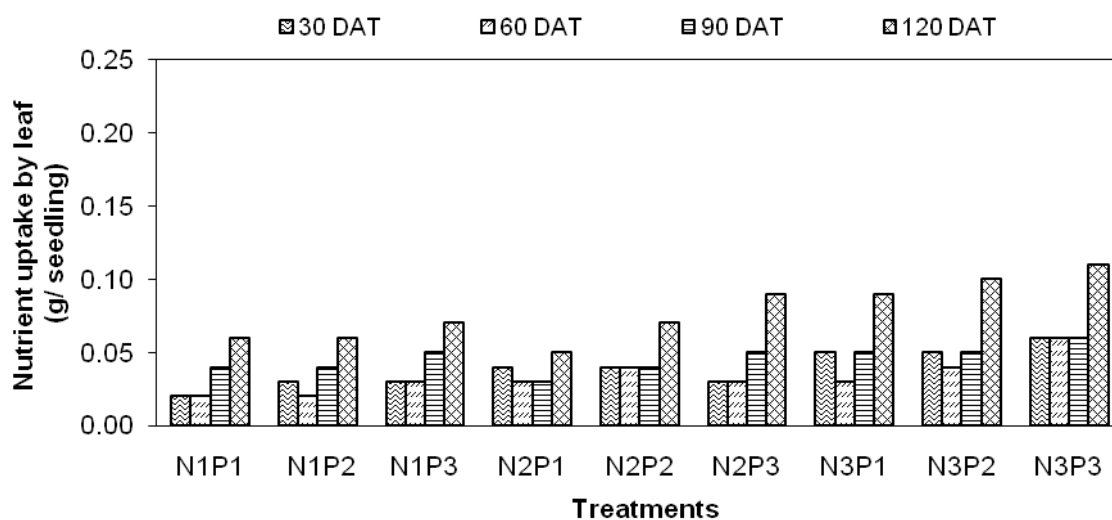
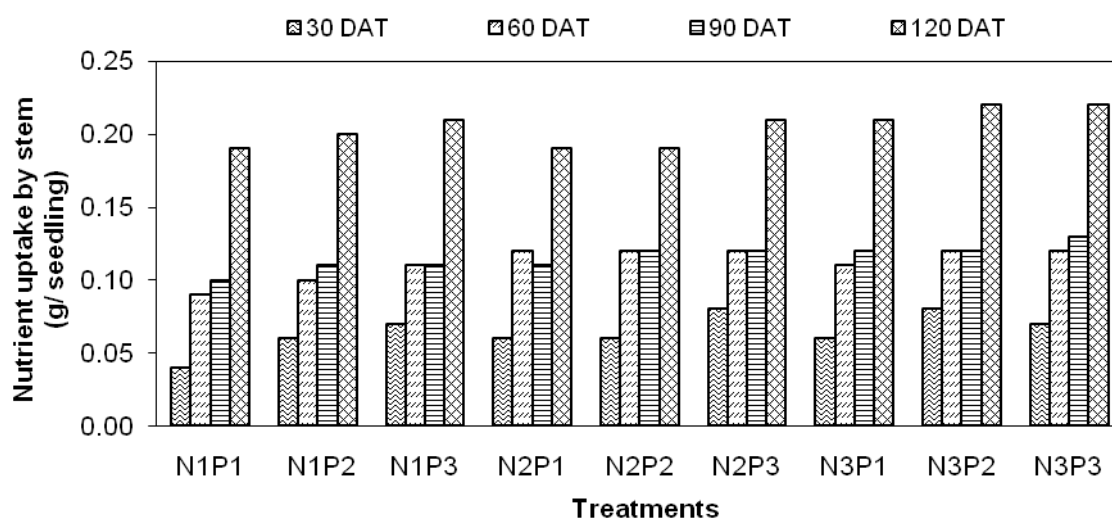
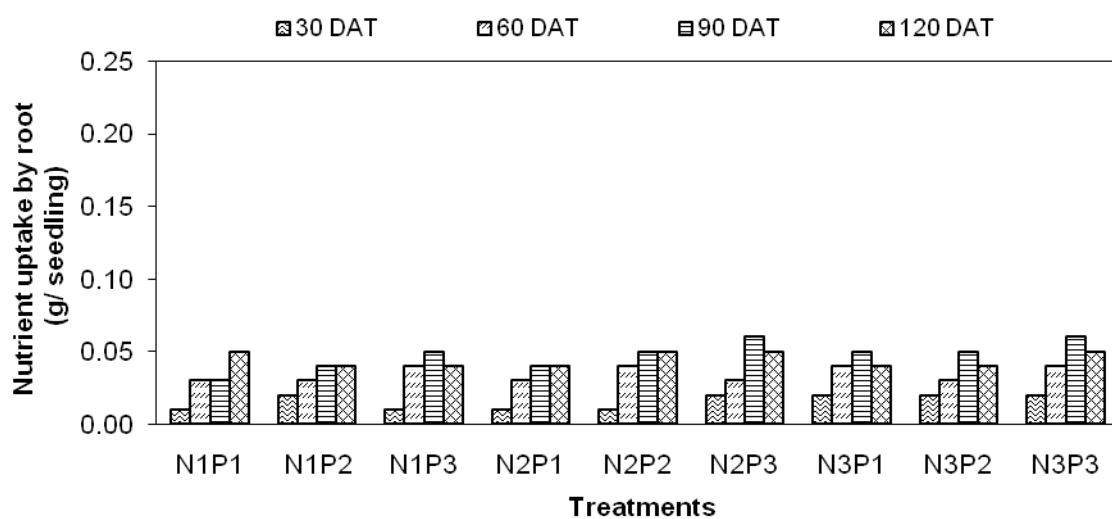


Fig.4.21 : Influence of Nitrogen and Phosphorus (N x P) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings.

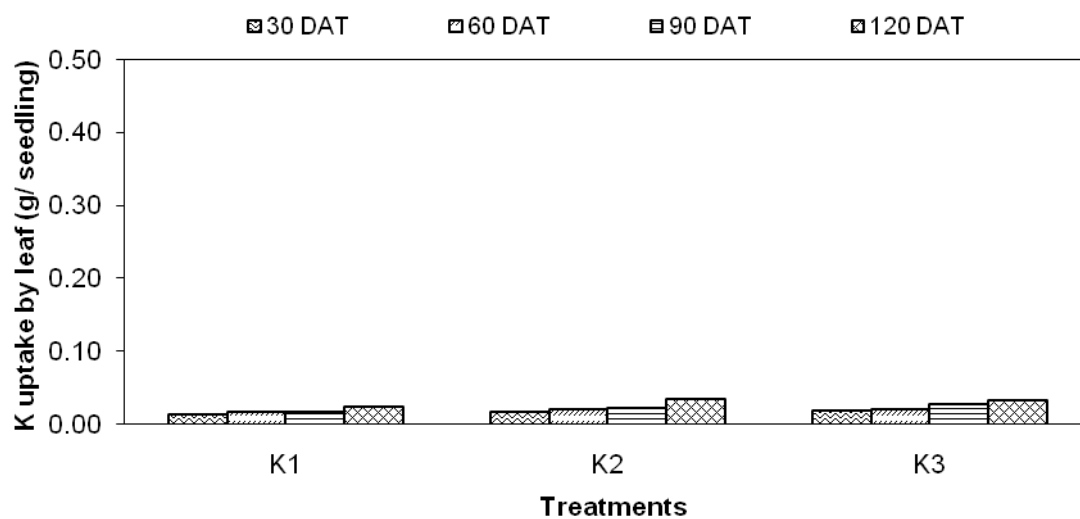
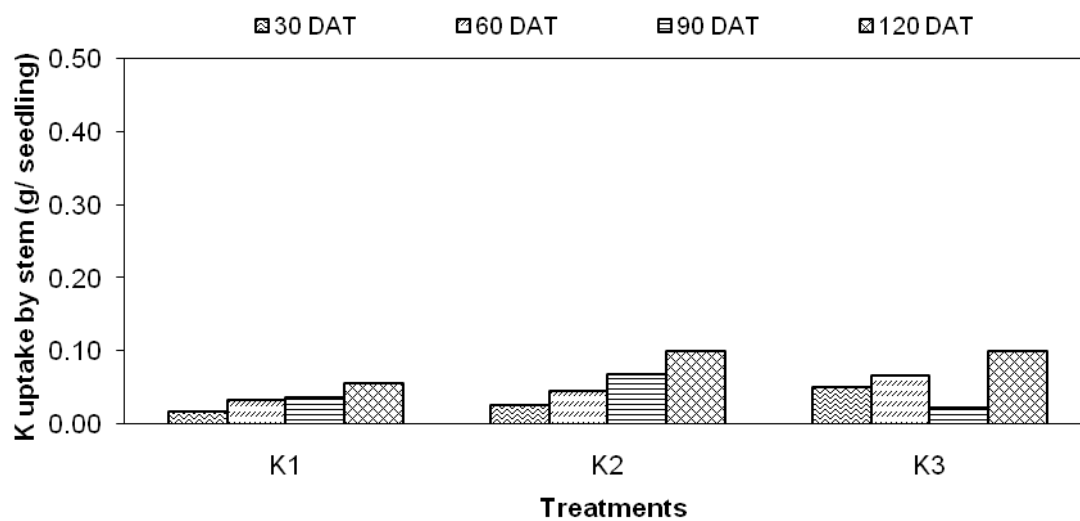
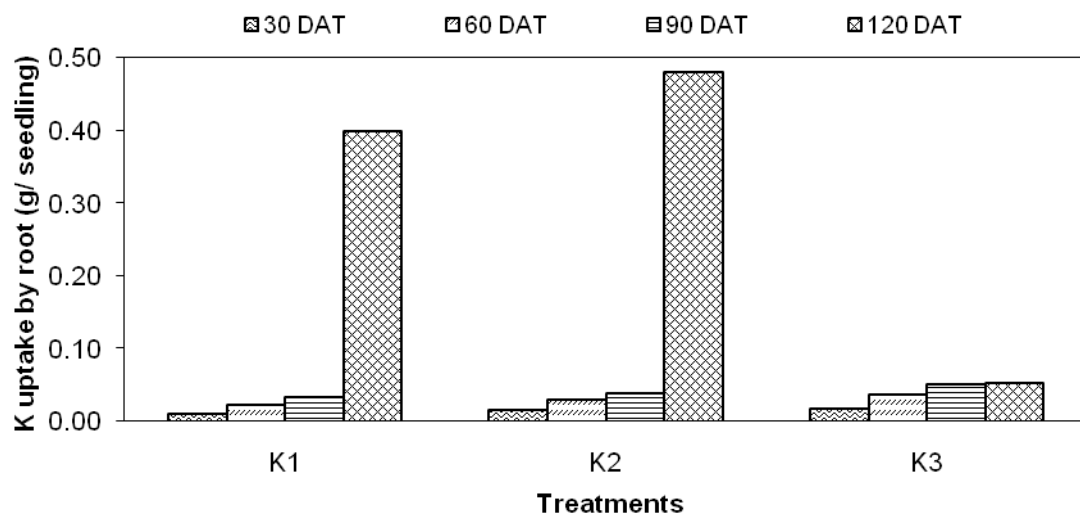


Fig.4.20 : Influence of Potassium on nutrient uptake by different plant parts of *Jatropha curcas* seedlings

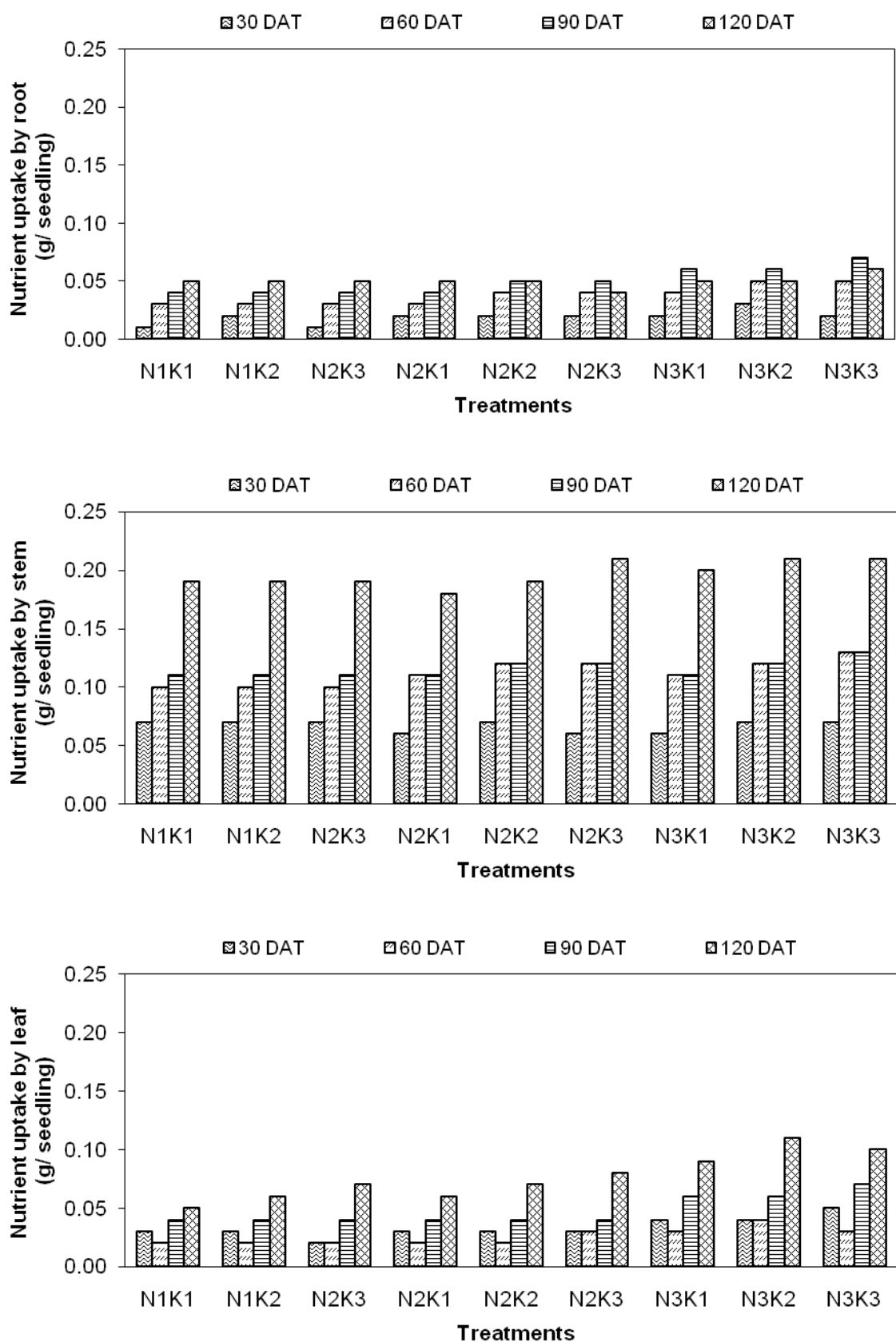


Fig.4.22 : Influence of Nitrogen and Potassium (N x K) interaction on nutrient uptake by different parts of *Jatropha curcas* seedlings.

