EFFECT OF GRADED LEVEL OF N, P AND K ON THE GROWTH AND YIELD OF AMARANTHUS Cv. LAL RAJGIRA

A Thesis submitted to the

MAHATMA PHULE AGRICULTURAL UNIVERSITY
RAHURI. DIST-Ahmednagar
Maharashtra State, (India)

in partial fulfilment of the requirements for the degree

of

Master of Science (Agriculture)

in

Horticulture

By

Navalnath Laxmanrao Tambe

DEPARTMENT OF HORTICULTURE
POST-GRADUATE INSTITUTE,
MAHATMA PHULE AGRICULTURAL UN
RAHURI- 413 722

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Approved by the Advisory Committee :

Dr. A.S. Kokate
Chairman and
Research Guide.

Dr. P.N. Kale
Committee Member

Dr. B.B. Desai
Committee Member

1989.

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part thereof has not been submitted by me or other person to any other University for a degree or diploma.

Rahuri,

Dated : 1st Nov 1989 (N.L. Tambe)

Dr. A.S. Kokate,
Professor,
Department of Horticulture,
Mahatma Phule Agricultural University,
RAHURI, Dist. - Ahmednagar.

CERTIFICATE

I am pleased to certify that this thesis entitled, "Effect of graded level of N, P and K on the growth and yield of Amaranthus cv. Lal Rajgira", embodies the results of investigations carried out by SHRI NAVALNATH L. TAMBE under my guidance and supervision and that no part of the thesis has been submitted for any diploma or degree. The assistance, help rendered during the course of investigations and source of literature have duly been acknowledged.

Rahuri,

Dated : 3-11-89

ASKokate

(Dr. A.S. Kokate)
Chairman,
Advisory Committee
&
Research Guide.

Dr. N.K. Umrani,
Associate Dean,
Post Graduate Institute,
Mahatma Phule Agricultural University,
RAHURI, Dist. - Ahmednagar (M.S.).

CERTIFICATE

This is to certify that the thesis entitled, "Effect of graded level of N, P and K on the growth and yield of Amaranthus cv. Lal Rajgira", submitted by Mr. Navalnath Laxmanrao Tambe to the Faculty of Agriculture, MPAU, Rahuri in partial fulfilment of the requirements for the degree of Master of Science (Agriculture) in Horticulture embodies the results of a piece of bonafide research work carried out by him under the guidance and supervision of Dr. A.S. Kokate, Professor of Horticulture, Department of Horticulture, MPAU, Rahuri and no part of thesis has been submitted anywhere for my other degree or distinction.

Rahuri,

Dated : 18/11/87

(Dr. N.K. Umrani)

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Dated : 1st Nov 1989

(Navalnath Tambe)

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ABSTRACT

EFFECT OF GRADED LEVELS OF N, P AND K ON THE GROWTH AND YIELD OF AMARANTHUS Cv. LAL RAJGIRA

By

N.L. Tambe

Mahatma Phule Agricultural University, Rahuri

1989

Research Guide	:	Dr. A.S. Kokate
Major field	:	Horticulture

An investigation was carried out to find out the optimum doses of N, P, K fertilizers for amaranthus as leafy greens and seed crops, their effects on growth and yield components and to study the quality of leafy greens under Rahuri conditions.

The fertilizer treatments consisted of three levels (0, 75, 150 kg) of nitrogen and three levels (0, 40, 80 kg) each of phosphorus and potassium per hectare.

It was found that the growth parameters viz., number of branches, number of leaves, weight of leaves, weight of stems, dry matter content/plant and average leaf size were significantly influenced by various fertilizer treatments. Nitrogen application significantly increased the growth parameters. Next in order of merit were the applications of P followed by those of K.

The N, P and K applications significantly influenced the yield of leafy greens, thousand seed

Contd...

weight and seed yield. Nitrogen application was most effective. Different levels of P and K were less effective.

The applications of N, P and K significantly increased the phosphorus, potash, crude fibre, iron and carotene contents of plants. Nitrogen content and crude protein contents were significantly increased only due to the nitrogen application. The different fertilizer treatments did not significantly affect the physiological weight losses in freshly harvested leafy greens at ambient temperatures.

Hence, it could be concluded that though the nitrogen application at higher levels was most effective, the application of N, P, K together can improve the nutritive quality as well as the yields of leafy greens and seeds of amaranthus.

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Introduction

1. INTRODUCTION

In India, the production and consumption of vegetables in general and that of leafy vegetables in particular, is extremely inadequate. According to FAO (1978), India produces about 40 million metric tonnes of vegetables annually. She needs about 75 million metric tonnes of both fruits and vegetables to meet the nutritional requirement of the existing population. Thus, it is necessary to boost the production of vegetables, including those of leafy greens.

The role of leafy vegetables in human nutrition has been well recognized. Particularly the Amaranthus are the vital sources of proteins, vitamins A, C and B and minerals like calcium and phosphorus. In addition to these essential nutrients, their value as a source of dietary fibre has been increasingly realized in recent years. They tone up the intenstinal canal. They are the rare examples wherein these essential dietary components are combined in one single vegetable. Besides, they grow fast and respond to recutting and yield a sizeable green matter. Thus, they can be of much value for the under nourished poor masses of our country.

Amaranthus is a short day plant and hence it is the only important summer leafy vegetable which is also grown for grains. The grain type Amaranthus are of

American origin. But to day, India is the only place where grain Amaranthus are being cultivated. Here, Amaranthus are cultivated, right from Himalayas to the plains of Gujarath, Maharashtra, Karnataka and Tamil Nadu States. Under south Indian conditions, the plants are normally pulled 20 to 30 days after seed sowing for use as tender greens.

The species of Amaranthus commonly grown as vegetables, are *Amaranthus urieslon* L., *Amaranthus blitum* L. (Choti Chauali), *Amaranthus oleraceous* L. (Tandulja) and *Amaranthus caudotas* L. (Rajgira). They have wide adaptability to varying soil and climatic conditions. Properly selected varieties can produce leafy greens throughout the year if sown in succession. Vietmayar (1979) reported that Amaranthus grows very fast and hence it is adapted well by the rural farmers in mixed cropping. Even to day, many species of Amaranthus found growing as weeds, are being occasionally consumed as leafy greens by the poor rural masses. In Maharashtra, the most commonly cultivated species is *Amaranthus caudotus*, locally known as "Rajgira". All of its tender parts including leaves, stems and shoots are being used as green vegetables.

Certain *Amaranthus species* could be grown for dual purpose, i.e. after taking 3 to 5 cuttings of leafy greens, they can be left for seeding. The average grain yield of this crop when grown on the border of the field is 3 to 4 q/ha and seed rate used is about 1 kg/ha. Under intensive cultivation, seed yield as high as 2.5 tons/ha can be obtained from the sole crop.

The Amaranthus grains have been considered as a sacred food. In Mexico and other South American countries, the seeds have been offered to Government of India, the Amaranthus grain is the only food permitted on fast days especially during Nawarathra, Dashahara festival, Shivaratri, Kartiki and Ashadhi Ekadashi etc. The grains are consumed in several ways. They may be popped and then mixed in sugar syrup for preparing flat cakes (Gud-dani or Chikki) or round balls (Laddus). Such preparations, being nutritious and also tasty, are very much favoured during school rest hours by the school going children. Besides, a large number of families in India have this type of confectionary as a means of livelihood.

However, Amaranthus has not received an adequate attention. Still they are being grown mainly in kitchen gardens (borders of fields) and as a sole crop around the local city markets only. Recently, Katwate (1985) screened 17 cultivars of Amaranthus and reported that Chaualai, Tandulja, Lal Rajgira, Co. 1, Co. 3, I.C. 13382 and I.C.38127 were promising for commercial cultivation under Rahuri conditions. Of these, Chavalai produced the highest yield of greens and responded very well to recutting. Lal Rajgira also was fairly good in this respect. However, the other cultural practices of Amaranthus have not yet been standardized. Particularly, its fertilizer requirements have not yet been worked out and so also its yield potential has not yet been fully explored. The present investigation was therefore planned with the following objectives.

1. To find out the optimum doses of N, P and K fertilizers for Amaranthus as leafy greens and seed crops.
2. To study the effects of graded levels of N, P and K on growth and yield components of Amaranthus.
3. To study the quality of leafy greens as affected by the fertilizer doses and periodical cuttings.

Review of Literature

2. REVIEW OF LITERATURE

Research workers all over the world have devoted considerable attention to the nutrition of plants since its supply is the most important factor limiting both growth and productivity. The most important nutrients and often required in large quantities are the nitrogen, phosphorus and potassium. Their effects on the growth and composition are well documented in most food crops. However, no systematic work has been carried out on fertilizer requirements of Amaranthus. Nevertheless, whatever the little work has been done earlier in this regard has been reviewed here under. It also includes relevant references on other leafy vegetables.

2.1 Growth

Ramachandra (1978) applied N @ 0-200 kg/ha and P_2O_5 @ 0-100 kg/ha to *Amaranthus gangeticus*, L. The highest rates increased plant height, dry weight, leaf area index and also the yield.

Olufolaji and Tayo (1980) in their studies into the growth and development of *Amaranthus cruentus* cvs. Large leaf, Light Red and Local Green recorded small differences among the cvs. with regard to the development of leaf area, number of shoots, number of nodes and dry weights of stem, root, flower and leaf.

Singh et al. (1985) studied the effects of split application of nitrogen on growth and yield of Amaranthus (Amaranthus tristia, L.). They applied N @ 20-60 kg/ha on 3 different dates to plants clipped on 10 different dates. The highest N rate in split dose (one half as a basal dressing, before seed sowing) and the other half as a top dressing after the 5th cutting) resulted in the maximum plant height.

Bressani et al.(1987) studied the effects of application of fertilizer mixture containing N, P, K, in the ratio of 12:24:12 on the growth and flowering of Amaranthus cruentus, Amaranthus hypochondriacus and Amaranthus caudatus. They reported that these doses respectively registered flowering on 44th, 50th, 43th and 57th day after sowing and corresponding plant heights of 60, 80, 43 and 65 cm. The plants were respectively ready for harvest on 102nd, 109th, 100th and 129th day after sowing, when their corresponding heights at harvest were 125, 150, 130 and 180 cm,respectively.

2.2 Yield

Verma et al. (1969) reported that the application of nitrogen @ 80, 120, 160 or 200 kg/ha resulted in an increase in the yield of leafy greens and dry matter content of the tops and in a decrease in the oxalic acid content.

Vergniaud and Huguet [redacted]. (1971) in their studies into the effects of planting seasons and application of nitrogen on spinach cv. Mataraus revealed that ammonium nitrate applied at the higher rates of 225 or 170 kg/ha increased the yields significantly vis-a-vis those obtained with applications at lower rates of 115 or 75 kg/ha. A split fertilizer application (i.e. half at sowing and half a month later), was more effective than a single application at sowing, especially in spring plantings. The split applications yielded 17.9 tonnes while single application yielded 14.0 tonnes of fresh green matter/ha. The corresponding yields from autumn plantings were 16.4 and 14.9 tonnes of fresh green matter/ha. However, the dry matter content declined with rising levels of this fertilizer.

Bhore and Patil (1978) reported that soil + foliar application of nitrogen to spinach gave an yield of 250 q/ha as compared to 85 q/ha in the control.

Purushothaman (1978) reported that in pot culture experiments with some malayrian leafy vegetables, significant differences were observed between the N sources and the rates. Calcium nitrate gave consistently higher yields while Ammonium sulphate out yielded urea in all the cases. For the cultivar Kangkong (*Ipomoea reptans*), 60 kg N/ha was sufficient to harvest good yield, while the yields after Bayam (*Amaranthus viridus*) increased significantly upto 120 kg/ha.

Sutater et al. (1980) studied fertilizer effects on the yield of amaranth (*Amaranthus spp.*). They applied 20 tonnes of stable manure alone and 10 tonnes + 100 kg urea/ha and obtained 601-897 kg yield per hectare.

Keskar et al. (1981) reported that *Amaranthus blitum* gave higher yield with 50 kg N/ha than the control or lower doses.

Ramachandra and Thimmaraju (1983) in two season-trial, applied N at 50 to 200 kg/ha or P_2O_5 at 50 to 100 kg/ha to plants of *Amaranthus gengetics* (tricolor) and reported that the yield was highest (116 q/ha) in the summer crop receiving the highest N rate. At the same N rate the autumn crop yielded 98 to 105 q/ha. The response to P was less.

Singh et al. (1985) applied N at 20-60 kg/ha in 3 splits to amaranthus plants (*Amaranthus tristis* L.) clipped on 10 different dates. The highest N rate applied in a split dose, gave the highest green leaf yield.

Keskar et al. (1983) applied N at 20-50 kg/ha through soil and in some cases N at 5 kg/ha through foliar sprays. The crop was harvested on 3 different dates. The highest average yield (121.7 q/ha) was obtained from plants which received 45 kg N/ha through soil application and further supplemented with 5 kg N/ha through foliar sprays.

Bressani et al. (1987) studied the effects of fertilizer applications on the grain yield of Amaranthus cruentus ecotypes from Guatemala, A. hypochondriacus from U.S.A. and A. caudatus from Peru. The plants received a fertilizer mixture containing N, P and K in the ratio of 12:24:12 @ 0, 30, 60 or 90 kg/ha. A. hypochondriacus yielded 2.77 - 4.41 tonnes of seeds/ha, A. cruentus 2.95 - 5.0 tonnes/ha, A. cruentus 1.24 - 2.71 tonnes/ha while A. caudatus yielded 1.24 - 2.71 tonnes of seeds/ha.

2.3 Nutritive value

Lexander et al. (1970) planted 29 species and varieties of different leafy vegetables in green house and analysed them for leaf proteins, digestibility and other nutritive values. They reported that Amaranthus coudatus and various species of Chenopodiaceae family were suitable for large scale production of leaf proteins for human consumption, since they gave higher yields of extractable proteins of high quality.

Hehl and Mengel (1972) reported that nitrogen was an important exogenous factor influencing the protein:

carbohydrate ratio in leaves and stems of oat. It was shown that with a limited supply of nitrogen, crude protein content was lowered, while the contents of sucrose, starch and fructose were considerably enhanced.

Stanilova et al. (1972) observed that, fertilization with N alone greatly increased the contents of crude protein, Ca and Mg in spinach. Fertilization with P alone increased the P and K contents and decreased the N, Ca and Mg contents.

Grubben (1974) reported on the dry weight basis that both the leaves and the stems of Amaranthus hybridus contained 4.44 % N, 0.43 % P, 3.59 % K, 3.14 % Ca and 1.86 % Mg. In chemical fertilizer trials, he obtained good results with the application of fertilizer mixture @ 400-800 kg/ha containing N, P, K in the ratio of 10:10:20.

Stafford et al. (1976) studied the effects of 0, 75, 150 or 225 kg N/ha applied through calcium ammonium nitrate on A. hybridus. The leaf analysis showed that with increasing N applications there was rise in the percentage of protein on dry weight basis, but this diminished with increasing maturity. The Fe content rose steeply when harvested untill the 63rd day after sowing.

Ramachandra (1978) studied the effects of different levels of N and P on the nutritive quality of Amaranthus gangetics L. He reported that the β-carotene content rose with increasing N level and ascorbic acid content was enhanced at the higher levels of N and P_2O_5.

Audonin and Kochubei (1979) reported that spinach plants grown on well cultivated soil contained more vitamins than the plants grown on moderately cultivated soil. Application of N decreased the ascorbic acid content but increased the contents of carotene, thiamin and riboflavin. Application of P and K decreased the carotene content while the application of N and K decreased the vitamin E content.

Olufalaji and Toyo (1980) studied three cultivars of amaranthus in a green house. They reported that all the three cultivars produced equal quantities of dry weight of leaves and stems. However, Amaranthus cruentus cv. "Local Green" had the highest contents of nitrogen, calcium, magnesium, iron and manganese.

Kansel et al. (1981) observed that the yield of green matter and the uptake of P, Fe, Mn, Zn and Cu in spinach were the highest in response to the highest rate of 90 kg N and 20 tonnes of FYM/ha.

Subbiah and Ramanathan (1982) applied N @ 20-80 kg/ha, K_2O @ 20-40 kg/ha, P_2O_5 @ 50 kg/ha and FYM @

10 tonnes/ha as a basal dose for two cultivars of *Amaranthus blitum* and reported that N increased the plant crude protein, carotene and chlorophyll contents, but decreased the ascorbic acid content. Potassium had no effect on carotene, ascorbic acid and chlorophyll levels but increased the crude protein contents.

Ramachander and Thimmaraju (1985) applied N @ 50-200 kg, P_2O_5 @ 50-100 kg and FYM @ 25 tonnes/ha as a basal dose to plants of *Amaranthus genetics* (tricolor). They harvested the crop one month after sowing and analysed the plant tissues for ascorbic acid, β-carotene, crude fibre, N, P and Fe contents. They reported that the plant response to N was generally greater than to P, as was shown by increase in all the indices as a result of N applications rather than P applications.

Singh et al. (1985) studied the effects of split applications of nitrogen on *Amaranthus tristis* L. They applied nitrogen @ 0-60 kg/ha in 3 different ways and at various stages of plant development (10 clipping stages) and reported that the highest N rate applied as split doses, one as a basal dose before seeding and the second after the 5th clipping, resulted in the highest leaf oxalic acid and hydrocyanic acid contents and the lowest crude fibre-content.

Thus, the above review indicates that leafy vegetables respond well to fertilizer application. It is generally observed that response to nitrogen is greater than to phosphorus and potassium. Further, it was also observed by majority of the workers that split application is better than the single application. Besides, the growth and yield, the nutritive quality of the plant as evidenced by vitamins, mineral composition and others such as crude protein and fibre were also significantly influenced by fertilizer application.

Materials and Methods

3. MATERIALS AND METHODS

A field experiment to study the effects of different levels of nitrogen, phosphorus and potassium on the growth and yield of Amaranthus, was conducted in the Instructional-cum-Research Orchard of the Department of Horticulture, Mahatma Phule Agricultural University, Rahuri during summer [redacted] of 1986.

3.1 Materials

3.1.1 Soil and its preparation

The soil of the experimental plot was medium black with good drainage. It was brought to a fine tilth by crosswise ploughings and harrowings. Then the random soil samples from 3 locations of the experimental area were taken up and analysed for various ingradients. From these samples, the initial soil reaction, carbon content and major nutrient fertility of soil were assessed. They have been given below in Table 1.

Table 1. Initial soil reaction, carbon content and major nutrient fertility of soil

Sr.No.	Determination	Values	Method used
1.	pH	8.4	pH meter soil water ratio 1:2.5
2.	EC(mmhos/cm^2)	0.312	Conductivity bridge
3.	Organic carbon (%)	0.70	Walkey and Black method
4.	$CaCO_3$ equiv. (%)	7.5	Rapid titration method
5.	Na me (%)	1.94	Flame photometer NH_4OAc extractant at 7.0 pH
6.	Available K_2O mgm(%)	42.50	-do-
7.	Available P_2O_5 mgm(%)	3.50	Olsen method. $NaHCO_3$ extractant at 8.5 pH.
8.	Available N	--	Modified Alkaline potassium permanganate method

Before final harrowing, well rotted FYM at the rate of 20 cartloads per hectare was incorporated in the soil. It was then planked and flat beds of 3 x 2 m size were prepared.

3.1.2 Seed

The seeds of Amaranthus (Lal Rajgira) were obtained from the Senior Vegetable Breeder, Department of Horticulture, Mahatma Phule Agricultural University, Rahuri.

3.2 Experimental details

The experiment was laid out in a factorial randomized block design. Nitrogen, phosphorus and potassium were supplied through straight fertilizers, namely, urea, single superphosphate and muriate of potash, respectively. Twenty seven treatment combinations comprising of 3 levels each of nitrogen, phosphorus and potassium were tried. The treatment details have been given in Table 2. The details of nutrient levels were as given below.

A) Treatments - 27.

1) Nitrogen ... 0, 75, 150 kg/ha

2) Phosphorus ... 0, 40, 80 kg/ha

3) Potassium ... 0, 40, 80 kg/ha

B) Replications - 3.

C) Plot size

a) Gross ... 3 x 2 m

b) Net plot ... 2.70 x 1.70 m

D) Date of sowing ... April 10, 1986.

Table 2. Treatment combinations

1)	$N_0P_0K_0$	10)	$N_1P_0K_0$	19)	$N_2P_0K_0$
2)	$N_0P_0K_1$	11)	$N_1P_0K_1$	20)	$N_2P_0K_1$
3)	$N_0P_0K_2$	12)	$N_1P_0K_2$	21)	$N_2P_0K_2$
4)	$N_0P_1K_0$	13)	$N_1P_1K_0$	22)	$N_2P_1K_0$
5)	$N_0P_1K_1$	14)	$N_1P_1K_1$	23)	$N_2P_1K_1$
6)	$N_0P_1K_2$	15)	$N_1P_1K_2$	24)	$N_2P_1K_2$
7)	$N_0P_2K_0$	16)	$N_1P_2K_0$	25)	$N_2P_2K_0$
8)	$N_0P_2K_1$	17)	$N_1P_2K_1$	16)	$N_2P_2K_1$
9)	$N_0P_2K_2$	18)	$N_1P_2K_2$	27)	$N_2P_2K_2$

3.2.1 Seed sowing

Before sowing, the Amaranthus seeds were thoroughly mixed with fine silt in proportion of 1:10(i.e. 1 part of seed mixed with 10 parts of fine silt). It was then uniformally sown in shallow furrows opened about 2 cm deep and 15 cm apart along width of flat beds. Then, a thin layer of fine silt was spread on it. Immediately, the beds were irrigated with a slow flowing water. The seed rate used was 10 kg/ha.

3.2.2 Fertilizer application

Before sowing, the experimental plot was manured with a basal dose of 20 cartloads of FYM per hectare. N, P and K doses were split into five equal fractions, the first being given before the seed sowing and each of the remaining ones after each cutting. The fertilizers were broadcast uniformally and mixed well into the soil.

3.2.3 Cultural operations

The cultural operations, such as plant protection, weeding, etc. were followed as and when required for normal cultivation of Amaranthus.

3.2.4 Harvesting

The first harvesting was done on the 45th days after seed sowing. The plants were cut 5 cm above the ground level. The 2nd, 3rd, 4th and 5th cuttings were taken at an interval of 30 days each. On the very next day of each cutting the N, P and K fertilizers were applied to each bed as per treatment, and the beds were irrigated immediately using some dry grass at the entrance of each bed so that the speed of flowing irrigation water could be sufficiently slowed down to avoid ~~dislodging of~~ carry over of the ~~sown seeds~~ applied fertilizers.

3.2.5 Observations

3.2.5.1 Period taken for seedling emergence

This was recorded as a period from date of seed sowing until the emergence of about 90 per cent of the young seedlings was completed.

3.2.5.2 Growth observations

For recording observations, namely, the plant height, number of leaves per plant, weight of leaves and stems, number of branches per plant and average leaf area per plant, 10 plants from each bed were randomly selected. The linear measurements were made correctly upto 0.1 cm. While weights upto 0.1 g (except for yield parameter which was accurate upto 5 g). Their averages were computed and presented in the results.

1. Height of plant at second cutting

The height of the individual plant at the time of second cutting was measured in centimeters from the ground level upto the tip (growing point) with the help of a flexible steel tape.

2. Number of leaves per plant

Just prior to the 2nd, 3rd, 4th and 5th cutting, all the leaves produced by the 10 selected plants were counted separately and the averages were computed and presented.

3. Number of branches per plant

Just prior to the 2nd, 3rd, 4th and 5th cutting all the branches produced by the 10 selected plants were counted separately and the averages were computed and presented.

4. Weight of leaves and stems

Just prior to the 2nd and 4th cutting the leaves of all the 10 selected plants were removed from the cut stems. They were separately weighed on a top pan balance. The average weights were computed and presented.

5. Dry matter content

Just prior to the 2nd and 4th cutting 50 g weighed fresh sample from each plot was subjected to oven drying at 70°C until two constant weights were obtained. The final weights of dried sample were noted and the dry matter contents were computed using formula -

$$\text{Dry matter content (\%)} = \frac{\text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100.$$

6. Physiological weight losses

Exactly one kilogram of fresh sample from each treatment was kept at the ambient temperature and subsequently, the same sample was weighed at an interval of 4 hrs until it registered the physiological weight loss to the tune of 10 per cent. The period in hours to attain 10 per cent reduction in weight of fresh sample was noted under each treatment and presented.

3.2.5.3 Cumulative yield

At each cutting, all plants from every treatment (bed) were cut about 5 cm above the ground level. They were bundled together with their intact leaves and weighed on a weighing balance. This green material was weighed with an accuracy of 2.5 g. The yield weights of the five cuttings from each treatment (bed) were summed up and the total fresh yield of each treatment (bed) was worked out. This was multiplied by a factor 2.18 to compute the yield/hectare and presented as cumulative yield per hectare.

3.2.5.4 Observation for seed crop

After 5th cutting the crop was left for seedling. The date of last cutting, flowering and also of harvesting of seed panicles were recorded.

About a week before flowering, 10 plants were randomly selected and tagged. Their panicles were cut with a sickle as soon as the seed turned brown in colour. In three to four cuttings, all the panicles could be harvested. All the harvested panicles were separately dried and threshed. The threshed material was winnowed with fan and seeds were collected and weighed and finally average seed yield per plant was computed for each treatment. This was multiplied by the plant population count of each treatment to have seed yield per plot. This was again multiplied by a factor 21.78 to compute seed yield per hectare for each treatment.

3.2.5.5 Chemical analysis

To know the effect of fertilizer treatments on chemical composition of the plant tissues the chemical analysis was carried out just before second cutting. The methods adopted have been given in Table 3.

Table 3. Methods used for chemical analysis of plant tissues

Sr. No.	Determination	Method used	Reference
1.	Nitrogen	Microkjeldahl	Bremner (1965)
2.	Phosphorus	Ammonium phosphomolybdate yellow method	Chapman and Pratt (1961)
3.	Potassium	Flame photometric	Ranganna (1977)
4.	Iron	Atomic absorption	Lindsay and Naruell (1975)
5.	Crude protein	N x 6.25	A.O.A.C. (1965)
6.	Crude fibre	Ether extraction method	Ranganna (1977)
7.	Vitamin 'A'	Spectronic-20	Ranganna (1977)

Exactly 1 kg of fresh composite sample was taken from individual plot and analysed for :

1) Crude fibre
2) Crude protein
3) Phosphorus
4) Potassium
5) Nitrogen
6) Carotene
7) Iron

3.2.5.6 Statistical analysis

The statistical analysis was carried out as per the methods suggested by Panse and Sukhatme (1967).

Results and Discussion

4. RESULTS AND DISCUSSION

The results obtained in the present investigation in respect of growth, yield and nutritive value of amaranthus as influenced by various levels of nitrogen, phosphorus and potassium are presented and discussed in this chapter under suitable headings.

4.1 Growth parameters

4.1.1 Plant height

The data recorded in Table 4 on plant height at the 2nd cutting revealed that the latter was not significantly influenced by various fertilizer treatments, although all the three fertilizer elements viz., N, P and K had shown slightly progressive increase with increase in their levels. Higher rates always resulted in more plant height as seen in Fig. 1. Ramchander (1978), Singh et al. (1985), Ramchander and Thimmeraju (1983) also reported maximum height with the highest rates of N application.

4.1.2 Number of branches produced per plant

The data pertaining to the number of branches produced per plant are presented in Table 5. The data revealed that the production of number of branches was significantly influenced by various fertilizer treatments at 2nd, 3rd, 4th and 5th cutting of the amaranthus greens.

At the time of second cutting, it was seen that the nitrogen had significantly affected the number of

Table 4. Effects of N, P and their interaction on height of plant at 2nd cutting (cm)

N/P	P_0	P_1	P_2	Mean
N_0	29.489	31.911	32.444	31.281
N_1	34.533	34.378	34.344	34.419
N_2	36.444	37.622	40.078	38.048
Mean	33.489	34.637	35.622	

Effect of N, K and their interaction on height

N/K	K_0	K_1	K_2	Mean
N_0	30.067	30.389	33.389	31.281
N_1	34.267	35.111	33.878	34.419
N_2	37.111	37.578	39.456	38.048
Mean	33.815	34.359	35.574	

Effect of P, K and their interaction on height

P/K	K_0	K_1	K_2	Mean
P_0	32.689	32.522	35.256	33.489
P_1	33.722	34.944	35.214	34.637
P_2	35.033	35.611	36.222	35.622
Mean	33.815	34.359	35.574	

	S.E. $\pm$	C.D. at 5 %
N	0.757	2.15*
P	0.757	NS
K	0.757	NS
NP	1.31	NS
NK	1.31	NS
PK	1.31	NS
NPK	2.27	NS

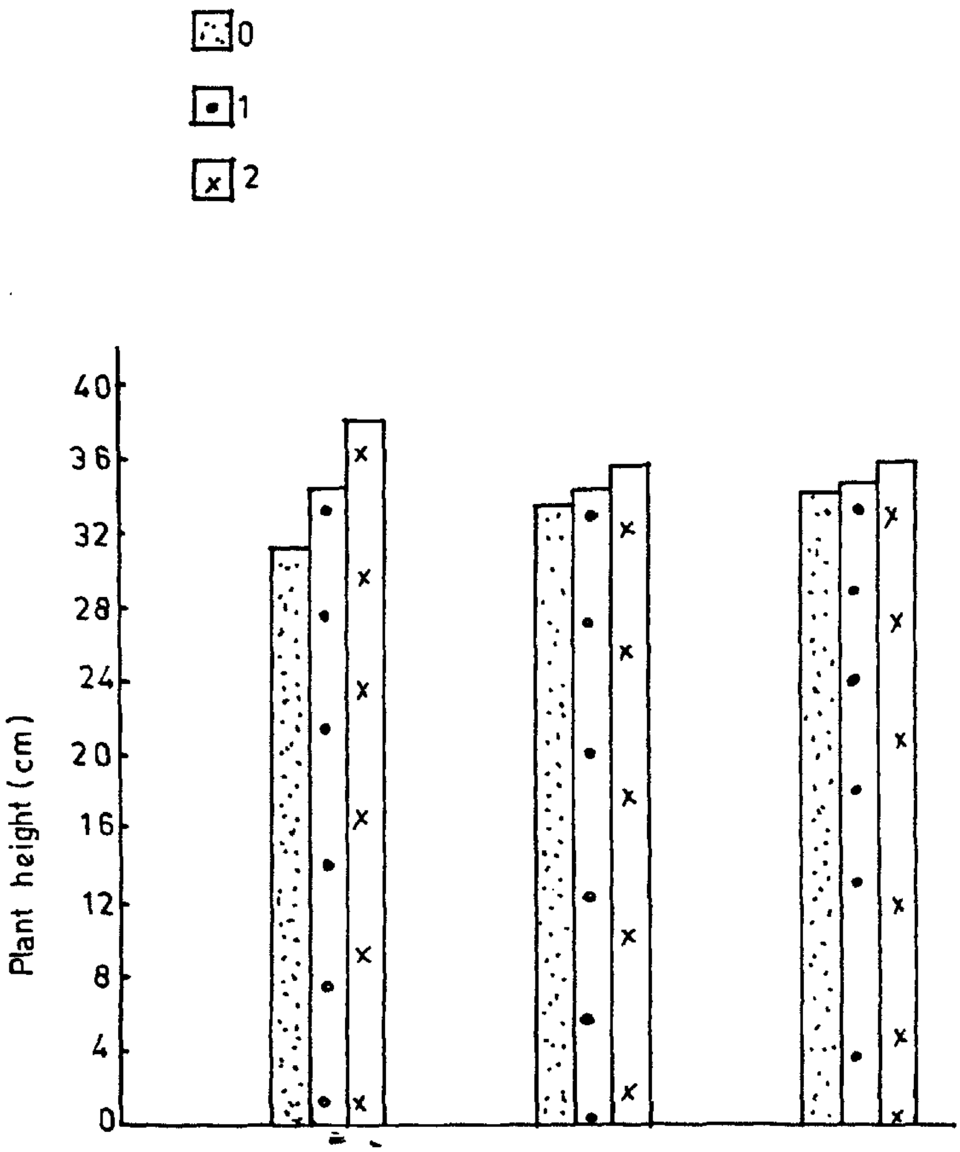

Fig.1. Final plant height (cm) of amaranthus plants as affected by N,P, K levels.

branches produced per plant. The plants under N_2 (receiving 150 kg N/ha) level registered the highest number of branches (7.085). It was significantly more than those registered by the plants under the rest of the N levels. The next in order of merit were the plants under N_1 levels followed by N_0 level. The latter produced the least (3.737) number of branches. It was interesting to note that with increase in the N level, there was significant improvement in this parameter. Almost similar trend was noticed at the time of 3rd, 4th and 5th cutting, indicating that nitrogen application had significantly contributed to the production of branches in amaranthus. However, no reports are available to support these findings and hence they need further confirmation.

A trend similar to that obtained with N levels was also noticed with P levels except that the differences at the second cutting were non-significant and the number of branches produced by the plants under P_0 level were at par with that under P_1 at all the subsequent cuttings while at 4th cutting the number of branches produced by the plants under P_2 level were at par with that under P_1 level. It was particularly interesting that with increase in P level, there was progressive increase in the production of branches, the increase being significant a subsequent cuttings. This suggested that application also had significantly contri

Table 5-a. Effect of N, P and their interaction on number of branches at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	3.622	3.956	3.633	3.737
N_1	4.689	5.700	5.567	5.319
N_2	6.300	6.689	8.267	7.085
Mean	4.870	5.448	5.822	

Effect of N, K and their interaction on number of branches at 2nd cutting

N/K	K_0	K_1	K_2	Mean
N_0	3.978	3.656	3.578	3.737
N_1	5.200	5.456	5.300	5.319
N_2	6.967	7.133	7.156	7.085
Mean	5.381	5.415	5.344	

Effect of P, K and their interaction on number of branches at 2nd cutting

P/K	K_0	K_1	K_2	Mean
P_0	4.767	4.833	5.011	4.870
P_1	5.400	5.611	5.333	5.448
P_2	5.978	5.800	5.689	5.822
Mean	5.381	5.415	5.344	

	S.E. $\pm$	C.D. at 5 %
N	0.291	0.830
P	0.291	NS
K	0.291	NS
NP	0.505	NS
NK	0.505	NS
PK	0.505	NS
NPK	0.875	NS

Table 5-b. Effect of N, P and their interaction on number of branches at 3rd cutting

N/P	P_0	P_1	P_2	Mean
N_0	3.411	3.556	4.233	3.733
N_1	4.544	4.833	5.933	5.104
N_2	5.833	6.722	7.989	6.848
Mean	4.596	5.037	6.052	

Effect of N, K and their interaction on number of branches at 3rd cutting

N/K	K_0	K_1	K_2	Mean
N_0	3.444	3.533	4.322	3.733
N_1	4.967	5.433	4.911	5.104
N_2	6.567	6.833	7.144	6.848
Mean	4.959	5.267	5.459	

Effect of P, K and their interaction on number of branches at 3rd cutting

P/K	K_0	K_1	K_2	Mean
P_0	4.411	4.878	4.500	4.596
P_1	4.833	4.822	5.456	5.037
P_2	5.633	6.100	6.422	6.052
Mean	4.959	5.267	5.459	

	S.E. $\pm$	C.D. at 5 %
N	0.31	0.89
P	0.31	0.89
K	0.31	-
NP	0.54	-
NK	0.54	-
PK	0.54	-
NPK	0.94	-

Table 5-c. Effect of N, P and their interaction on number of branches at 4th cutting

N/P	P_0	P_1	P_2	Mean
N_0	3.444	3.644	4.278	3.789
N_1	4.844	6.056	6.422	5.774
N_2	6.467	7.178	7.700	7.115
Mean	4.919	5.626	6.133	

Effect of N, K and their interaction on number of branches at 4th cutting

N/K	K_0	K_1	K_2	Mean
N_0	3.433	3.811	4.122	3.789
N_1	5.600	5.722	6.000	5.774
N_2	6.533	7.244	7.567	7.115
Mean	5.189	5.593	5.896	

Effect of P, K and their interaction on number of branches at 4th cutting

P/K	K_0	K_1	K_2	Mean
P_0	4.456	5.000	5.300	4.919
P_1	5.156	5.711	6.011	5.626
P_2	5.956	6.067	6.378	6.133
Mean	5.189	5.593	5.896	

	S.E. $\pm$	C.D. at 5 %
N	0.25	0.72
P	0.25	0.72
K	0.25	-
NP	0.43	-
NK	0.43	-
PK	0.43	-
NPK	0.76	-

Table 5-d. Effect of N, P and their interaction on number of branches at 5th cutting

N/P	P_0	P_1	P_2	Mean
N_0	3.556	3.833	4.178	3.656
N_1	4.778	5.278	6.133	5.396
N_2	6.622	6.233	7.967	6.941
Mean	4.985	5.115	6.093	

Effect of N, K and their interaction on number of branches at 5th cutting

N/K	K_0	K_1	K_2	Mean
N_0	3.678	4.100	3.789	3.656
N_1	5.089	5.178	5.922	5.396
N_2	6.256	6.933	7.633	6.941
Mean	5.007	5.404	5.781	

Effect of P, K and their interaction on number of branches at 5th cutting

P/K	K_0	K_1	K_2	Mean
P_0	4.678	5.078	5.200	4.985
P_1	4.444	5.300	5.600	5.115
P_2	5.900	5.633	6.544	6.093
Mean	5.007	5.404	5.781	

	S.E. $\pm$	C.D. at 5 %
N	0.33	0.94
P	0.33	0.94
K	0.33	-
NP	0.57	-
NK	0.57	-
PK	0.57	-
NPK	1.00	-

branching in amaranthus. However,no reports are available to support these findings and hence this needs further confirmation.

Regarding the application of potassium, it was seen that the results thereof were non-significant at all the cuttings under study. But it was worth noting that in all these cuttings, with an increase in the K levels there was progressive increase in branching of the amaranthus plants. This implied that application of potassium also contributed to improve branching at least to some extent. However, in the absence of reports it needs further confirmation.

The interaction effects were non-significant in all the cuttings, indicating that all these fertilizers behaved independently.

4.1.3 Number of leaves produced per plant

The data pertaining to the number of leaves produced per plant have been presented in Table 6. The data revealed that the production of number of leaves was significantly influenced by various fertilizer treatments at 2nd, 3rd, 4th and 5th cutting of the amaranthus greens.

At the time of second cutting, it was seen that the nitrogen had significantly affected the number of leaves produced per plant. The plants under N_2 (receiving 150 kg N/ha) level registered the highest number of leaves (74.60).

Table 6-a. Effect of N, P and their interaction on number of leaves/plant at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	42.533	51.744	59.578	51.285
N_1	63.289	57.044	64.811	61.715
N_2	68.444	70.989	84.378	74.604
Mean	58.089	59.926	69.589	

Effect of N, K and their interaction on number of leaves/plant at 2nd cutting

N/K	K_0	K_1	K_2	Mean
N_0	44.978	51.778	57.100	51.285
N_1	62.189	60.622	62.133	61.715
N_2	66.756	79.544	77.511	74.604
Mean	57.974	64.048	65.581	

Effect of P, K and their interaction on number of leaves/plant at 2nd cutting

P/K	K_0	K_1	K_2	Mean
P_0	53.444	59.511	61.611	58.089
P_1	53.022	62.689	64.067	59.926
P_2	67.456	70.244	71.067	69.589
Mean	57.974	64.048	65.581	

	S.E.$\pm$	C.D. at 5 %
N	3.18	9.06*
P	3.18	9.06*
K	3.18	-
NP	5.52	-
NK	5.52	-
PK	5.52	-
NPK	9.56	-

Table 6-b. Effect of N, P and their interaction on number of leaves at 3rd cutting

N/P	P_0	P_1	P_2	Mean
N_0	38.867	47.300	45.422	43.863
N_1	54.367	54.767	44.844	54.993
N_2	62.556	66.744	76.767	68.689
Mean	51.930	56.270	59.344	

Effect of N, K and their interaction on number of leaves at 3rd cutting

N/K	K_0	K_1	K_2	Mean
N0	42.633	45.900	43.056	43.863
N_1	55.889	52.267	56.822	54.993
N_2	63.044	67.622	75.400	68.689
Mean	53.856	55.263	58.426	

Effect of P, K and their interaction on number of leaves at 3rd cutting

P/K	K_0	K_1	K_2	Mean
P_0	49.676	53.111	57.000	51.930
P_1	58.044	51.344	59.422	56.270
P_2	53.844	61.333	62.856	59.344
Mean	53.856	55.263	58.426	

	S.E.$\pm$	C.D. at 5 %
N	3.53	10.03*
P	3.53	-
K	3.53	-
NP	6.11	-
NK	6.11	-
PK	6.11	-
NPK	10.59	-

Table 6-c. Effect of N, P and their interaction on number of leaves at 4th cutting

N/P	P_0	P_1	P_2	Mean
N_0	41.489	50.944	52.167	48.200
N_1	60.567	63.089	71.711	65.122
N_2	68.522	79.033	87.833	78.463
Mean	56.859	64.356	70.570	

Effect of N, K and their interaction on number of leaves at 4th cutting

N/K	K_0	K_1	K_2	Mean
N_0	44.889	50.411	49.300	48.200
N_1	59.800	67.578	67.989	65.122
N_2	75.633	75.189	84.567	78.463
Mean	60.107	64.393	67.285	

Effect of P, K and their interaction on number of leaves at 4th cutting

P/K	K_0	K_1	K_2	Mean
P_0	51.711	60.256	58.611	56.859
P_1	63.511	62.367	67.189	64.356
P_2	65.100	70.556	76.056	70.570
Mean	60.107	64.393	67.285	

	S.E.±	C.D. at 5 %
N	3.642	10.35*
P	3.642	10.35*
K	3.642	NS
NP	6.308	NS
NK	6.308	NS
PK	6.308	NS
NPK	10.927	NS

Table 6-d. Effect of N, P and their interaction on number of leaves at 5th cutting

N/P	P_0	P_1	P_2	Mean
N_0	45.989	53.111	53.633	50.911
N_1	53.144	61.144	65.289	59.859
N_2	70.200	77.044	84.867	77.370
Mean	56.444	63.767	67.930	

Effect of N, K and their interaction on number of leaves at 5th cutting

N/K	K_0	K_1	K_2	Mean
N_0	50.267	48.500	53.967	50.911
N_1	56.922	62.500	60.156	59.859
N_2	72.789	78.233	81.084	77.370
Mean	59.993	63.078	65.070	

Effect of P, K and their interaction on number of leaves at 5th cutting

P/K	K_0	K_1	K_2	Mean
P_0	55.078	57.367	56.889	56.444
P_1	60.700	64.033	65.567	63.767
P_2	64.200	67.833	71.756	67.930
Mean	59.993	63.078	65.070	

	S.E. $\pm$	C.D. at 5 %
N	3.83	10.90
P	3.83	-
K	3.83	-
NP	6.64	-
NK	6.64	-
PK	6.64	-
NPK	11.50	-

had significantly contributed to the production of number of leaves in amaranthus. However, no such reports are available and hence this needs confirmation.

Regarding the application of potassium, it was seen that the results thereof were non-significant at all the cuttings under study i.e. 2nd, 3rd, 4th and 5th cutting. But it was worthnothing that in all these cuttings, with an increase in the K level there was a progressive increase in the production of number of leaves. This implied that application of potassium also contributed to improve leaf production at least to some extent. However, no such reports are, available and hence this needs confirmation.

The interaction effects were non-significant at all the cuttings, indicating that all these fertilizers behaved independently.

4.1.4 Weight of leaves at 2nd and 4th cuttings

The data in respect of fresh weight of leaves at the 2nd and 4th cuttings have been presented in Table 7. The data revealed that the fresh weight of leaves at both the cuttings was not significantly influenced by various treatment combinations under study. However, levels of both N and P were found to exert their significant effect on this parameter. This did not hold good with K and other interactions namely NP, NK, PK and NPK.

Table 7-a. Effect of N, P and their interaction on weight of leaves at 2nd cutting (g/plant)

N/P	P_0	P_1	P_2	Mean
N_0	4.686	5.619	5.542	5.282
N_1	6.613	8.187	8.693	7.831
N_2	13.708	15.630	17.631	15.656
Mean	8.336	9.812	10.622	

Effect of N, K and their interaction on weight of leaves at 2nd cutting

N/K	K_0	K_1	K_2	Mean
N_0	4.777	5.510	5.560	5.282
N_1	7.416	6.797	8.281	7.831
N_2	15.160	15.514	16.294	15.656
Mean	9.118	9.607	10.045	

Effect of P, K and their interaction on weight of leaves at 2nd cutting

P/K	K_0	K_1	K_2	Mean
P_0	7.995	8.319	8.693	8.336
P_1	9.359	9.491	10.586	9.812
P_2	9.999	11.011	10.857	10.622
Mean	9.118	9.607	10.045	

	S.E. ±	C.D. at 5 %
N	0.504	1.43
P	0.504	1.43
K	0.504	-
NP	0.873	-
NK	0.873	-
PK	0.873	-
NPK	1.51	-

Table 7-b. Effect of N, P and their interaction on weight of leaves at 4th cutting (g/plant)

N/P	P_0	P_1	P_2	Mean
N_0	4.646	4.937	5.418	5.033
N_1	6.682	8.053	8.906	7.880
N_2	13.548	15.678	18.112	15.779
Mean	8.325	9.556	10.812	

Effect of N, K and their interaction on weight of leaves at 4th cutting

N/K	K_0	K_1	K_2	Mean
N_0	4.757	4.648	5.696	5.033
N_1	7.330	8.006	8.306	7.880
N_2	14.974	15.727	16.637	15.779
Mean	9.020	9.460	10.213	

Effect of P, K and their interaction on weight of leaves at 4th cutting

P/K	K_0	K_1	K_2	Mean
P_0	7.897	8.287	8.792	8.325
P_1	8.893	9.191	10.583	9.556
P_2	10.271	10.902	11.262	10.812
Mean	9.020	9.460	10.213	

	S.E. ±	C.D. at 5 %
N	0.419	1.19
P	0.419	1.19
K	0.419	NS
NP	0.725	NS
NK	0.725	NS
PK	0.725	NS
NPK	1.25	NS

It was seen that at the time of 2nd and 4th cutting the nitrogen had significantly affected the average weight of leaves per plant. At the time of 2nd cutting, the plants under N_2 level registered the maximum fresh weight of leaves (15.65 g). It was significantly more than that registered under control (N_0). The latter registered the lowest weight of 5.28 g. The next in order of merit was the weight registered under N_1 level (7.83 g); all being significantly different from each other. Almost a similar trend was noticed with the data recorded at the time of 4th cutting also.

It was, however, worth noting that with an increase in N level, there was a progressive increase in the weight of leaves, indicating significant influence of N on weight of leaves.

A trend similar to that obtained with N levels, was also noticed with P levels except that the difference between weight of leaves due to P_1 and P_2 levels was not significant at the 2nd cutting. Here also, it was worth noting that there was a progressive increase in weight of leaves with an increase in the P level. This indicated strong influence of P on the weight of leaves. But levels of K did not show any such influence in either of the cuttings. Still it was worth noting that with an increase in K level there was an increase in weight of leaves.

But in the absence of any report, the present results could not be supported. They need further confirmation.

4.1.5 Weight of stem at 2nd and 4th cuttings

The data in respect of fresh weight of stem at the 2nd and 4th cuttings have been presented in Table 8. The data revealed that the fresh weight of stem at both the cuttings were not significantly influenced by various treatment combinations under study. However, levels of both N and P were found to exert their significant influence on this parameter. This did not hold good with K and other interactions, namely NP, NK, PK and NPK.

It was seen that at the time of 2nd and 4th cutting the nitrogen had significantly affected the average fresh weight of stem. At the time of 2nd cutting, the plants under N_2 level registered the maximum fresh weight of stem (23.13 g). It was significantly more than that registered under control (N_0). The latter registered the lowest weight of 7.59 g. The next in order of merit was the weight registered under N_1 level (13.40 g); all being significantly different from each other. Almost a similar trend was noticed with the data recorded at the time of 4th cutting also.

It was, however, worth noting that with an increase in N level, there was a progressive and significant increase in the weight of stem, indicating significant influence of N on this parameter.

Table 8-a. Effect of N, P and their interaction on weight of stem at 2nd cutting (g/plant)

N/P	P_0	P_1	P_2	Mean
N_0	6.946	7.890	7.939	7.591
N_1	10.783	13.933	15.492	13.403
N_2	21.668	23.462	24.276	23.135
Mean	13.132	15.095	15.902	

Effect of N, K and their interaction on weight of stem at 2nd cutting (g/plant)

N/K	K_0	K_1	K_2	Mean
N_0	6.920	7.931	7.923	7.591
N_1	12.458	13.289	14.462	13.403
N_2	23.451	22.169	23.786	23.135
Mean	14.276	14.463	15.390	

Effect of P, K and their interaction on weight of stem at 2nd cutting (g/plant)

P/K	K_0	K_1	K_2	Mean
P_0	13.400	12.518	13.479	13.132
P_1	14.347	14.631	16.108	15.095
P_2	15.082	16.040	16.584	15.902
Mean	14.276	14.463	15.390	

	S.E. $\pm$	C.D. at 5 %
N	0.655	1.862
P	0.655	1.862
K	0.655	-
NP	1.135	-
NK	1.135	-
PK	1.135	-
NPK	1.966	-

Table 8-b. Effect of N, P and their interaction on weight of stem at 4th cutting (g)

N/P	P_0	P_1	P_2	Mean
N_0	6.650	7.909	8.497	7.685
N_1	10.164	13.793	14.329	12.762
N_2	18.266	19.784	23.500	20.517
Mean	11.693	13.829	15.442	

Effect of N, K and their interaction on weight of stem at 4th cutting (g)

N/K	K_0	K_1	K_2	Mean
N_0	8.019	7.016	8.021	7.685
N_1	12.131	12.994	13.161	12.762
N_2	20.009	20.116	21.426	20.517
Mean	13.386	13.375	14.203	

Effect of P, K and their interaction on weight of stem at 4th cutting (g)

P/K	K_0	K_1	K_2	Mean
P_0	11.527	11.631	11.932	11.693
P_1	13.260	13.354	14.672	13.829
P_2	15.372	15.140	15.613	15.442
Mean	13.386	13.375	14.203	

	S.E.$\pm$	C.D. at 5 %
N	0.537	1.52
P	0.537	1.52
K	0.537	-
NP	0.931	-
NK	0.931	-
PK	0.931	-
NPK	1.612	-

A trend almost similar to that obtained with N levels, was also noticed with P levels except that the difference between weight of stem due to P_1 and P_2 levels was not significant at the 2nd cutting. Here also it was wotth noting that there was a progressive and significant increase in the weight of stem with increase in the P level. This indicated strong influence of P on this parameter. But levels of K did not show any such influence at either of the cuttings. Still it was worth noting that with an increase in K level there was a consistent increase in the fresh weight of stem. However, no such reports are available and hence these findings need further confirmation.

4.1.6 Dry matter content per plant as recorded at the time of 2nd and 4th cuttings (g)

The data pertaining to the dry matter content per plant as recorded at the time of 2nd and 4th cuttingshave been presented in Table 9. The data revealed that the dry matter content per plant at both the cuttings was not significantly influenced by various treatment combinations under study. But the levels of N, P and K have significantly influenced the dry matter content. The interaction effects, namely NP, NK, PK and NPK were however, not significant.

Table 9-a. Effect of N, P and their interaction on dry matter content per plant at 2nd cutting (g)

N/P	P_0	P_1	P_2	Mean
N_0	5.790	5.884	6.320	5.998
N_1	7.197	7.487	7.730	7.471
N_2	9.358	9.934	10.148	9.813
Mean	7.448	7.769	8.066	

Effect of N, K and their interaction on dry matter content per plant at 2nd cutting (g)

N/K	K_0	K_1	K_2	Mean
N_0	5.848	6.003	6.143	5.998
N_1	7.343	7.483	7.587	7.471
N_2	9.410	9.880	10.150	9.813
Mean	7.534	7,789	7.960	

Effect of P, K and their interaction on dry matter content per plant at 2nd cutting(g)

P/K	K_0	K_1	K_2	Mean
P_0	7.274	7.470	7.600	7.448
P_1	7.699	7.713	7.893	7.769
P_2	7.628	8.183	8.387	8.066
Mean	7.534	7.789	7.960	

	S.E.$\pm$	C.D. at 5 %
N	0.097	0.27
P	0.097	0.27
K	0.097	0.27
NP	0.16	-
NK	0.16	-
PK	0.16	-
NPK	0.29	

Table 9-b. Effect of N, P and their interaction on dry matter content per plant at 4th cutting (g)

N/P	P_0	P_1	P_2	Mean
N_0	4.947	5.040	5.140	5.042
N_1	6.843	7.290	7.343	7.159
N_2	9.557	10.160	10.173	9.967
Mean	7.119	7.497	7.552	

Effect of N, K and their interaction on dry matter content per plant at 4th cutting(g)

N/K	K_0	K_1	K_2	Mean
N_0	4.990	4.947	5.190	5.042
N_1	6.990	7.187	7.300	7.159
N_2	9.613	10.093	10.193	9.967
Mean	7.198	7.409	7.561	

Effect of P, K and their interaction dry matter content per plant at 4th cotting(g)

P/K	K_0	K_1	K_2	Mean
P_0	6.807	7.087	7.463	7.119
P_1	7.427	7.543	7.520	7.497
P_2	7.360	7.597	7.700	7.552
Mean	7.198	7.409	7.561	

	S.E. ±	C.D. at 5 %
N	0.091	0.26
P	0.091	0.26
K	0.091	0.26
NP	0.15	-
NK	0.15	-
PK	0.15	-
NPK	0.27	-

It was seen that at the time of both 2nd and 4th cutting the N levels had significantly influenced the dry matter content. At the time of 2nd cutting, the plants under N_2 level registered the maximum dry weight (9.813 g). It was significantly more than that recorded under control (N_0). The latter recorded the least dry matter content of 5.998 g. It was significantly less than those recorded under both N_2 and N_1 levels. Almost a similar trend was noticed with the data recorded at the time of 4th cutting also. It was further noteworth that with an increase in N level, there was a progressive and significant increase in the dry matter content of amaranthus plants, indicating strong influence of N on this parameter. These findings coroborate with those of Verma et al.(1969) in Spinach and Ramachandra (1978) in amaranthus.

A trend similar to that obtained with N levels was also noticed that P levels, except that the difference between dry matter contents due to P_1 and P_2 was not significant. Here also, it was worth noting that there was a progressive increase in dry matter contents with an increase in P level. This indicated strong influence of P on this parameter. These findings almost confirm those of Ramchandra (1978) in amaranthus. He reported increased dry matter contents contents with the highest rate of application of P at 80 kg/ha.

Regarding the application of potassium it was seen that the data at the 2nd and 4th cutting revealed almost a similar trend. At the time of 2nd cutting the plants under K_2 level registered maximum dry matter content of 7.96 g. It was significantly more than that recorded under control (K_0), but at par with that recorded under K_1 level. The control (K_0) registered the least dry matter content which however, was at par with that recording under K_1. A very similar trend was noticed also at the time of 4th cutting. It was interesting to note that at both the cuttings, there was a progressive increase in the dry matter content with increase in K level. This indicated a significant contribution also of K in this respect. However, in absence of reported findings, this needs further confirmation.

4.1.7 Leaf size (cm^2)

The data pertaining to the leaf size (area) produced per plant have been presented in Table 10. The data revealed that the leaf size was not significantly/influenced by various fertilizer treatment combinations at 3rd and 5th cuttings of the amaranthus greens. However, levels of N, P and K were found to exert their significant influence at both the cuttings.

Table 10-a. Effect of N, P and their interaction on leaf size (cm^2/plant) at 3rd cutting

N/P	P_0	P_1	P_2	Mean
N_0	11.957	14.648	13.760	13.455
N_1	13.987	16.697	18.760	16.481
N_2	21.331	22.686	30.167	24.724
Mean	15.758	18.010	20.892	

Effect of N, K and their interaction on leaf size (cm^2/plant)

N/K	K_0	K_1	K_2	Mean
N_0	11.343	12.487	16.534	13.455
N_1	15.067	17.000	17.297	16.481
N_2	23.147	24.271	26.756	24.724
Mean	16.519	17.946	20.196	

Effect of P, K and their interaction on leaf size (cm^2/plant)

P/K	K_0	K_1	K_2	Mean
P_0	13.926	17.930	15.419	15.758
P_1	15.601	17.908	20.521	18.010
P_2	20.030	18.000	24.647	20.892
Mean	16.519	17.946	20.196	

	S.E.$\pm$	C.D.at 5 %
N	0.88	2.51
P	0.88	2.51
K	0.88	2.51
NP	1.53	-
NK	1.53	-
PK	1.53	-
NPK	2.65	-

Table 10-b. Effect of N, P and their interaction on leaf size (cm^2/plant) at 5th cutting

N/P	P_0	P_1	P_2	Mean
N_0	10.311	12.027	16.357	12.898
N_1	20.057	20.787	17.680	19.508
N_2	19.950	23.076	23.890	22.355
Mean	16.773	18.630	19.309	

Effect of N, K and their interaction on leaf size (cm^2/plant)

N/K	K_0	K_1	K_2	Mean
N_0	14.104	11.833	12.757	12.898
N_1	16.740	22.710	19.073	19.508
N_2	20.177	23.110	23.629	22.305
Mean	17.007	19.218	18.486	

Effect of P, K and their interaction on leaf size (cm^2/plant)

P/K	K_0	K_1	K_2	Mean
P_0	15.478	18.240	16.600	16.773
P_1	17.333	20.967	17.584	18.630
P_2	18.210	18.447	21.270	19.309
Mean	17.007	19.218	18.486	

	S.E. $\pm$	C.D. at 5 %
N	0.645	1.86*
P	0.645	1.86*
K	0.645	1.85*
Np	1.118	3.22*
NK	1.118	3.22*
PK	1.118	3.22NS
NPK	1.937	-

At the time of 3rd cutting, it was seen that the nitrogen had significantly affected the leaf size. The plants under N_2 (receiving 150 kg N/ha) level registered maximum leaf size (area) of 24.72 cm^2. It was significantly greater than those registered by the plants under the rest of the N levels. The next in order of merit were the plants under N_1 level followed by N_0 level. The latter N levels (N_1 and N_0) registered the least (13.45 and 12.8 cm^2, respectively) leaf area of 13.45 cm^2. It was significantly smaller than that registered under N_1 level. A more or less similar trend was evident also at the time of 5th cutting. It was interesting to note that with increase in N level, there was a significant and progressive improvement in this parameter. This indicated significant influence of N levels on this parameter. These findings support those of Ramachandra (1978) who reported increased leaf area of amaranthus with highest rate of N/ha (i.e. 200 kg/ha).

At the time of 3rd cutting, P had significantly influenced the leaf area of the plants under P_2 level registered maximum leaf area of 20.69 cm^2. It was significantly greater than those of the rest of the P levels. The next in order of merits was the leaf area registered under P_1 level. The latter was, however, at par with that of P_0 level which registered the smallest leaf area of 15.75 cm^2. A more or less similar trend was noticed also at the time of 5th cutting except that the leaf area under P_2 level was at par with that registered under P_1 level. It was, however, interesting to note that there was a progressive and significant increase in leaf area with an increase in P level. This indicated strong influence of P on the leaf area of amaranthus. These results are almost in confirmity with those of Ramchandra (1978). He reported increased leaf area with the highest rate of P application in amaranthus.

At the time of 3rd cutting, the plants under K_2 level registered the greatest leaf area of 20.19 cm^2. It was significantly greater than that registered under control (K_0) which registered the smallest leaf area of 16.51 cm^2. The latter was, however, at par with those under K_1. Almost similar trend was evident also at the time of 5th cutting. It was, however, worth noting that there was progressive and significant increase in leaf area with increase in the K levels under study. This indicated strong influence of K on this parameter.

The interaction effects, namely NP, NK, PK and NPK were found to be non-significant at the time of the 3rd cutting. But at the time of 5th cutting the NP, NK interaction effects were found to be significant. The combination N_2P_2 resulted in the maximum leaf area of 23.89 cm^2. It was significantly greater than those of N_0P_0 and N_0P_1, N_0P_2 and N_1P_2, N_2P_0 and N_1P_0 combination but at par with those of N_1P_1 and N_2P_1 combination. A more or less similar trend in leaf area due to NK interaction effects was noticed at the time of 5th cutting. Here also N_2K_2 combination resulted in the maximum leaf area of 23.62 cm^2. It was significantly greater than those of N_0K_1, N_0K_2, N_0K_0, N_1K_0, N_1K_2 and N_2K_0 combinations but at par with those of N_1K_1 and N_2K_1 combinations.

4.2 Effect of N, P and K with different levels on yield of amaranthus

4.2.1 Yield of greens (kg/plot)

The data pertaining to the yield of leafy greens have been presented in Table 11. The data revealed that the production of leafy greens was not significantly influenced by various fertilizer treatment combinations at 1st, 2nd, 3rd, 4th and 5th cutting of the amaranthus cultivar under study. However, the levels of fertilizer elements, namely N and P exerted profound influence on this parameter.

At the time of first cutting, it was seen that the nitrogen had significantly affected the yield of greens. The plants under N_2 (receiving 150 kg/ha) registered the highest yield of greens (6.31 kg). It was significantly more than those registered by the plants under the rest of the N levels. The next in order of merit were the

Table 11-a. Effect of N, P and their interaction on yield of green at 1st cutting (kg/plot)

N/P	P0	P_1	P_2	Mean
N_0	1.333	1.700	1.767	1.600
N_1	2.633	3.089	3.700	3.141
N_2	4.711	6.378	7.867	6.319
Mean	2.893	3.722	4.444	

Effect of N, K and their interaction on yield of green at 1st cutting (kg/plot)

N/K	K_0	K_1	K_2	Mean
N_0	1.378	1.689	1.733	1.600
N_1	2.933	3.200	3.289	3.141
N_2	5.667	6.167	7.122	6.319
Mean	3.326	3.685	4.048	

Effect of P, K and their interaction on yield of green at 1st cutting (kg/plot)

P/K	K_0	K_1	K_2	Mean
P_0	2.644	3.022	3.011	2.893
P_1	3.456	3.767	3.944	3.722
P_2	3.878	4.267	5.189	4.444
Mean	3.326	3.685	4.048	

	S.E.$\pm$	C.D. at 5 %
N	0.32	0.92
P	0.32	0.92
K	0.32	NS
NP	0.56	NS
NK	0.56	NS
PK	0.56	NS
NPK	0.97	NS

Table 11-b. Effect of N, P and their interaction on yield of green at 2nd cutting (kg/plot)

N/P	P_0	P_1	P_2	Mean
N_0	3.086	3.878	4.233	3.732
N_1	5.111	6.006	7.478	6.198
N_2	10.117	12.222	12.444	11.594
Mean	6.104	7.364	8.052	

Effect of N, K and their interaction on yield of green at 2nd cutting (kg/plot)

N/K	K_0	K_1	K_2	Mean
N_0	3.322	3.817	4.058	3.732
N_1	5.789	6.106	6.700	6.198
N_2	11.156	11.594	12.033	11.594
Mean	6.756	7.172	7.597	

Effect of P, K and their interaction on yield of green at 2nd cutting (kg/plot)

P/K	K_0	K_1	K_2	Mean
P_0	5.756	6.044	6.513	6.104
P_1	7.061	7.444	7.600	7.364
P_2	7.450	8.028	8.678	8.052
Mean	6.756	7.172	7.597	

	S.E.$\pm$	C.D.at 5%
N	0.61	1.73
P	0.61	NS
K	0.61	NS
NP	1.05	NS
NK	1.05	NS
PK	1.05	NS
NPK	1.83	NS

Table 11-c. Effect of N, P and their interaction on weight of green at 3rd cutting (kg/plot)

N/P	P_0	P_1	P_2	Mean
N_0	1.033	1.456	1.744	1.411
N_1	2.156	2.800	3.167	2.707
N_2	4.044	5.033	6.378	5.152
Mean	2.411	3.096	3.763	

Effect of N, K and their interaction on weight of green at 3rd cutting (kg/plot)

N/K	K_0	K_1	K_2	Mean
N_0	1.311	1.400	1.522	1.411
N_1	2.322	2.689	3.111	2.707
N_2	4.800	5.133	5.522	5.152
Mean	2.811	3.074	3.85	

Effect of P, K and their interaction on weight of green at 3rd cutting (kg/plot)

P/K	K_0	K_1	K_2	Mean
P_0	2.289	2.367	2.578	2.411
P_1	2.956	2.967	3.367	3.096
P_2	3.189	3.889	4.211	3.763
Mean	2.811	3.074	3.385	

	S.E. $\pm$	C.D. at 5 %
N	0.26	0.75
P	0.26	0.75
K	0.26	NS
NP	0.45	NS
NK	0.45	NS
PK	0.45	NS
NPK	0.79	NS

Table 11-d. Effect of N, P and their interaction on weight of green at 4th cutting (kg/plot)

N/P	P_0	P_1	P_2	Mean
N_0	1.656	1.822	2.167	1.881
N_1	3.222	4.122	4.622	3.989
N_2	4.828	4.894	5.083	4.935
Mean	3.235	3.613	3.957	

Effect of N, K and their interaction on weight of green at 4th cutting (kg/plot)

N/K	K_0	K_1	K_2	Mean
N_0	1.778	1.867	2.000	1.881
N_1	3.739	3.944	4.283	3.989
N_2	4.833	4.967	5.006	4.935
Mean	3.450	3.593	3.763	

Effect of P, K and their interaction on weight of green at 4th cutting (kg/plot)

P/K	K_0	K_1	K_2	Mean
P_0	3.122	3.228	3.356	3.235
P_1	3.456	3.578	3.806	3.613
P_2	3.772	3.972	4.128	3.957
Mean	3.450	3.593	3.763	

	S.E. $\pm$	C.D. at 5%
N	0.28	0.80
P	0.28	NS
K	0.28	NS
NP	0.49	
NK	0.49	-
PK	0.49	-
NPK	0.85	-

Table 11-e. Effect of N, P and their interaction on weight of green at 5th cutting (kg/plot)

N/P	P_0	P_1	P_2	Mean
N_0	0.656	1.172	1.656	1.161
N_1	2.117	2.246	2.844	2.402
N_2	2.650	3.344	3.778	3.257
Mean	1.807	2.254	2.759	

Effect of N,K and their interaction on weight of green at the 5th cutting(kg/plot)

N/K	K_0	K_1	K_2	Mean
N0	1.017	1.044	1.422	1.161
N_1	2.200	2.439	2.568	2.402
N_2	2.772	3.356	3.644	3.257
Mean	1.996	2.280	2.545	

Effect of P, K and their interaction on weight of green at the 4th cutting(kg/plot)

P/K	K_0	K_1	K_2	Mean
P_0	1.628	1.756	2.039	1.807
P_1	1.917	2.278	2.568	2.254
P_2	2.444	2.806	3.028	2.759
Mean	1.996	2.280	2.545	

	S.E.±	C.D.at 5%
N	0.24	0.70
P	0.24	0.70
K	0.24	-
NP	0.42	-
NK	0.42	-
PK	0.42	-
NPK	0.74	-

plants under N_1 level followed by control (N_0 level). The latter (N_0) produced the least (1.60 kg/ha) yield of greens. Almost similar trend was noticed also at the time of 2nd, 3rd, 4th and 5th cutting, indicating that nitrogen application had significantly contributed to the production of yield of green in amaranthus. It was interesting to note that with increase in N level, there was significant improvement in this parameter. These findings support those reported earlier by Verma et al. (1969), Vergniand and Huguet (1971), Bhore and Patil (1978) in spinach, and byPurushathaman (1978). Ramchandra and Thimmaraju (1983), Keskar et al. (1983) and Singh et al. (1985) in amaranthus.

A trend similar to that obtained with N levels was also noticed with P levels except that the differences at the second and fourth cutting were non-significant, while at 1st, 3rd and 5th cutting the yields of greens under P_2 level were at par with that under P_1 level while the latter was at par with P_0. It was particularly interesting to note that with an increase in P level there was a progressive increase in the yield of greens; the increase being significant at all the cuttings. This suggested that phosphorus application had significantly contributed to the yield of greens in amaranthus.

These results are parallel with those obtained by Ramachandra (1978). He reported that both the nutrients, namely N and P applied respectively at highest rates of 200 kg and 100 kg/ha produced the highest yield of leafy greens in amaranthus.

The results regarding K application and interaction with N, P and K were non-significant.

4.2.2 Cumulative yield (ton/ha)

The data pertaining to the cumulative yield of leafy greens have been presented in Table 12 and Fig. 2. The data revealed that the production of leafy greens was not significantly influenced by the various fertilizer treatment combinations under study. But the levels of nitrogen, phosphorus and potash significantly influenced this parameter.

In respect of nitrogen application, the plants under N_2 level registered the highest cumulative yield of 68.14 tonnes/ha. It was significantly more than those registered by the plants under rest of the N levels. The next in order of merit were the plants under N_1 level followed by those under N_0 level. The latter (N_0) level registered the least yield of 21.33 tonnes/ha. But all were significantly different from each other. It showed that with increase in the N level, there was significant improvement in this parameter.

Table 12. Effect of N, P and their interaction on cumulative yield (ton/ha)

N/P	P_0	P_1	P_2	Mean
N_0	16.919	21.861	25.215	21.332
N_1	33.209	39.812	47.548	40.190
N_2	57.443	69.481	77.499	68.141
Mean	35.857	43.718	50.088	

Effect of N, K and their interaction on cumulative yield (ton/ha)

N/K	K_0	K_1	K_2	Mean
N_0	19.196	21.400	23.399	21.332
N_1	37.012	40.064	43.493	40.190
N_2	63.717	68.052	72.655	68.141
Mean	39.975	43.172	46.516	43.221

Effect of P, K and their interaction on cumulative yield (ton/ha)

P/K	K_0	K_1	K_2	Mean
P_0	33.645	35.788	38.138	35.857
P_1	41.081	43.673	46.400	43.718
P_2	45.199	50.055	55.009	50.088
Mean	39.975	43.172	46.516	

	S.E.$\pm$	C.D.at 5%
N	1.73	4.92
P	1.73	4.92
K	1.73	4.92
NP	2.99	-
NK	2.99	-
PK	2.99	-
NPK	5.19	-

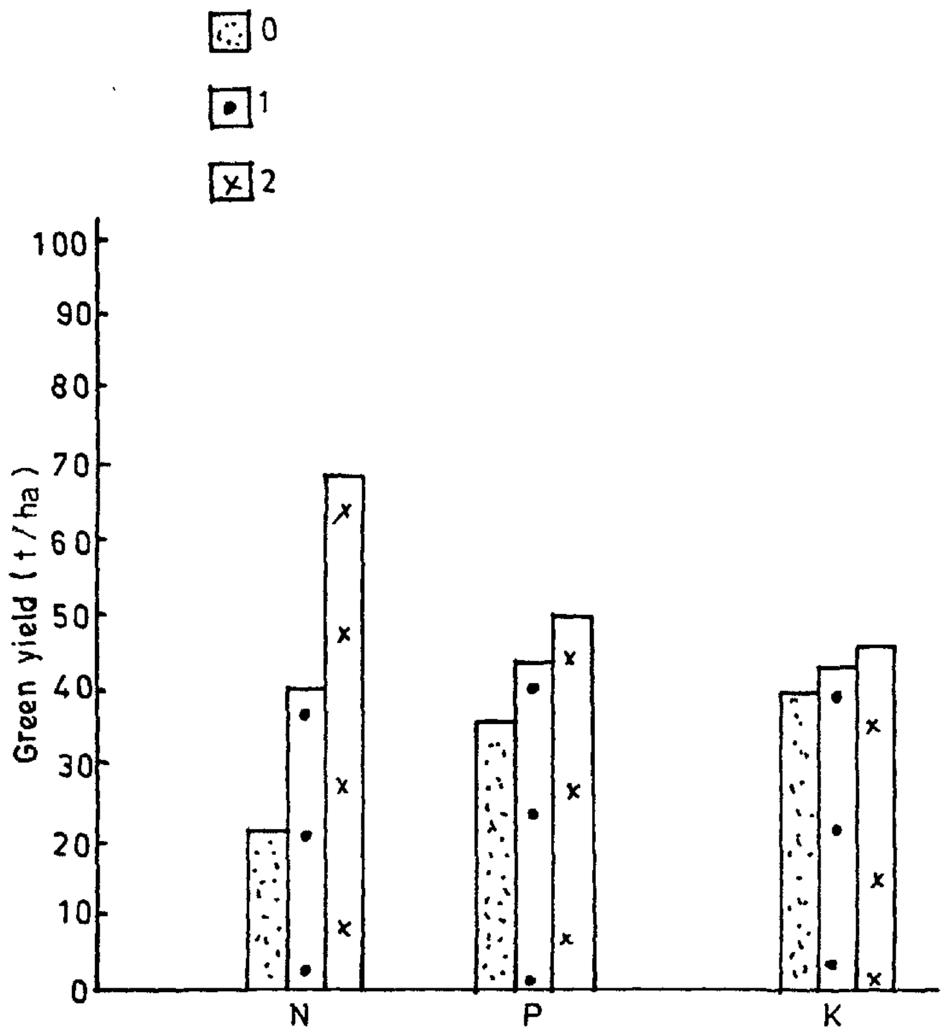

Fig.2. Cumulatives green yield (t/ha) of amaranthus as affected by N,P, K levels.

Almost similar results were also reported by Verma et al. (1969), Vergniand and Hugaet (1971), Bhore and Patil (1978) in spinach and by Purushothaman (1978), Ramachandra and Thimmaraju (1983), Keskar et al. (1983) and Singh et al. (1985) in amaranthus.

A trend, similar to that obtained with N level was also noticed with P levels. With increase in the P level, the cumulative yield of greens was also increased significantly. This indicated that P influenced profoundly the yield of leafy greens in amaranthus. Almost similar results were reported by Ramchandra (1978).

Regarding the application of potash, however, it was seen that yield of leafy greens of plants under K_2 level was at par with those under K_1 level, while the latter was at par with that of K_0 level. However, no such reports are available and hence this needs further confirmation.

The interaction effects between N, P and K were found to be statistically non-significant.

4.2.3 Thousand seed weight (mg)

The data pertaining to the weight of thousand seed have been presented in Table 13. The thousand seed weight was not significantly influenced by the various fertilizer combinations. Only nitrogen application significantly influenced this parameter while P and K applications proved to be non-significant.

Table 13. Effect of N, P and their interaction on weight of 1000-seeds (mg)

N/P	P_0	P_1	P_2	Mean
N_0	35.926	36.757	34.667	35.783
N_1	40.338	43.417	41.566	41.773
N2	43.399	46.831	51.586	47.272
Mean	39.887	42.335	42.606	

Effect of N, K and their interaction on weight of 1000 seeds (mg)

N/K	K_0	K_1	K_2	Mean
N_0	36.057	36.703	34.589	35.783
N_1	46.774	37.996	40.550	41.773
N_2	45.338	46.149	50.329	47.272
Mean	42.723	40.283	41.623	

Effect of P, K and their interaction on weight of 1000-seeds (mg)

P/K	K_0	K_1	K_2	Mean
P_0	42.756	36.748	40.159	39.887
P_1	43.958	41.008	42.039	42.335
P_2	41.456	43.092	43.270	42.606
Mean	42.723	40.283	41.623	

	S.E. $\pm$	C.D. at 5%
N	1.93	5.49
P	1.93	-
K	1.93	-
NP	3.34	-
NK	3.34	-
PK	3.34	-
NPK	5.80	-

In respect of nitrogen, the seeds under N_2 level registered the highest weight of 47.27 mg. It was significantly more than those registered by the seeds under rest of the N levels. The next in order of merit was N_1 followed by N_0. The letter (N_0) level registered the least weight of 35.78 mg. It showed that with increase in the N level, there was significant and progressive improvement in this parameter.

The application of P and K and the interaction effects between N, P and K were found to be statistically non-significant.

4.2.4 Seed yield per hectare (q/ha)

The data on seed yield in quintals per hectare recorded in Table 14 and Fig. 3, revealed that the seed yield were not significantly influenced due to various fertilizer combination treatments. But they were found to be significantly influenced only due to nitrogen application. The interaction effects between N, P and K also were not significant.

The N_2 level registered the maximum seed yield of 19.49 q/ha. It was significantly more than that registered under control (N_0) which registered the lowest seed yield of 12.52 quintals/ha. The seed yield under N_1 level was in between. However, it was interesting to note that with

Table 14. Effect of N, P and their interaction on seed yield/ha (q)

N/P	P_0	P_1	P_2	Mean
N_0	11.613	12.167	13.782	12.521
N_1	14.880	15.840	17.494	16.071
N_2	18.063	20.236	20.182	19.494
Mean	14.652	16.081	17.153	

Effect of N, K and their interaction on seed yield/ha (q)

N/K	K_0	K_1	K_2	Mean
N_0	12.646	13.532	11.384	12.521
N_1	16.979	16.707	14.529	16.071
N_2	18.913	20.066	19.502	19.494
Mean	16.179	16.768	15.139	

Effect of P, K and their interaction on seed yield/ha (q)

P/K	K_0	K_1	K_2	Mean
P_0	13.404	17.390	13.762	14.652
P_1	16.944	16.203	15.094	16.081
P_2	18.189	16.711	16.559	17.153
Mean	16.179	16.768	15.139	

	S.E.$\pm$	C.D.at 5%
N	1.23	3.5
P	1.23	-
K	1.23	-
NP	2.14	-
NK	2.14	-
PK	2.14	-
NPK	3.71	-

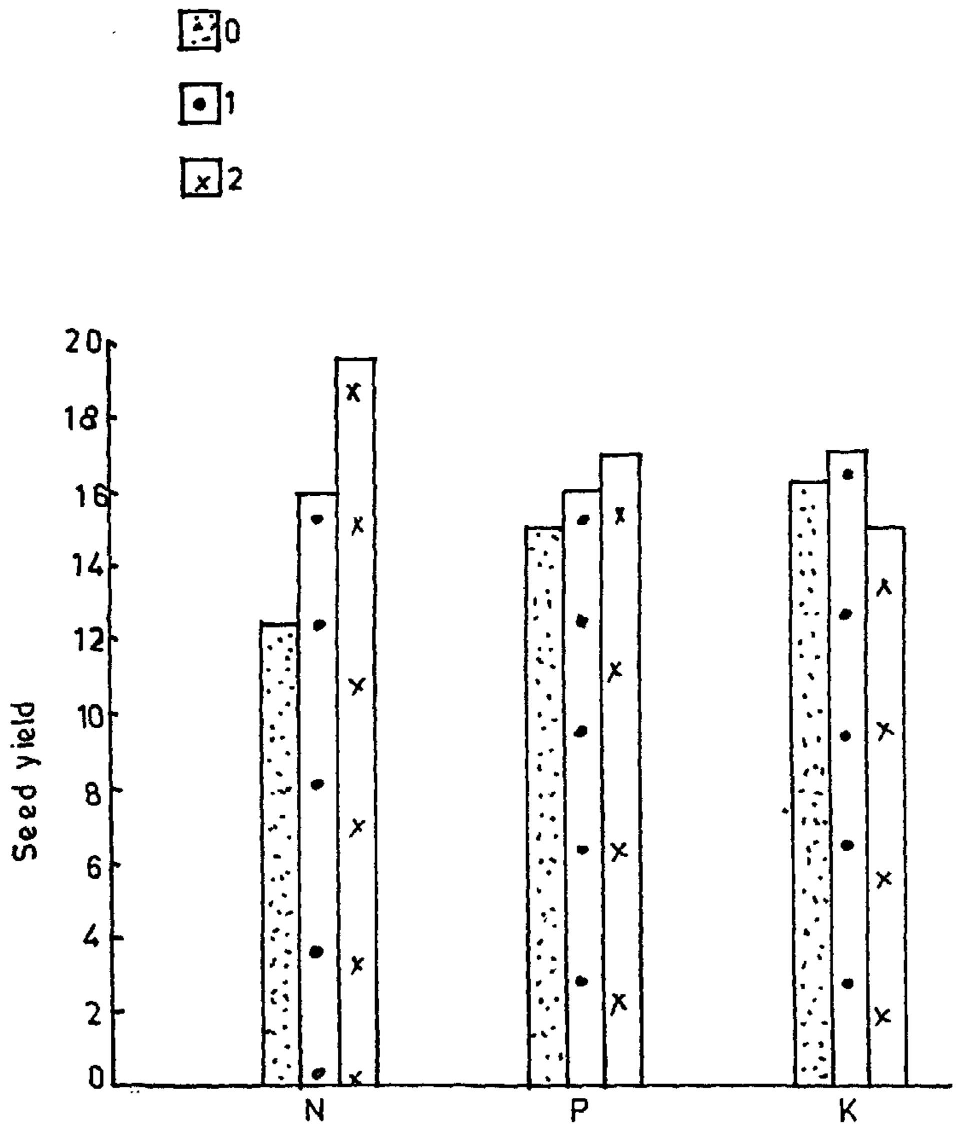

Fig.3.Seed yield of amaranthus as affected by N, P, K levels.

the increase in N dose there was significant and consistent increase in the seed yield of amaranthus per hectare. This indicated that nitrogen fertilizer profoundly influenced the seed yield of amaranthus cv. Lal Rajgira.

These results are more or less matching with those reported by Bressani et al. (1987) for grain yield of amaranthus. They reported seed yield of 1.77 to 2.67 tonnes/ha in *A. cruentus* from USA and 1.24 to 2.71 tonnes/ha in *A. caudatus* from Peru due to highest dose of nitrogen.

4.3 Effect of N, P and K on nutritive value of amaranthus greens

4.3.1 Physiological weight loss at 4th and 8th hrs after cutting

The data pertaining to the physiological weight losses have been presented in Table 15.

The data revealed that the physiological weight losses at the end of 4th and 8th hrs of cutting and at ambient temperature were statistically non-significant due to application of various fertilizer treatments. Probably 4 hours interval for recording weight losses in the greens like amaranthus may be a too long after recording initial weight of samples and as a result the treatment effects might have been masked. This however, therefore needs confirmation.

Table 15-a. Effect of N, P and their interaction on physiological weight losses after 4th hour (kg/g)

N/P	P_0	P_1	P_2	Mean
N_0	0.865	0.878	0.893	0.879
N_1	0.886	0.874	0.871	0.877
N_2	0.885	0.872	0.886	0.881
Mean	0.879	0.875	0.883	

Effect of N, K and their interaction on physiological weight losses after 4th hour (kg/g)

N/K	K_0	K_1	K_2	Mean
N0	0.858	0.895	0.882	0.879
N_1	0.872	0.879	0.880	0.877
N_2	0.874	0.903	0.865	0.881
Mean	0.868	0.892	0.876	

Effect of P, K and their interaction on physiological weight losses after 4th hour (kg/g)

P/K	K_0	K_1	K_2	Mean
P_0	0.852	0.889	0.895	0.879
P_1	0.876	0.881	0.867	0.875
P_2	0.877	0.907	0.865	0.883
Mean	0.868	0.892	0.876	

	S.E.±	C.D. at 5 %
N	0.009	N.S.
P	0.009	N.S.
K	0.009	N.S.
Np	0.015	N.S.
NK	0.015	N.S.
PK	0.015	N.S.
NPK	0.027	N.S.

Table 15-b. Effect of N, P and their interaction on physiological weight losses after 8 hours (kg/g)

N/P	P_0	P_1	P_2	Mean
N_0	0.789	0.807	0.822	0.806
N_1	0.816	0.807	0.817	0.814
N_2	0.827	0.788	0.843	0.819
Mean	0.811	0.801	0.827	

Effect of N, K and their interaction on physiological weight losses after 8 hours (kg/g)

N/K	K_0	K_1	K_2	Mean
N_0	0.802	0.797	0.818	0.806
N_1	0.830	0.813	0.797	0.814
N_2	0.798	0.855	0.805	0.819
Mean	0.810	0.822	0.807	

Effect of P, K and their interaction on physiological weight losses after 8 hrs (kg/g)

P/K	K_0	K_1	K_2	Mean
P_0	0.799	0.822	0.811	0.811
P_1	0.807	0.804	0.790	0.801
P_2	0.824	0.839	0.819	0.827
Mean	0.810	0.822	0.807	

	S.E.±	C.D. at 5 %
N	0.009	N.S.
P	0.009	N.S.
K	0.009	N.S.
NP	0.016	N.S.
NK	0.016	N.S.
PK	0.016	N.S.
NPK	0.028	N.S.

4.3.2 Nitrogen content of plant (%)

The data recorded in Table 16 and Fig. 4 in respect of nitrogen content, were found to be not significantly influenced by the various fertilizer treatments combinations. However, only N levels were found to have significantly influenced this particular parameter. Levels of P and K did not do so.

The plants under N_2 level (receiving 150 kg N/ha) registered the maximum N percentage of 3.11. It was significantly greater than that of control (N_0) and N_1 level also; all being significantly different from each other. However, it was worth noting that with increase in the dose of nitrogenous fertilizer applied, there was a consistent and progressive increase in N contents of plant tissue. This indicated that there was increased uptake of N by the plants under higher nitrogenous fertilizer dose and thereby there was higher tissue contents of N. The results reported in the present study are more or less similar with those obtained by Grubben (1974), who reported 4.44 per cent N in plants on dry weight basis as a result of application of highest rate (225 kg N/ha) of N application.

4.3.3 Phosphorus content

The data pertaining to the phosphorus content of amaranthus tissues have been presented in Table 17 and Fig. 5.

Table 16. Effect of N, P and their interaction on nitrogen content of plant (%) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	2.233	2.234	2.250	2.239
N_1	2.773	2.770	2.783	2.776
N_2	3.097	3.110	3.136	3.114
Mean	2.701	2.705	2.723	

Effect of N,K and their interaction on nitrogen content of plant (%)

N/K	K_0	K_1	K_2	Mean
N_0	2.237	2.237	2.244	2.239
N_1	2.773	2.777	2.777	2.776
N_2	3.110	3.103	3.129	3.114
Mean	2.707	2.706	2.717	

Effect of P, K and their interaction on nitrogen content of plant (%)

P/K	K_0	K_1	K_2	Mean
P_0	2.700	2.697	2.707	2.701
P_1	2.703	2.697	2.714	2.705
P_2	2.717	2.723	2.719	2.723
Mean	2.707	2.706	2.717	

	S.E.$\pm$	C.D.at 5 %
N	0.059	0.16
P	0.059	-
K	0.059	-
NP	0.103	-
NK	0.103	-
PK	0.103	-
NPK	0.178	-

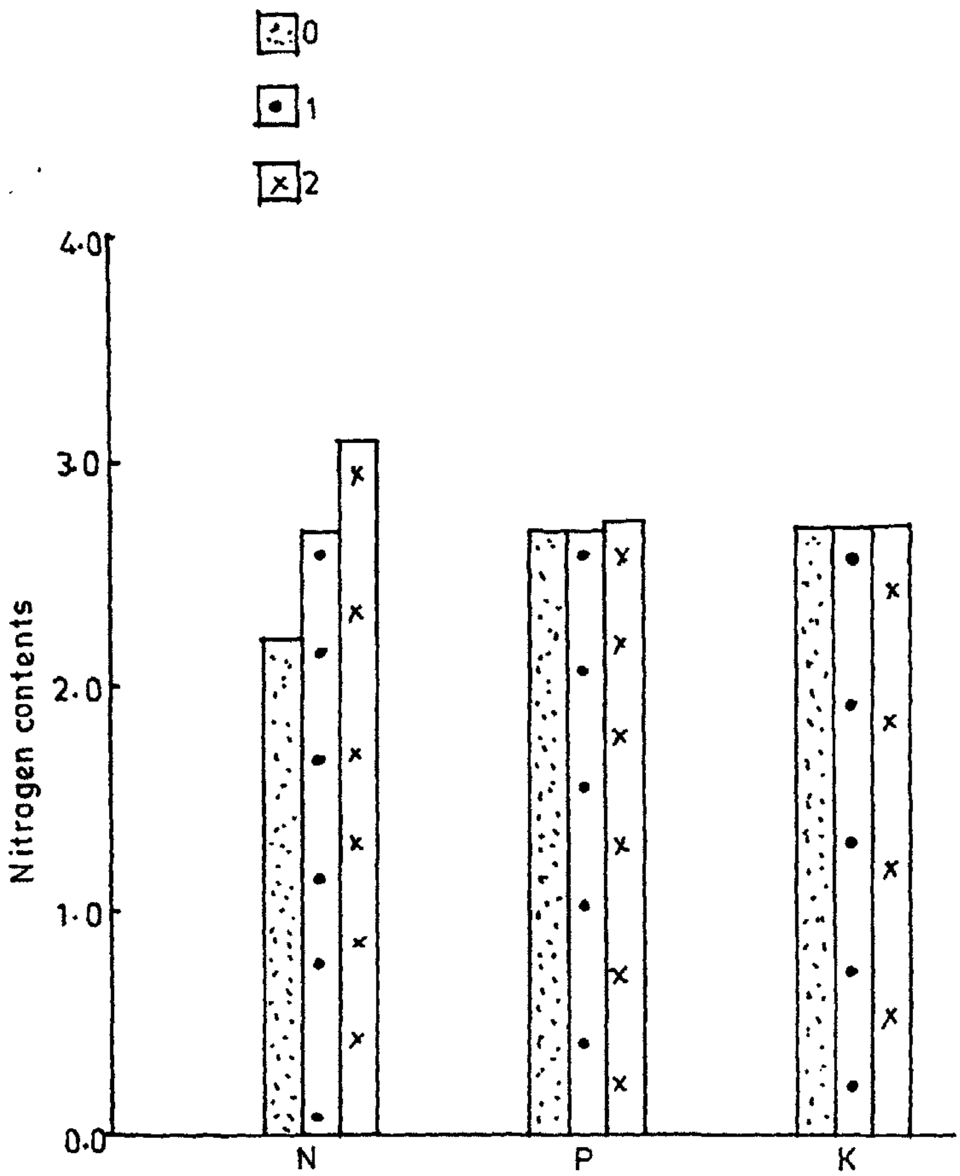

Fig.4. Nitrogen content of amaranthus tissue as affected by N,P,K levels.

Table 17. Effect of N, P and their interaction on phosphorus content of plant (%) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	0.150	0.198	0.319	0.222
N_1	0.251	0.307	0.362	0.307
N_2	0.313	0.377	0.469	0.386
Mean	0.238	0.294	0.383	

Effect of N, K and their interaction on phosphorus content of plant (%)

N/K	K_0	K_1	K_2	Mean
N_0	0.195	0.217	0.255	0.222
N_1	0.296	0.304	0.320	0.307
N_2	0.352	0.398	0.409	0.386
Mean	0.281	0.306	0.328	

Effect of P, K and their interaction on phosphorus content of plant (%)

P/K	K_0	K_1	K_2	Mean
P_0	0.227	0.231	0.256	0.238
P_1	0.267	0.292	0.322	0.294
P_2	0.349	0.395	0.406	0.383
Mean	0.281	0.306	0.328	

	S.E. $\pm$	C.D. at 5 %
N	0.011	0.032
P	0.011	0.032
K	0.011	0.032
NP	0.020	-
NK	0.020	-
PK	0.020	-
NPK	0.034	-

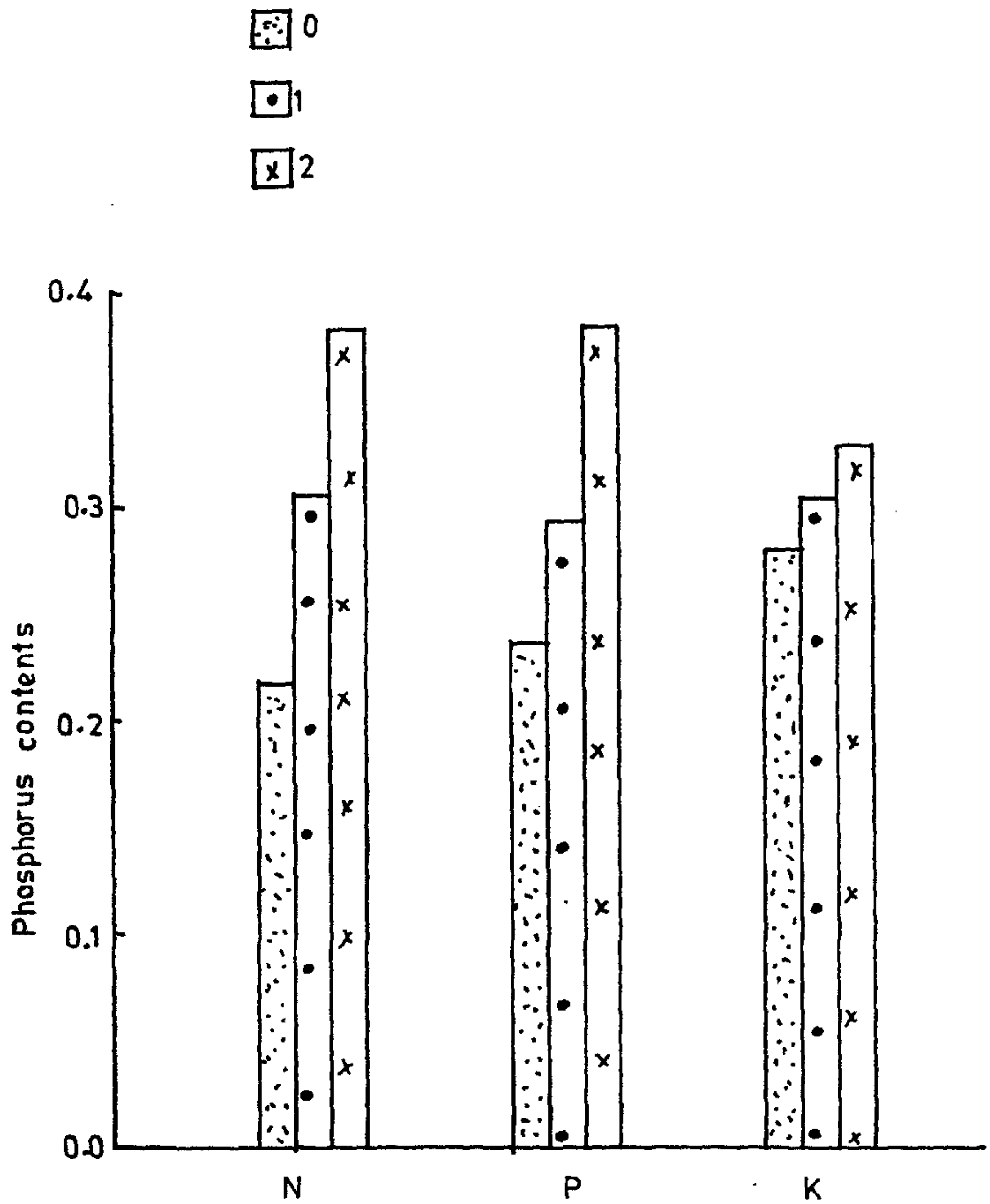

Fig.5. Phosphorus contents of amaranthus tissue as affected by N, P, K levels.

The data revealed that the phosphorus content was not significantly influenced by various fertilizer treatment combinations. However, the levels of all the three major fertilizer elements significantly influenced this parameter, their interaction effects, however, being non-significant.

The plants under N_2 level registered the highest phosphate content of 0.38 per cent. It was significantly higher than that registered under control (N_0) which recorded the lowest phosphate content of 0.22 per cent. The phosphate content of plants under N_1 level was in between. All were, however, significantly different from each other. It was worth noting that with increase in N levels, there was progressive and consistent increase in the phosphate content of the plant tissue. This could be attributed to the increased absorption of N and along with that of P. P was required to supply energy in terms of ATP and ADP and therefore the plant tissue might have showed higher content of P. These findings coroborate with those obtained by Kansel et al. (1981) who reported that the uptake of P, Fe, Mn, Zn and Cu in spinach was the highest in response to the highest rate of 30 kg N and 20 tonnes of FYM/ha.

A more or less similar trend was also noticed with P levels. This suggested that the phosphorus application ultimately improved the 'P' content of plant. Interestingly, there was consistent and progressive increase in P content of plant tissue with increase in P levels. This definitely indicated the profound influence of phosphate fertilizer application on the P content of plant tissue. These findings are more or less similar to those obtained by Stanilova et al. (1972) who reported that fertilization with N alone greatly increased the P and K contents in the plant tissue. This could also be attributed to the greater demand for energy in terms of ATP/ADP in the metabolic activity of the plant tissue.

Regarding the application of potash, the latter was found to influence this parameter. K_2 level (80 kg K/ha) was significantly superior to K_0 level, but it was at par with K_1 level. Also K_1 and K_0 levels were at par with each other.

In general, however, there was progressive increase in the P content of plant tissue with increase in the K levels in the fertilization. This certainly indicated a significant influence of K on this parameter.

The results are coinciding with those obtained by Grubben (1974) who reported increased level of P in plant tissue with increased level of ground application of K fertilizers.

4.3.4 Potash content of [redacted] plant (%)

The potash contents of plant tissues recorded in Table 18 and Fig. 6 were found to be not significantly influenced by the various fertilizer treatment combinations. However, the levels of the three major fertilizer elements, namely, NP and NK were found to influence this parameter significantly. The interaction effects, namely, PK and NPK were non-significant.

The plants under N_2 level registered the highest K content of 2.90 per cent. It was significantly higher than that registered under control (N_0)which recorded the lowest K content of 2.46 per cent. The K content of plants under N_1 was in between. But all were significantly different from each other. It was, however, seen that there was progressive and consistent increase in the K content of plant tissue with the increase in the level of N application. This definitely suggested that the N application significantly influenced this parameter. These findings are more or less in line with those obtained by Grubben (1974) who reported 3.59 per cent K in plant tissue as a result of highest rate of K fertilizer application.

Regarding application of phosphorus, it was seen that the plants under P_1 level registered the highest level of K in plant tissue (2.73 %). It was significantly

Table 18. Effect of N, P and their interaction on potash content of plant (%) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	2.242	2.603	2.540	2.462
N_1	2.622	2.630	2.772	2.641
N_2	2.793	3.063	2.843	2.900
Mean	2.553	2.732	2.719	

Effect of N, K and their interaction on potash content of plant (%)

N/K	K_0	K_1	K_2	Mean
N_0	1.733	2.247	3.406	2.462
N_1	1.663	2.656	3.606	2.641
N_2	2.057	3.080	3.563	2.900
Mean	1.818	2.661	3.525	

Effect of P, K and their interaction on potash content of plant (%)

P/K	K_0	K_1	K_2	Mean
P_0	1.697	2.526	3.436	2.553
P_1	1.793	2.840	3.563	2.732
P_2	1.963	2.617	3.576	2.719
Mean	1.818	2.661	3.525	

	S.E.±	C.D. at 5 %
N	0.043	0.12
P	0.043	0.12
K	0.043	0.12
NP	0.075	0.21
NK	0.075	0.21
PK	0.075	-
NPK	0.131	-

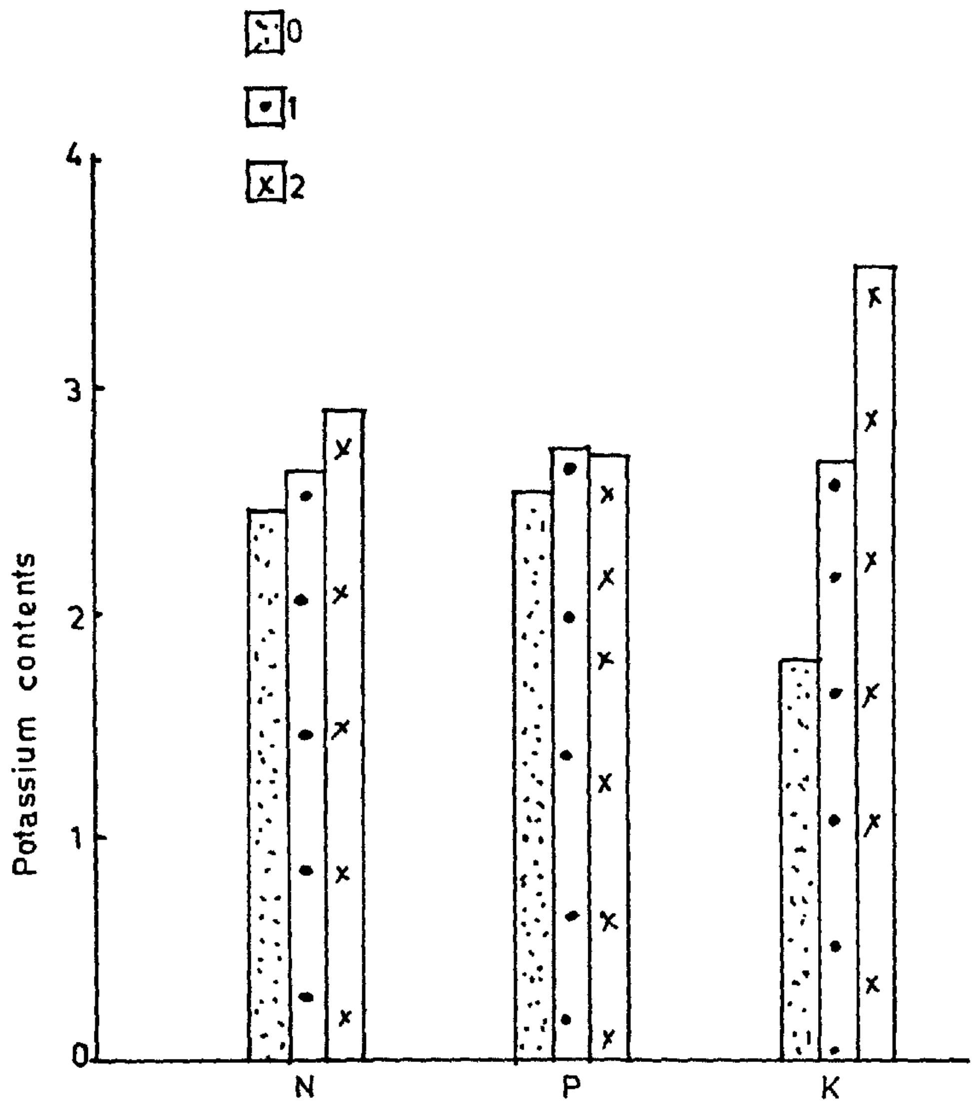

Fig. 6. Potassium contents of amaranthus tissue as affected by N, P, K levels.

higher than that registered under control (P_0) which registered the lowest K content of 2.55 per cent. The plants under P_2 were in between and at par with that of P_1. It was, however, noticed that with increase in the level of phosphate fertilizer, there was progressive increase in the K content of plant tissue, indicating significant influence of the former on the latter.

These findings are more or less in line with those obtained by Stanilova et al. (1972) who reported that the fertilization with P alone increased the P and K content of the plant tissues.

A trend similar to that obtained with N level was also noticed with application of K levels. The plants under K_2 level (receiving 80 kg/ha) registered the highest potash content of 3.52 per cent. It was significantly more than that of K_0 (control) which recorded the lowest K content of 1.81 per cent in plant tissue. The plants under K_1 were in between. But all were significantly different from each other. Further, it was noticed that with increase in the level of potassic fertilizer application, there was progressive increase in the K content of plant tissues, indicating significant influence of the former on the latter. These findings are almost in line with those obtained by Grubben (1974) who reported on dry weight basis that both leaves and stems of

Amaranthus hybrids contained 4.44 per cent N, 0.43 per cent P and 3.59 per cent K. In a chemical fertilizer trial, he obtained good results with the application of fertilizer mixture @ 400-800 kg/ha, containing N, P, K in the ratio of 10:10:20.

The present investigation for potash content of the Amaranthus shows very good response for N, P and K application and interaction of N with P and K. The higher doses of N, P, K showed significant increase in the potash content of the amaranthus and also higher N doses in combination with P and K. These results clearly suggest that to have higher potash percentage in an amaranthus plant should apply nitrogenous fertilizer in combination with P and K i.e. as NP and NK.

4.3.5 Crude protein content of plant (%)

The crude protein contents of plants, recorded in Table 19 and Fig. 7, were found to be not significantly influenced due to various fertilizer treatment combinations under study. However, only N levels were found to influence this parameter significantly. The levels of P and K, however, did not show such influence on this parameter.

The plants under N_2 level registered the highest crude protein content of 19.31 per cent. It was significantly higher than those registered under control (N_0)

Table 19. Effect of N, P and their interaction on crude protein content of plant (%) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	13.956	13.962	14.061	13.993
N_1	17.331	17.310	17.396	17.346
N_2	18.908	19.437	19.597	19.314
Mean	16.731	16.903	17.018	

Effect of N, K and their interaction on crude protein content of plant (%)

N/K	K_0	K_1	K_2	Mean
N_0	13.976	13.977	14.027	13.993
N_1	17.330	17.353	17.353	17.346
N_2	19.217	19.170	19.554	19.314
Mean	16.841	16.833	16.978	

Effect of P, K and their interaction on crude protein content of plant (%)

P/K	K_0	K_1	K_2	Mean
P_0	16.651	16.629	16.914	16.731
P_1	16.894	16.850	16.964	16.903
P_2	16.977	17.021	17.056	17.018
Mean	16.841	16.833	16.978	

	S.E.$\pm$	C.D.at 5 %
N	0.35	1.01
P	0.35	-
K	0.35	-
NP	0.61	-
NK	0.61	-
PK	0.61	-
NPK	1.07	-

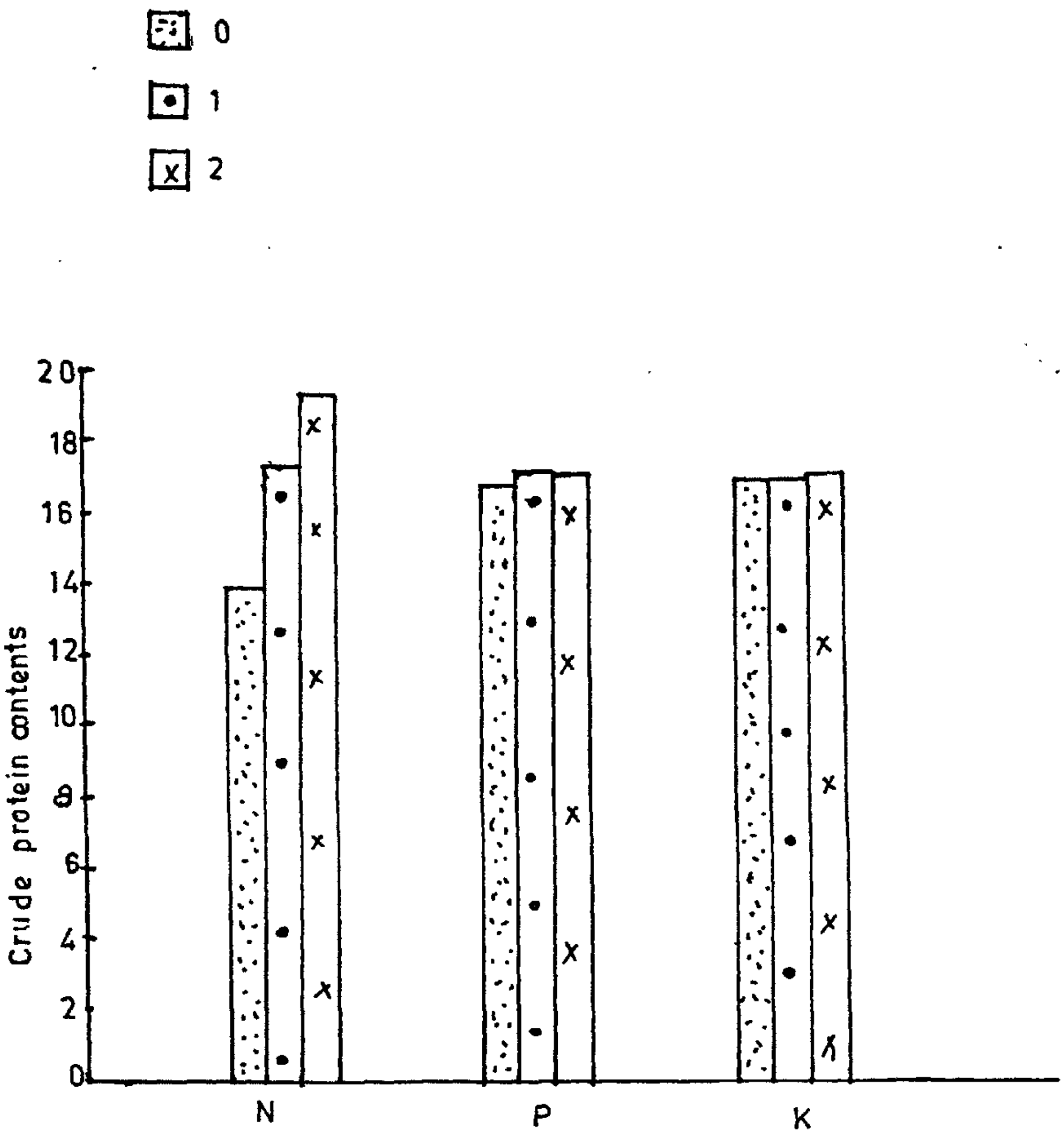

Fig.7. Crude protein content of amaranthus tissue as affected by N,P, K levels.

which recorded the lowest value of 13.99 per cent. The crude protein content of plants under N_1 level was in between and significantly different from rest of the treatments. It was, however, worth noting that with increase in the level of nitrogenous fertilizer applied, there was consistent and significantly increased level of crude protein in the plant tissues. This indicated that the absorption of N was more with increased rate of application. This increased nitrogen may have been metabolised in the production of increased crude protein in the plant tissue.

The results reported in present study are coinciding with those obtained earlier by Lexander et al. (1970), Stafford et al. (1976), Subbiah and Ramanathan (1982).

The doses of P, K and their interactions with N were non-significant.

4.3.6 Crude fibre content of plant (%)

The crude fibre contents recorded in Table 20 and Fig. 8, were not found to significantly influenced by the various fertilizer treatment combinations. However, levels of N, P and K significantly influenced this parameter; their interactions, however, being non-significant.

The plants under N_2 level registered the 21.33 per cent crude fibre. It was the highest of all and

Table 20. Effect of N, P and their interaction on crude fibre content of plant (%) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	16.923	17.620	17.783	17.442
N_1	18.813	19.373	20.000	19.396
N_2	20.747	21.220	22.031	21.333
Mean	18.828	19.404	19.938	

Effect of N, K and their interaction on crude fibre content of plant (%)

N/K	K_0	K_1	K_2	Mean
N_0	16.917	17.660	17.750	17.442
N_1	19.203	19.260	19.723	19.396
N_2	21.113	21.227	21.658	21.333
Mean	19.078	19.382	19.710	

Effect of P, K and their interaction on crude fibre content of plant (%)

P/K	K_0	K_1	K_2	Mean
P_0	18.517	18.900	19.067	18.828
P_1	19.083	19.380	19.750	19.404
P_2	19.633	19.867	20.314	19.938
Mean	19.078	19.382	19.710	

	S.E.$\pm$	C.D.at 5%
N	0.101	0.28
P	0.101	0.28
K	0.101	0.28
NP	0.175	NS
NK	0.175	NS
PK	0.175	NS
NPK	0.303	NS

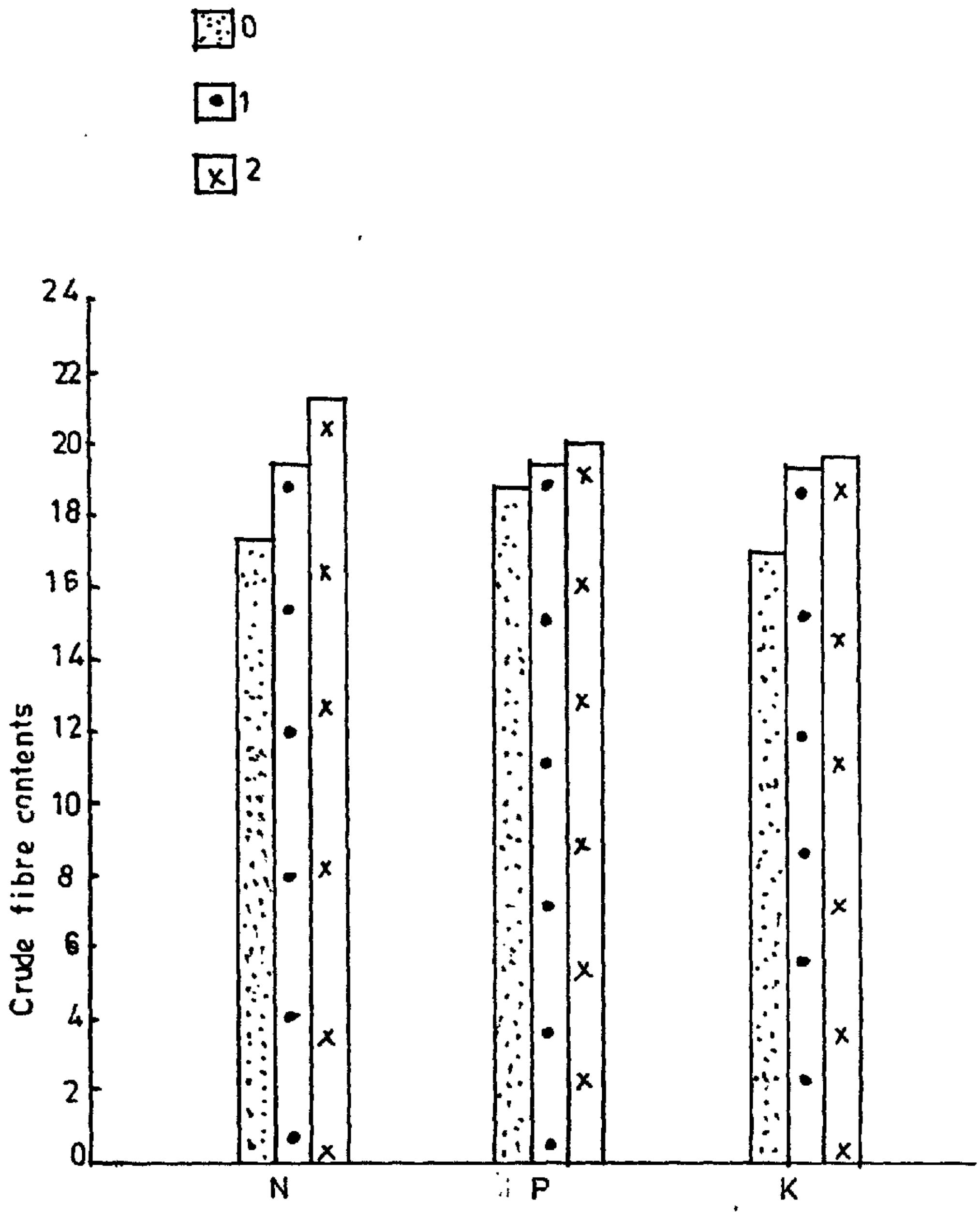

Fig.8. Crude fibre contents of amaranthus tissue as affected by N,P,K levels.

significantly higher than that registered under control (N_0) which registered the lowest percentage of crude fibre content (17.44 %), the latter recorded under N_1 level being in between.

The levels of P and K showed almost similar trend in crude fibre content of the plant tissues. It was further interesting to note that the increase in the crude fibre content was significant and progressive with increase in the levels of N, P and K. This suggested that all the three major nutrients had profoundly influenced this parameter.

The results obtained due to N application in the present study are almost in line with those reported by Ramchandera and Thimmaraju (1985) in Amaranthus genetics (tricolor) and contradicting with those reported by Singh et al. (1985) in respect of crude fibre content of Amaranthus. Ramchandra and Thimmaraju (1985) reported that the response of plants to N in this respect was more marked than that to P. This holds good also with the present investigation.

4.3.7 Iron content of plant (mg/100 g)

The data pertaining to the iron content of amaranthus have been presented in Table 21 and Fig. 9. The data revealed that the iron content was significantly influenced by various fertilizer elements and their combinations.

Table 21. Effect of N, P and their interaction on iron content of plant (mg/100 g) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	35.900	36.213	36.777	36.297
N_1	37.657	39.180	40.347	39.062
N_2	41.640	42.127	48.480	44.082
Mean	38.399	39.173	41.868	

Effect of N, K and their interaction on iron content of plant (mg/100 g)

N/K	K_0	K1	K_2	Mean
N_0	36.117	36.270	36.503	36.297
N_1	38.523	39.293	39.367	39.061
N_2	43.853	43.967	44.427	44.082
Mean	39.498	39.843	40.093	

Effect of P, K and their interaction on iron content of plant (mg/100 g)

P/K	K_0	K_1	K_2	Mean
P_0	38.157	38.374	38.567	38.399
P_1	38.790	39.197	39.533	39.173
P_2	41.547	41.860	42.197	41.868
Mean	39.498	39.843	40.099	

	S.E.$\pm$	C.D.at 5 %
N	0.12	0.34
P	0.12	0.34
K	0.12	0.34
NP	0.21	0.59
NK	0.21	-
PK	0.21	-
NPK	0.36	-

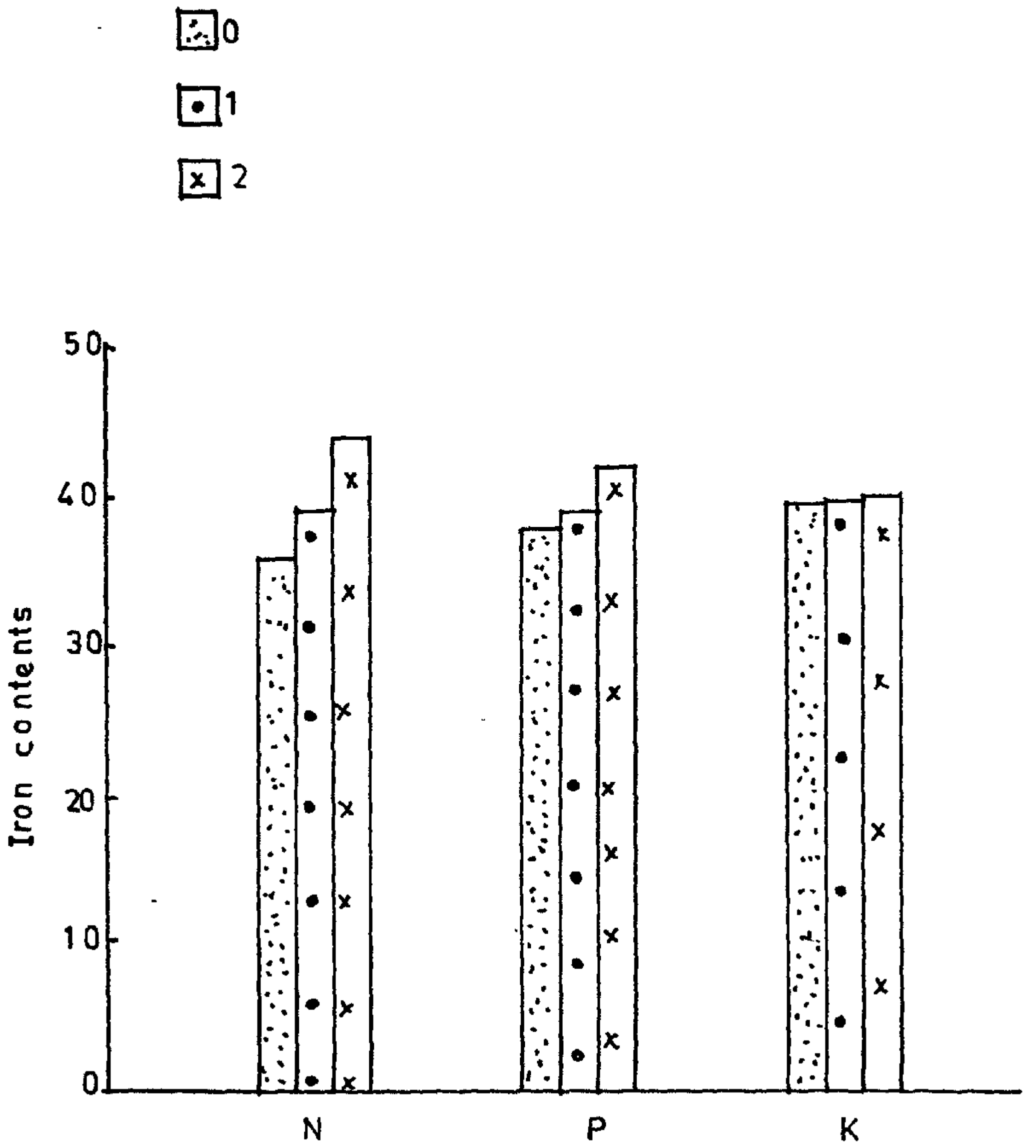

Fig.9. Iron contents of amaranthus tissue as affected by N,P, K levels.

It was seen that the nitrogen had significantly affected the iron content of plant tissue. The plants under N_2 (receiving 150 kg N/ha) level registered the highest iron content (44.08 mg/100 g). It was significantly more than those registered by the plants under rest of the N levels including N_0 (Control) which recorded the least iron content of 36.29 mg/100 g. The iron content of plants under N_1 was in between, but significantly higher than control and significantly less than N_2 level. It was interesting to note that there was progressive increase in the iron content with increase in the N level of soil application. This definitely indicated that N significantly contributed in increasing the iron contents of amaranthus and thereby improving its nutritive quality. It also indicated that there was more demand for iron and indirectly it was made available by supplying nitrogen to the soil.

These findings are in line with those reported by Stafford et al. (1976), Kansel et al. (1981) and Ramchandra and Thimmaraju (1985).

Almost similar trend was also noticed with P levels. The plants under P_2 level registered the highest iron content of 41.86 mg/100 g. It was significantly more than those registered by the plants under rest of the P levels including the P_0 level (control) which recorded the least iron content of 38.39 mg/100 g. The iron content of plants under P_1 was in between but significantly higher than control and significantly less than that under P_2. It was similarly interesting to note that the iron content was increased progressively with increase in the level of P application. It also indicated that there was more demand for iron and it was indirectly made available to plants by supplying higher phosphatic fertilizer to the soil. These findings are similar to those obtained by Ramachandra and Thimmaraju (1985) who reported that in A. gangeticus the iron content of plant tissue was increased by addition of N from 50 to 200 kg/ha and P from 50 to 100 kg; the response to P application being relatively rather less. This confirms that application of phosphorus increases iron content of amaranthus plant tissues and thereby improves its nutritive quality.

Regarding the application of potassium also a more or less similar trend was noticed. The iron content of plants under K_2 level registered the highest iron content of 40.09 mg/100 g of dry sample. It was significantly higher than that registered by the plants under K_0 level (control) which registered the lowest iron content of 39.49 mg/100 g. The iron content of plant under K_1 level, however, was in between and at par with K_2 level.

It was similarly interesting to note that there was progressive increase with increase in K application to soil.

However, there are no reports to show that with increase in K application to soil there is increase of iron in the plant tissue. This therefore, needs further confirmation.

These results suggested that all N, P and K applications significantly improved the iron content of amaranthus.

The interaction of nitrogen with phosphorus was significant which indicated that combination of NP increases the Fe content of the amaranthus. It was worth noting that a combination of N_2P_2 registered the highest Fe content of 48.48 mg/100 g of dry sample. It was significantly higher than that registered under N_1P_1 combination which was also significantly higher than that of N_0P_0 combination. This definitely indicated that there was synergestic effect on iron content of plant tissue in the presence of both N and P elements. Other interactions i.e. NK, PK and NPK were non-significant, indicating that there was no influence of treatment combinations onthe Fe content.

4.3.8 Vitamin-A content of plant (mg/100 g)

The data pertaining to the vitamin A content of amaranthus have been presented in Table 22 and Fig. 10. The data revealed that the vitamin A content was significantly influenced by various fertilizer treatment.

Table 22. Effect of N, P and their interaction on vitamin A content of plant (mg/100 g) at 2nd cutting

N/P	P_0	P_1	P_2	Mean
N_0	9.150	9.807	10.226	9.727
N_1	10.337	10.440	10.580	10.452
N_2	10.799	10.873	11.453	11.042
Mean	10.095	10.373	10.753	

Effect of N, K and their interaction on vit. A content of plant (mg/100 g)

N/K	K_0	K_1	K_2	Mean
N_0	9.460	9.840	9.882	9.727
N_1	10.353	10.487	10.517	10.452
N_2	10.862	11.097	11.167	11.042
Mean	10.225	10.474	10.522	

Effect of P, K and their interaction on Vit. A content of plant (mg/100 g)

P/K	K_0	K_1	K_2	Mean
P_0	9.972	10.123	10.190	10.095
P_1	10.087	10.490	10.543	10.373
P_2	10.617	10.810	10.832	10.753
Mean	10.225	10.474	10.522	

	S.E.$\pm$	C.D. at 5 %
N	0.067	0.19
P	0.067	0.19
K	0.067	0.19
NP	0.116	0.33
NK	0.116	-
PK	0.116	-
NPK	0.201	-

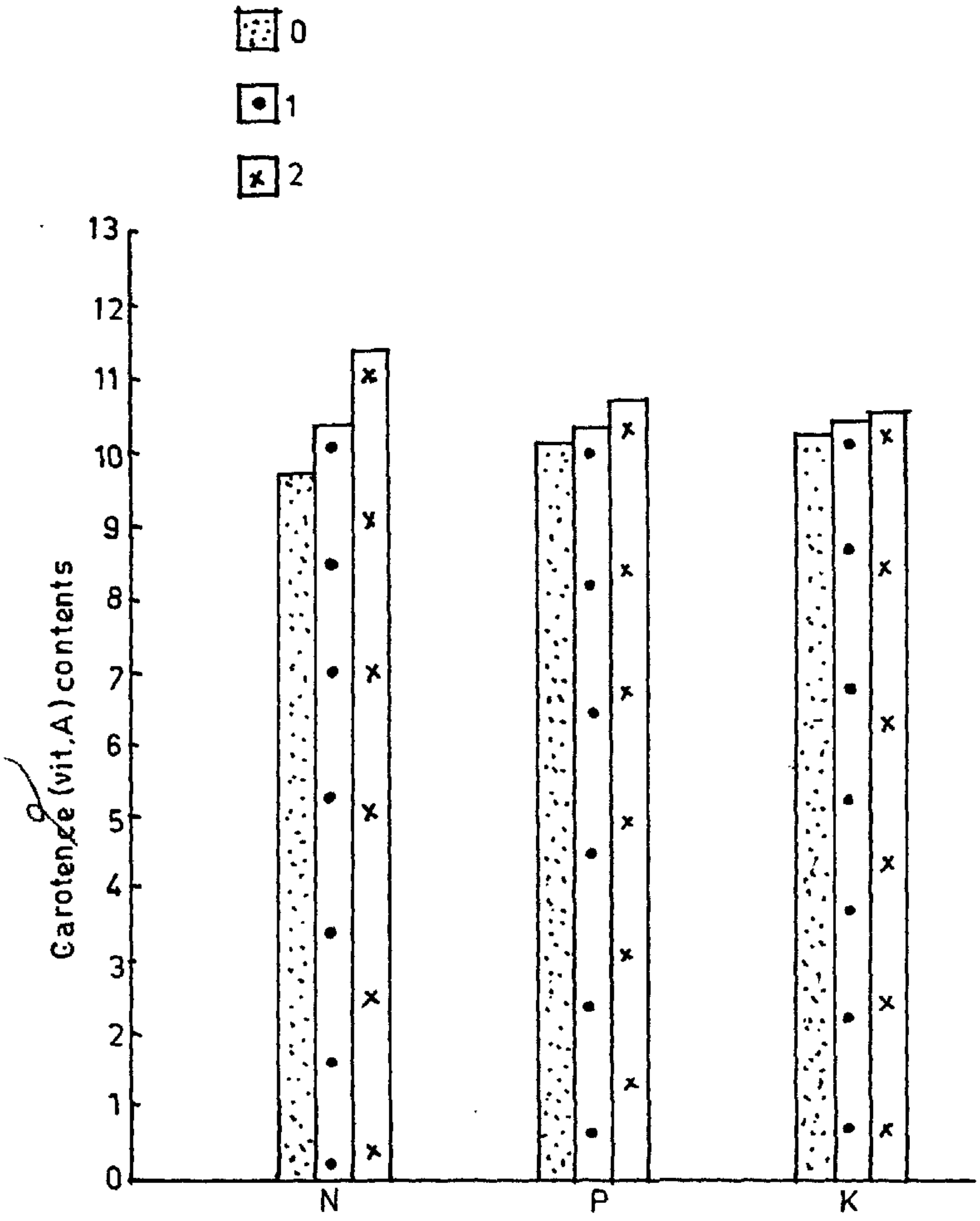

Fig.10. Carotene (vit. A) contents of amaranthus tissue as affected by N,P, K levels.

It was seen that the nitrogen had significantly affected the vitamin A content of plants. The plants under N_2 level registered the highest vitamin A content of 11.04 mg/100 g. It was significantly more than those registered under rest of the N levels. The N_0 level recorded the least vitamin A content of 9.72 mg/100 g. The vitamin A content of plants under N_1 was in between but significantly higher than N_0 and less than N_2 level. It was, however, seen that there was progressive increase in vitamin A content with increase in the N application to soil. This definitely indicated the significant influence of N on increasing the vitamin A content of amaranthus plants and thereby improving their nutritive quality. Almost similar results were obtained by Ramachandra (1978) and Subbiah and Ramanathan (1982) who reported increased carotene content of amaranthus plants as a result of application of highest dose of N application.

A trend similar to that obtained with N levels was also noticed with P levels. The plants under P_2 level registered the highest vitamin A content of 10.75 mg/100 g. It was significantly more than those recorded under rest of the P levels. The P_0 level (control) recorded the least carotene content of 10.09 mg100 g. The carotene content of plants under N_1 was in between but significantly higher than N_0 and less than N_2 level. But there was progressive increase in this parameter with increase in the N application to the soil. This was indicative of significant influence of N application on the carotene content of amaranthus plants. However, there are no reports of such findings and therefore they need further confirmation.

Regarding the application of potassium, it was seen that the plants under K_2 level registered the highest carotene content of 10.52 mg/100 g. It was significantly higher than that recorded under K_0 (control). The carotene content of plants under K_1 level was in between. It was however, significantly higher than K_0 but at par with that of K_2 level. But there was progressive increase in the carotene content with increase in the K application to the soil. This indicated significant influence of K application to soil in increasing the level of this parameter and thereby improving the nutritive quality of amaranthus. However, in absence of such reports, these findings need further confirmation.

The interaction of nitrogen with phosphorus was significant, which indicated that combination of N and P increases the carotene content of amaranthus. It was worth noting that a combination of N_2P_2 registered the highest carotene content of 11.45 mg/100 g. It was significantly higher than that registered under N_1P_1 combination. The carotene content of plants under N_1P_1 combination also was significantly higher than N_0P_0 combination. This definitely indicated that there was synergestic effect on carotene content of amaranthus plant tissues in presence of both N and P elements. Other interactions i.e. NK, PK and NPK were non-significant.

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Summary and Conclusions

5. SUMMARY AND CONCLUSION

The studies in to the effects of graded levels of nitrogen, phosphorus and potassium on growth and yield characters of amaranthus were carried out, during summer season of 1986-87 at the Instructional-cum-Research Orchard of Department of Horticulture, Mahatma Phule Agricultural University, Rahuri, with a view to find out the optimum dose of fertilizers for amaranthus under Rahuri conditions.

The fertilizer treatments consisted of three levels (0, 75, 150 kg) of nitrogen, three levels (0, 40, 80 kg) each of phosphorus and potassium per hectare. There were, thus, 27 treatment combinations replicated thrice in a factorial randomised block design.

5.1 Growth parameters

5.1.1 The plant height was not significantly influenced by various fertilizer treatments under study.

5.1.2 The number of branches produced per plant were significantly influenced by various fertilizer treatments. The most effective was the N followed by P. K was almost ineffective.

5.1.3 Number of leaves produced per plant due to N applications were the highest of all at the time of 2nd, 3rd, 4th and 5th cutting. It was followed by P applications. Applications of K fertilizer were just slightly effective.

5.1.4 The weight of leaves at the 2nd and 4th cutting was significantly increased due to application of nitrogen followed by P application. Application of K was just slightly effective.

5.1.5 Both N and P applications significantly increased the fresh weight of stems. K application did not do so.

5.1.6 Dry matter content per plant was significantly increased by N, P and K applications.

5.1.7 Average leaf size (area) was significantly increased by all the fertilizers under study.

5.2 Effect of N, P and K with different levels on the yield

5.2.1 The yield of leafy greens at each cutting was significantly increased due to N application followed by P and K applications. This held good also for the cumulative yield for 5 cuttings.

5.2.2 With increase in the N level there was significant and progressive increase in thousand seed weight. The addition of P and K at different levels did not affect this parameter.

5.2.3 The application of N significantly increased the seed yield per hectare. Applications of P and K were ineffective in this respect.

5.3 Effect of N, P and K on nutritive value of amaranthus greens

5.3.1 Physiological weight losses of freshly harvested leafy greens at ambient temperature at 4th and 8th hour after harvesting were not significant although they had received differential fertilizer treatments.

5.3.2 Nitrogenous fertilizer application significantly increased the nitrogen content of plant tissue. P and K applications did not do so.

5.3.3 The application of N, P and K at different levels significantly increased the phosphorus and potash contents of plants.

5.3.4 Application of nitrogen alone significantly increased the ~~true~~ Crude protein content of plant tissue. Applications of P and K failed to show this effect.

5.3.5 Crude fibre content of plant was found to be significantly influenced by N, P and K fertilizer applications.

5.3.6 The iron and carotene contents of plants were significantly increased by the addition of N, P and K at different levels.

Thus, overall assessment of the results indicated that both N and P increased the yield contributing characters of Amaranthus, namely number of branches, number of leaves, weight of leaves and stems. K also similarly contributed to increase in the leaf size and yield of leafy greens. All these fertilizers significantly improved nutritive quality of Amaranthus vegetable by increasing its contents of crude protein, crude fibre, carotene, iron, phosphorus and potassium. Besides, nitrogen alone significantly improved the yield and quality of seeds.

The above results indicated that the major nutrients namely N, P and K should be applied together. The higher doses of fertilizers showed significant improvement both in yield as well as quality of leafy greens and seeds. Studies indicated that still higher doses of N fertilizers may be tried to explore yield and quality potentials of this important leafy vegetable.

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Vita

7. VITA

NAVALNATH LAXMANRAO TAMBE

A Candidate for the Degree of
MASTER OF SCIENCE
(AGRICULTURE)

Title of Thesis	:	Effect of graded level of N, P and K on the growth and yield of Amaranthus Cv. Lal Rajgira
Major field	:	HORTICULTURE
Personal data	:	Born on 3rd September, 1963 at Nashik, Dist. Nashik, Son of Shri Laxmanrao Rambhau Tambe.
Educational	:	Attended Primary and Secondary education at Swami Vivekanand Vidyalaya, Nashik and Higher Secondary at K.T.H.M. College, Nashik. Received Bachelor's degree in Agriculture from College of Agriculture, Pune.