

**STUDIES ON LEAF NUTRIENT STATUS IN RELATION TO
DIFFERENT PERIOD AND POSITION IN AONLA
(*Emblica officinalis* Gaertn) CULTIVAR GUJARAT AONLA-1**

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OF
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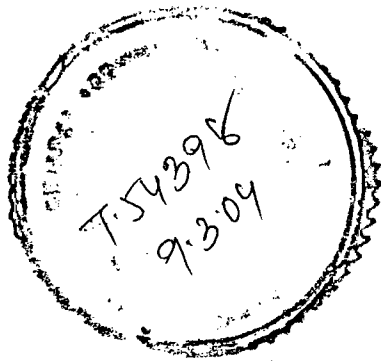
**IN
HORTICULTURE**

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2002

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*DEAR
PARENTS
TODAY
I AM VERY HAPPY
TO BE
AT YOUR
EXPECTATIONS*

Abstract

**STUDIES ON LEAF NUTRIENT STATUS IN RELATION TO DIFFERENT
PERIOD AND POSITION IN AONLA (*Emblica officinalis*, Gaertn)
Cultivar Gujarat Aonla-1**

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ABSTRACT

The investigation on “Studies on leaf nutrient status in relation to different period and position in aonla (*Emblica officinalis*, Gaertn) Cultivar “Gujarat Aonla-1” was carried out at Horticultural Research Farm, B.A.College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand during the year 2000-2001. Leaf was chosen as an index tissue and it was collected from five different position of shoot at bimonthly interval starting from June, 2000 to April, 2001 and leaf samples were analyzed for the nitrogen, phosphorus, potassium, calcium and magnesium content on dry weight basis. The experimental trees received uniform cultural practices but manures and fertilizers each at two levels before on set of monsoon. Vegetative growth and yield were also recorded for different 16 treatment combinations.

Significantly highest leaf level of nitrogen content (3.09 per cent) was found in treatment combination $N_2P_1K_1F_1$ (i.e. 1500 g N + 750 g P + 750 g K + 100 kg FYM/tree) in the month of August when leaf samples were collected from the top portion of the indeterminate branch from middle position of tree and it was lowest (0.08 per cent) in treatment $N_1P_0K_0F_0$ (i.e. 1000 g N + 0 g P + 0 g K + 0 kg FYM/tree) in the month of February at the basal position.

• Treatment $N_2P_1K_1F_1$ recorded significantly higher leaf level of phosphorus content (1.32 per cent) in the month of August at basal position while, it was lowest in the treatment $N_1P_0K_1F_0$ (0.03 per cent) in the month of February at top position.

Leaf level of potassium content was significantly highest (1.41 per cent) in treatment $N_2P_1K_1F_1$ in the month of June when leaf samples were collected from top portion of indeterminate branch from middle portion of the tree and it was lowest (0.10 per cent) in treatment combination $N_1P_1K_0F_0$ in the month of August at basal position.

An interaction between treatment, period and position for leaf level of calcium content was found to be significant and it was recorded maximum (1.54 per cent) in treatment combination $N_2P_1K_1F_1$ in the month of October at basal position and minimum (0.30 per cent) in $N_1P_0K_0F_0$ treatment in the month of June at top position.

Significantly highest (1.32 per cent) leaf level of magnesium content was recorded in treatment $N_2P_1K_1F_1$ in the month of August at basal position, while it was lowest (0.07 per cent) with treatment combination $N_1P_0K_0F_0$ in the month of June at top position.

Significant effect of different treatments were found on plant spread (East-west), stem girth, number of fruits/tree and fruit yield (kg/tree). Fruit yield was found highest in treatment $N_2P_1K_1F_1$ and it was lowest in treatment $N_1P_1K_0F_0$.

The fruit yield (kg/tree) was significantly and positively correlated with number of fruits per tree, leaf level of N, P, K, Ca and Mg in different periods. More or less same trend was observed between number of fruits per tree with the said nutrient. There was significant and positive relationship between different leaf nutrients content and different periods.

Despite the marked fluctuation of leaf nutrients throughout the year, stability period for nitrogen, phosphorus and magnesium were noted in the month of August to October; potassium in June to August and calcium in October to December. All these nutrients were found stabilized at middle position of indeterminate branch when samples were collected from middle position of tree. To assess nitrogen, phosphorus, potassium, calcium and magnesium status of aonla tree leaf sample should be collected from middle position of the tree during their respective stabilize period. Besides these, aonla trees requires to be applied N, P, and K alongwith FYM for higher yield.

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C E R T I F I C A T E

This is to certify that the thesis entitled "STUDIES ON LEAF NUTRIENT STATUS IN RELATION TO DIFFERENT PERIOD AND POSITION IN AONLA (*Emblica officinalis* Gaertn) CULTIVAR GUJARAT AONLA-1" submitted by MAYANKKUMAR A. PARMAR in partial fulfilment of the requirements for the award of the degree of DOCTOR OF PHILOSOPHY in the subject of HORTICULTURE of the Gujarat Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

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Date : 28 October, 2002


(K. P. KIKANI)
Major Advisor

CERTIFICATE

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DECLARATION

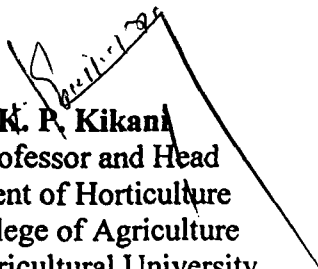
This is to declare that whole of the research work now submitted in this thesis for the partial fulfilment of the requirements for the degree of **Doctor of Philosophy** in the subject of **Horticulture** by the undersigned is the result of investigation done by me under the direct guidance and supervision of **Dr. K.P. Kikani**, Retd. Professor & Head, Department of Horticulture, B.A.College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand and no part of the work has been submitted for any other degree so far.

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गुरुर्ब्रह्मः गुरुर्विष्णुः | गुरुर्देवो महेश्वरः ॥
गुरुसंज्ञात परब्रह्मः | तस्मै श्रीगुरुवे नमः ॥

This pious Sanskrit “Shloka” reminds us of Gurukul education system has its roots from this great age-old tradition. My Guru **Dr. K.P. Kikani**, Retd. Professor and Head, Department of Horticulture, B.A.College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand, is not a mere major advisor for me, but a principled, disciplined, kind hearted, decent personality which always strongly supported me, boosted up my morale, bestowed upon me an invaluable fatherly affection, throughout the period of study and from whom, I could learn a lot besides the subject. His invaluable guidance and constructive suggestions has made me obliged and indebted forever.

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CONTENTS

CHAPTER	TITLE	PAGE NO.
I	INTRODUCTION.....	1-4
II	REVIEW OF LITERATURE.....	5-23
	2.1 Effect of soil application of fertilizers on leaf level of nutrients content.....	6
	2.2 Standardization of foliar sampling technique.....	9
	2.2.1 Choice of tissue.....	9
	2.2.2 Position of leaf.....	10
	2.2.3 Leaf composition.....	13
	2.3 Foliar nutritional status of leaf at different period..	14
	2.3.1 Nitrogen.....	14
	2.3.2 Phosphorus.....	16
	2.3.3 Potassium.....	17
	2.3.4 Calcium.....	18
	2.3.5 Magnesium.....	19
	2.4 Period and stage for leaf sampling technique in some fruit crops.....	20
	2.5 Correlation studies.....	22
III	MATERIAL AND METHODS.....	24-32
	3.1 General.....	24
	3.1.1 Location.....	24
	3.1.2 Climate and weather condition.....	24
	3.1.3 Soil characteristics.....	25
	3.2 Experimental material.....	25
	3.3 Experimental details.....	26
	3.3.1 Guidelines for leaf sampling.....	26
	3.3.2 Treatments.....	27
	3.3.2.1 Position of leaf.....	27
	3.3.2.2 Period of sampling.....	28
	3.3.3 Selection of sample.....	28
	3.4 Observation recorded.....	29
	3.5 Detailed procedure of recording observations.....	29
	3.5.1 Nutrient element status in leaves, N, P, K, Ca, Mg (%)......	29
	3.5.1.1 Preparation of sample for chemical analysis.....	29
	3.5.2 Vegetative growth parameters.....	31
	3.5.2.1 Plant height.....	31
	3.5.2.2 Stem girth.....	31
	3.5.2.3 Plant spread.....	31
	3.5.3 Yield parameters.....	31
	3.5.3.1 Number of fruits/tree.....	31
	3.5.3.2 Yield	31
	3.6 Statistical analysis.....	31

CHAPTER	TITLE	PAGE NO.
IV	RESULTS.....	33-78
4.1	Nitrogen.....	33
	4.1.1 Effect of treatment on leaf level of N content.....	33
	4.1.2 Effect of period on leaf level of N content....	33
	4.1.3 Interaction effect (Treatment x Period) on leaf level of N content.....	36
	4.1.4 Effect of position on leaf level of N content.	36
	4.1.5 Interaction effect (Treatment x Position) on leaf level of N content.....	36
	4.1.6 Interaction effect (Period x Position) on leaf level of N content.....	36
	4.1.7 Interaction effect (Treatment x Period x Position) on leaf level of N content.....	38
4.2	Phosphorus.....	38
	4.2.1 Effect of treatment on leaf level of P content	38
	4.2.2 Effect of period on leaf level of P content....	43
	4.2.3 Interaction effect (Treatment x Period) on leaf level of P content.....	43
	4.2.4 Effect of position on leaf level of P content..	43
	4.2.5 Interaction effect (Treatment x Position) on leaf level of P content.....	44
	4.2.6 Interaction effect (Period x Position) on leaf level of P content.....	44
	4.2.7 Interaction effect (Treatment x Period x Position) on leaf level of P content.....	44
4.3	Potassium.....	48
	4.3.1 Effect of treatment on leaf level of K content.....	48
	4.3.2 Effect of period on leaf level of K content....	48
	4.3.3 Interaction effect (Treatment x Period) on leaf level of K content.....	48
	4.3.4 Effect of position on leaf level of K content.	51
	4.3.5 Interaction effect (Treatment x Position) on leaf level of K content.....	51
	4.3.6 Interaction effect (Period x Position) on leaf level of K content.....	51
	4.3.7 Interaction effect (Treatment x Period x Position) on leaf level of K content.....	53

CHAPTER	TITLE	PAGE NO.
	4.4 Calcium.....	53
	4.4.1 Effect of treatment on leaf level of Ca content.....	53
	4.4.2 Effect of period on leaf level of Ca content...	58
	4.4.3 Interaction effect (Treatment x Period) on leaf level of Ca content.....	58
	4.4.4 Effect of position on leaf level of Ca content	58
	4.4.5 Interaction effect (Treatment x Position) on leaf level of Ca content.....	59
	4.4.6 Interaction effect (Period x Position) on leaf level of Ca content.....	59
	4.4.7 Interaction effect (Treatment x Period x Position) on leaf level of Ca content.....	59
	4.5 Magnesium.....	63
	4.5.1 Effect of treatment on leaf level of Mg content.....	63
	4.5.2 Effect of period on leaf level of Mg content..	63
	4.5.3 Interaction effect (Treatment x Period) on leaf level of Mg content.....	63
	4.5.4 Effect of position on leaf level of Mg content.....	66
	4.5.5 Interaction effect (Treatment x Position) on leaf level of Mg content.....	66
	4.5.6 Interaction effect (Period x Position) on leaf level of Mg content.....	66
	4.5.7 Interaction effect (Treatment x Period x Position) on leaf level of Mg content.....	68
	4.6 Performance of vegetative growth and yield in aonla Cv. Gujarat Aonla-1.....	68
	4.7 Correlation between yield, number of fruits per tree and leaf level of nutrients in different period in aonla Cv. Gujarat Aonla-1.....	72
V	DISCUSSION.....	79-98
	5.1 Nitrogen.....	79
	5.1.1 Effect of treatment on leaf level of N content.....	79
	5.1.2 Effect of period on leaf level of N content...	80
	5.1.3 Interaction effect (Treatment x Period) on leaf level of N content.....	81
	5.1.4 Effect of position on leaf level of N content..	81
	5.1.5 Interaction effect (Treatment x Position) on leaf level of N content.....	81
	5.1.6 Interaction effect (Period x Position) on leaf level of N content.....	82
	5.1.7 Interaction effect (Treatment x Period x Position) on leaf level of N content.....	82

CHAPTER	TITLE	PAGE NO.
5.2	Phosphorus.....	83
	5.2.1 Effect of treatment on leaf level of P content	83
	5.2.2 Effect of period on leaf level of P content.....	84
	5.2.3 Interaction effect (Treatment x Period) on leaf level of P content.....	84
	5.2.4 Effect of position on leaf level of P content..	85
	5.2.5 Interaction effect (Treatment x Position) on leaf level of P content.....	85
	5.2.6 Interaction effect (Period x Position) on leaf level of P content.....	85
	5.2.7 Interaction effect (Treatment x Period x Position) on leaf level of P content.....	86
5.3	Potassium.....	87
	5.3.1 Effect of treatment on leaf level of K content.....	87
	5.3.2 Effect of period on leaf level of K content.....	87
	5.3.3 Interaction effect (Treatment x Period) on leaf level of K content.....	88
	5.3.4 Effect of position on leaf level of K content..	88
	5.3.5 Interaction effect (Treatment x Position) on leaf level of K content.....	89
	5.3.6 Interaction effect (Period x Position) on leaf level of K content.....	89
	5.3.7 Interaction effect (Treatment x Period x Position) on leaf level of K content.....	90
5.4	Calcium.....	90
	5.4.1 Effect of treatment on leaf level of Ca content.....	90
	5.4.2 Effect of period on leaf level of Ca content...	91
	5.4.3 Interaction effect (Treatment x Period) on leaf level of Ca content.....	91
	5.4.4 Effect of position on leaf level of Ca content	92
	5.4.5 Interaction effect (Treatment x Position) on leaf level of Ca content.....	92
	5.4.6 Interaction effect (Period x Position) on leaf level of Ca content.....	93
	5.4.7 Interaction effect (Treatment x Period x Position) on leaf level of Ca content.....	93
5.5	Magnesium.....	94
	5.5.1 Effect of treatment on leaf level of Mg content.....	94
	5.5.2 Effect of period on leaf level of Mg content..	94
	5.5.3 Interaction effect (Treatment x Period) on leaf level of Mg content.....	94
	5.5.4 Effect of position on leaf level of Mg content.....	95

CHAPTER	TITLE		PAGE NO.
		5.5.5 Interaction effect (Treatment x Position) on leaf level of Mg content.....	95
		5.5.6 Interaction effect (Period x Position) on leaf level of Mg content.....	95
		5.5.7 Interaction effect (Treatment x Period x Position) on leaf level of Mg content.....	96
	5.6	Performance of vegetative growth and yield in aonla Cv. Gujarat Aonla-1.....	97
	5.7	Correlation	97
VI	SUMMARY AND CONCLUSION.....		99-105
	6.1	Nitrogen.....	99
	6.2	Phosphorus.....	100
	6.3	Potassium.....	101
	6.4	Calcium.....	102
	6.5	Magnesium.....	103
	6.6	Performance of vegetative growth and yield in aonla Cv. Gujarat Aonla-1.....	104
	6.7	Correlation.....	104
	REFERENCES.....		i - xi
	APPENDIX.....		I

LIST OF TABLES

Table No.	Title	Page No.
3.1	Physico-chemical composition of soil (on air dry basis).....	25
4.1	Leaf level of N content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	34
4.2	Leaf level of N content of different position and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	35
4.3	Leaf level of N content in different period and position in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	37
4.4	Leaf level of N content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1.....	39
4.5	Leaf level of P content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	41
4.6	Leaf level of P content of different position and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	42
4.7	Leaf level of P content in different period and position in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	45
4.8	Leaf level of P content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1.....	46
4.9	Leaf level of K content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	49
4.10	Leaf level of K content of different position and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	50
4.11	Leaf level of K content in different period and position in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	52

Table No.	Title	Page No.
4.12	Leaf level of K content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1.....	54
4.13	Leaf level of Ca content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	56
4.14	Leaf level of Ca content of different position and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	57
4.15	Leaf level of Ca content in different period and position in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	60
4.16	Leaf Ca content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1.....	61
4.17	Leaf level of Mg content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	64
4.18	Leaf level of Mg content of different position and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	65
4.19	Leaf level of Mg content in different period and position in aonla Cv. Gujarat Aonla-1 on dry weight basis (%).....	67
4.20	Leaf level of Mg content in different position and period in different treatments in aonla Cv. Gujarat Aonla-1.....	69
4.21	Effect of different treatments on vegetative growth and yield in aonla Cv. Gujarat Aonla-1.....	71
4.22	Correlation between yield, number of fruits per tree and leaf level of nutrients in different periods in aonla Cv. Gujarat Aonla-1.....	73
4.23	Correlation coefficient among vegetative growth parameters and different leaf nutrient content in different periods in aonla Cv. Gujarat Aonla-1.....	76

LIST OF FIGURES

Figure No.	Title	After page No.
1	Leaf N content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1.....	37
2	Leaf P content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1.....	45
3	Leaf K content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1.....	52
4	Leaf Ca content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1.....	60
5	Leaf Mg content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1.....	67

LIST OF APPENDIX

Appendix No.	Title	Page No.
I	Meteorological data for the period (June, 2000 - April, 2001)...	I

Introduction

CHAPTER – I INTRODUCTION

The aonla (*Emblica officinalis*, Gaertn Syn. *Phyllanthus emblica*) is an important minor and under exploited fruit crop alongwith lot of commercial significance. It belongs to family Euphorbiaceae, sub family Phyllanthoideae and native of India, Ceylon, Malaysia and China is known as amla, amlaki, amali, ambala, amalakamu and nelli in different parts of India. It is quite hardy, prolific bearer and highly remunerative even without much care because it is an important arid fruit crop. Aonla tree has taproot system and can absorb water and nutrients from deeper layer of the soil hence, can tolerate adverse climatic and soil conditions to some extent so it is highly suitable fruit crop in arid region. Plants have capacity for adoption in dry region and salt affected soil. Being a hardy fruit crop it may be grown in waste lands and also in marginal lands.

The fruit is highly nutritive and it is the right source of Vitamin “C” ranging from 200 to 1814 mg/100 g. The fruits are made into preserves (murabba), sauce, candy, dried chips, tablets, jellies, pickles, tea, powder etc. The ascorbic acid and other constituents are well retained in dried aonla fruits. An easy way to prepare aonla murabba with high Vitamin “C” content has been reported by many scientists. The variations in ascorbic acid content have been recorded by various workers. The aonla powder is superior to synthetic Vitamin “C” in treating deficiencies or in physiological disorder. The stability of ascorbic acid and presence of astringency in aonla fruit may be assigned to the presence of polyphenols or leucoanthocyanin (Bajpai and Shukla, 1996).

It is valued as antiscorbutic, diuretic, laxative, alternative and antibiotic. One or other parts of plant could be used in treating chronic dysentery, bronchitis,

diabetes, fever, diarrhoea, jaundice, dyspepsia, cough and in tanning and dyeing industries. The literature regarding its diverse medicinal, industrial and other applications have been reviewed. The properties and nature of inhibitors of potato virus in the plant extract, pharmacological activities of phyllembelin isolated from fruit pulp, protective effect of fruit extract in myocardia necrosis and antiviral activity have been reported by Bajpai and Shukla (1996).

In India present area under aonla cultivation is about 0.1 million hectares with an annual production of about 0.2 million tones (Anon., 1992). Commercial cultivation of aonla can be observed mainly in Uttar Pradesh and Gujarat. In Gujarat, Kheda and Anand are an excellent pockets for aonla cultivation. At present exact area and production of aonla in Gujarat state is not available. However, it is estimated more than 10000 hectares (Kikani , 2001). Day by day cultivation of aonla is increasing and the crop has become very popular among farmers.

Nutrients are essential and limiting factors for the productivity and quality of different fruits. The perennial fruit crops are quite different from other seasonal crops in their nutritional requirement due to their size, density, rate of growth, root pattern and phenomenon of the fruit bud differentiation in previous season and its relationship with the yield in following year. Determination of the nutritional needs of fruit trees must be made prior to the renewed growth or determination of the potential yield. However, a reliable information is needed to decide, how much manures and fertilizers should be applied to the fruit trees for an economic response. This may be obtained upto an optimum level with the use of one or more diagnostic methods in consideration with a background of the research results.

Soil analysis, plant analysis, leaf analysis and radio-tracer techniques are the method for nutritional diagnosis. Among the different methods to judge nutrient requirements leaf analysis has been recognized as the most reliable and powerful diagnostic tool for determining the nutritional status of fruit trees (Bhargava and Chadha, 1988). The standard sampling is of immense value (Singh *et al.*, 1989). The portion of the leaf, its position and time of sampling are quite essential to know the nutritional status of the fruit plants (Chapman, 1964). Such information are not available on aonla crop. Therefore, the leaf nutrient study has been undertaken at bimonthly intervals at different period and position of the tree.

Since leaf is the principal site of plant metabolism, changes in nutrient supply are reflected in the composition of leaf, these changes are more pronounced at certain stages of development and the concentration of nutrients in the leaf stages are related to the performance of the crop. Leaf analysis indicates the status of soil fertility, its availability to plants and the critical level of nutrient is “The range of a given element in the leaf, below which the yield is limited and above which the use of fertilizer is no longer economical”. However, before going for leaf analysis, it is pre-requisite to standardize the sampling technique. It has been worked out in many fruit crops like mango (Pathak and Pandey, 1976), citrus (Nadir, 1962), guava (Chadha *et al.*, 1973) and grape (Gill *et al.*, 1973). But no attempts have been made so far to standardize the technique in aonla. Hence, studies on leaf nutrient status and its relation to different period and position in aonla (*Emblica officinalis*, Gaertn) Cv. “Gujarat Aonla-1” has been carried out with the following objectives.

- (1) To evaluate the leaf level of nutrients in different positions during its growth and development.
- (2) To find out the period of stability of leaf level of nutrients with respect to different period and at different positions.
- (3) To know the nutrients status of leaf for the major elements like; Nitrogen, Phosphorus, Potassium, Calcium and Magnesium.
- (4) To correlate the different leaf nutrients levels with yield and vegetative growth parameters at different period.

Review of Literature

CHAPTER – II

REVIEW OF LITERATURE

The mineral nutrients are repaired by the fruit trees as a source of energy and body building materials. The practical side of plant nutrition is its source, time of application, age and stage of crop and quantity. However, for efficient and judicial use needs proper diagnosis in order to judge requirements. Among the different methods leaf analysis is a powerful tool to achieve high economic yield and quality of production in fruit crops. In view of this facts, available literature has been reviewed here on fruit crops in order to understand the present status of nutrients in leaf in correlation with its periods and position of sampling.

Plant analysis as a diagnostic tool to indicate the availability of mineral elements was first expressed over a century ago (Winhold, 1962). Over a past century the pendulum of analytical diagnosis has swung from soil analysis to plant analysis. Lagatu and Maume (1926) were the first to adopt the technique of “Diagnostic Foliar” for assessing the nutritional status of plant. Ulrich (1948) defined the ‘Critical nutrient level’ for detecting the deficiencies in plants, on the range of concentration at which growth of the plant is restricted in comparison with that of plant at higher nutrient level.

Presently, the leaf analysis is widely accepted as a efficient diagnostic technique for assessing the nutritional status of the plants and for evaluating plant response to the application of nutrients (Goodall and Gregory, 1947). Aonla has tap root system and can absorbed water and nutrient from deeper layer of soil to meet the nutritional requirements for different physiological processes. Thus, soil analysis may not give a true picture about these processes. Leaf analysis is, therefore, a better accepted method for better understanding of the nutrient

uptake and their utilization. Hence, leaf analysis needs to be carried out for finding a better and workable relationship of the foliar nutrient status with the tree efficiency.

Kenworthy (1961) opined that leaves have been the general diagnostic tissue to use because they not only reflected a general picture of nutritional conditions of the tree but also satisfied two additional requirements; namely, (i) that of always being present regardless of size of crop or age of tree and (ii) being easily sampled by removal without serious harm to the tree. Chapman (1964) reported that foliar analysis has been used as aid for interpreting the results of research and confirming visual symptomatology and not only nutritional deficiencies but also excesses and imbalance in plants; thus helping to guide soil fertility and management practices as well, whether the crop requires nutrients or not can be judged by the leaf nutrient concentration.

Mineral nutrient trails as soil application are time consuming and lot of space is needed for conducting them. Also these trails may be affected by a variety of factors such as the soil type, climatic conditions and disease and insect pest attack etc. which, limit their wide applicability. Some work has been done by different investigators on this aspect in India and abroad have been reviewed here under.

2.1 EFFECT OF SOIL APPLICATION OF FERTILIZERS ON LEAF LEVEL OF NUTRIENTS CONTENT

Bansal and Motiramani (1968) reported that N content of guava leaves increased with increasing levels of N and P application and was not affected by K levels. The leaf P content increased by added P but was not affected by N and K levels. Likewise, Ca and Mg content of leaves were not affected markedly by N, P and K treatment. Ramaswamy (1971) observed leaf nutrient levels of 3.29 per cent N,

0.44 per cent P_2O_5 , 3.11 per cent K_2O , 2.12 per cent Ca and 0.24 per cent Mg with soil application of 170 g N per plant which was optimum for increased yield in Robusta banana. Randhawa *et al.* (1973) found that with increase in the level of nitrogen application, there was increase of quadratic nature in the nitrogen content of leaf tissue. The optimum level was found to be 206.1 g N/plant resulting 3515 per cent of N dry matter of leaf tissue and 44.43 t/ha of fruit yield and also found that potassium content of leaf tissue was affected by potash levels in Robusta banana.

A field trial conducted to determine the response of pineapple var. Kew to N, P and K application by Subramanian *et al.* (1974) for the study of relationship between N, P and K application and leaf nutrient content at various growth stages. The leaf analysis were done at 5th, 8th and 11th month after planting. In the 5th and 8th months, application of N, P and K was not clearly reflected in the leaf nutrient contents. In the 11th month sampling, however, there were significant increases in leaf N, P and K corresponding to N, P and K application. Singh and Rajput (1976) suggested that muraite of potash application appreciably increased K content and decreased N content in guava leaves. The nutrient content in leaves were on peak before flush growth commenced and decline gradually with advancement of growth. January-February and July-August were the most suitable period for potassium study.

Samra *et al.* (1978) reported that leaf N content was increased with an increase in level of N fertilizer as a soil application for two year study and observed that N at 2 kg gave higher leaf N content than N at 0, 0.5, 1.0 and 1.5 kg/tree in mango. Rajput *et al.* (1981) studied leaf nutrient status as influenced by individual application of N, P and K in 'Dashehari' mango and observed that application of N,P and K increased their levels in leaf. A nutritional trial on Robusta banana was carried out by Kohli *et*

al. (1984) with six levels of nitrogen (i.e. 0, 150, 300, 450, 600 and 750 g/plant) and found that both leaf nitrogen content and available nitrogen in the soil increased with increasing levels of applied nitrogen.

Hariprakashrao *et al.* (1988) conducted a fertilizer trial on passion fruit var. Purple with different levels of N, P and K was utilized to study the relationship between leaf nutrient status and fruit yield. The increase level of N, P and K application was reflected in leaf N, P and K status of leaves, respectively during flowering stage. Wagh and Mahajan (1988) found that leaf N content increased with the soil application of nitrogenous fertilizers. The leaf P, Ca and Mg content also increased significantly with increasing N rates up to 600 g N/tree but declined afterwards. Leaf P content also increased with the applied P and had a synergistic effect on the uptake of N, K, Ca and Mg. However, there was no appreciable increase in leaf K content by fertilization but there was a marked increase in N, Ca and Mg content in guava. Tassar *et al.* (1989) reported that leaf nitrogen level of 2.20 per cent obtained by application of 400 g N/tree was best for terminal shoot growth and fruit yield for rainy season crop of guava. In winter season 2.08 per cent leaf nitrogen obtained by application of 600 g N/tree proved superior for shoot growth and fruit yield.

Sarooshi *et al.* (1991) studied fruit yield, leaf nutrient concentrations and growth response of young valencia orange tree to 4 rates of nitrogen (75-450 kg/ha), phosphorus (0-180 kg/ha) and potassium (0-360 kg/ha). A leaf N concentrations increased with amount of N applied and slightly increased with K applications but not with P. Leaf P concentrations was increased with higher rate of applied P and at the lowest rate of applied N. Leaf K increased with amount of applied K.

2.2 STANDARDIZATION OF FOLIAR SAMPLING TECHNIQUE

2.2.1 Choice of tissue

In order to ascertain the nutritional requirements of fruit plants, a number of tissues have been used because, analyzing the whole tree plant may be undesirable (impracticable) because minerals in inactive tissues may mask the functional differences (Lundegardh, 1951). Lagatu and Maume (1934) investigated that the leaf is the ideal tissue to sample because of its being a chemical factory for plant. Thomas (1945) selected the leaves on the basis of physiological and practical considerations such as sensitivity, homogeneity and accessibility particularly with respect to the ability to select morphologically homogeneous tissues particularly in case of apple. Chapman (1960) showed that the leaf was as sensitive as or more sensitive than any other plant part as an indicator of nutritional status of several elements in citrus. In mango, technique was standardized in Florida by Koo and Young (1972) in 'Irwin' cultivar of mango.

Shorrocks (1962) found little differences in the nutrient composition of *Hevea brasiliensis* leaves with and without mid ribs, but the petiole showed marked differences from the leaf blade for all nutrients except K and Ca. Leaves with mid rib usually showed clear responses to changes in fertilizer application than that of leaves without mid ribs. The petiole was no more sensitive to these changes than the leaf.

Zidan and Maximos (1962) reported that N content was much higher in leaf blades than petiole portion in mango. Chadha *et al.* (1976) observed that N, S and Cu contents in mango more higher in whole leaf as compared to leaf blade and petiole. However, petiole showed higher contents of P, K and Ca than whole leaf and blade, while leaf blade possessed higher amounts of Mg content than rest of the two parts.

while leaf blade possessed higher amounts of Mg content than rest of the two parts. Lekhova (1976) working on young bearing apple trees of Golden Delicious on M-7 (root stock) suggested that for foliar diagnosis of whole leaves (blade and petiole) should be used, taken from the centre third of one year old shoots. He also observed that more K and much less N and P contents in the petiole than in blades. Further, he found the differences in nutrient concentrations of different parts of the same leaf and in leaves from different parts of the same tree. Amongst leaf tissues and their different positions in mango Cv. 'Kesar', leaf with petiole had intermediate nutrient status, thereby indicating it's suitability for nutritional diagnosis (Kher, 1996).

2.2.2 Position of leaf

To make most efficient use of leaf analysis as a diagnostic tool, one must know which factors influence the concentration of a given element in the leaves and to what extent. Some attempts have been made to study the effect of age and position of leaf (Koo and Young, 1972; Pathak and Pandey, 1976, 1978_a) and soil type, cultivar, fruiting and non-fruiting terminals (Young and Koo, 1971; Samra *et al.*, 1978). On the mineral composition of citrus leaves as associated with position on the tree and reported that the position of the leaf on the twig had a distinct effect on mineral composition of leaf. They observed wide variations in K and Ca contents and to a less degree in N and Mg contents between leaves from tip and from the base on the same twigs. Emmert (1957) compared the apple leaves from tip, mid and basal shoot positions and total soluble tests, as indicators of N and K nutrition. His results supported the contemporary practice in diagnostic work of analyzing mid shoot leaves for total nutrient contents. The data also indicated that an appraisal of different leaves from the stand-point of responses to changes in plant nutrition will vary according to

the chemical test employ. Beyers (1962) recommended that the mid terminal leaves for foliar analysis in deciduous fruit trees. Moon and Hymas (1964) reported significant differences in nutrient composition between leaves from the terminal, middle and basal positions of the extension shoot in apple. Poulsen and Hansen (1965) reported that the concentrations of N, P and K in the apple leaves generally increased with ascending leaf positions from the base to the tip of the shoot. The increase was most marked for N and P and was more marked in the young shoots. They recommended the sampling from middle part of the shoot in order to minimize the effect of leaf position on mineral contents.

Koo and Young (1972) found that basal leaf was lower in N and Ca but higher in P and K contents as compared with terminal leaf of the same shoot in case of 'Erwin' mango. They observed that a very small differences between fruiting and non-fruiting shoots. Pathak and Pandey (1976) observed an increase in the level of N, Ca and Mg contents of mango leaves as they increased in age; whereas, P and K contents decreased with the advancement of leaf age from base to top of the shoot. Similarly, Pathak and Pandey (1978_a) found that leaf N, Ca and Mg contents increased and P and K contents decreased from base to top of the shoots. Further, working on 'Deshehari' cultivar of mango, Kumar and Pandey (1979) reported that the levels of N, Ca and Mg increased from base to the top, while reverse was true for P and K contents. They observed stabilization of all the constituents in five months old leaves borne on position 5th from the shoot base. Thus, for considering the nutrient status of the mango tree as a whole, they suggested that leaves of this age and position should be sampled.

Chadha *et al.* (1980) studied the effects of leaf age and leaf position on the shoot, sampling direction and sampling height of leaves of mango Cv. 'Chausa' on the mineral composition and reported continuous increase in Ca and Mg contents and decrease in P, K and Mn contents of leaves from basal to terminal leaves on the shoots. Thakur *et al.* (1981) further working on 'Chausa' cultivar of mango reported that P and K contents decreased with age whereas Ca increased. Basal leaves contained more P and K and less N and Ca contents than the terminal leaves on the same shoot. Moreover, differences between fruiting and non-fruiting shoots were not significant.

Badyal and Kar (1985) found leaf samples taken from middle portion of shoot exhibited less fluctuation for N, P and K contents and found suitable for sampling in plum cultivar 'Santarosa'. The most recently matured leaf starting from shoot tip was considered ideal for sampling of N, P and K in guava (Sanyal and Mitra, 1990_a) and litchi (Menzel *et al.*, 1987 and Sanyal and Mitra, 1990_b). It was also found that fifth and sixth pair of leaves for Ca, Mg and S from vertical shoots representing all the four directions may be used for estimating the nutritional status in litchi (Sanyal and Mitra, 1990_b). Sanyal *et al.* (1990) studied the N, P, K, Ca and Mg contents of two papaya Cvs. 'Washington' and 'Pusa Delicious' at different growth stages and found that the concentration of all the minerals were recorded higher in leaf blade except K, which was found higher in petiole and the leaf blade tissues for P, Ca and Mg and petiole for K at flowering. This may be used as index tissues in order to determine the nutritional status of the cultivars while it is better to use either of the tissue at two months after flowering to estimate the N status of plants.

Awasthi *et al.* (1993) reported that when the leaf sample of aonla tree Cv. 'Chakaiya' taken from middle position of shoots showed higher leaf N and K content at the top position of shoot, P content at the basal shoot, Ca at mid position and Mg content at basal position of shoot. A leaf with petiole (whole leaf) and from middle position of shoot were ideal index tissue for nutritional diagnosis in mango Cv. 'Kesar' and 'Totapuri' (Kher, 1996).

2.2.3 Leaf composition

After a good deal of analysis of leaves from variously fed trees, the deficient or responsive levels, the critical or optimum levels and high or low levels are identified, to give guidance for fertilizer application. Routhor *et al.* (1958) reported that leaves have been found to be a practical, sensitive and convenient index of nitrogen status and leaf analysis is considered to be a basic research tool for investigation of soil fertility problems of orchard crops.

Garg and Khanduja (1976) found leaf level of different nutrients as 1.2% N, 0.05% P, 0.62% K, 1.01% Ca and 0.9% Mg in alkaline soil in aonla. While, Awasthi *et al.* (1993) reported 1.4% N, 0.09% P, 0.78% K, 1.44% Ca and 0.73% Mg in leaves from the middle portion of aonla shoots Cv. 'Chakaiya'. Similarly, Shukla and Pathak (1999) recorded 2.5%, 1.88% and 2.08% N; 0.145%, 0.108% and 0.111% P; 0.897%, 0.780% and 0.751% K; 1.348%, 1.445% and 1.054% Ca and 0.489%, 0.534% and 0.410% Mg in normal soil, saline soil and sodic soil, respectively in different cultivars of aonla leaves.

2.3 FOLIAR NUTRITIONAL STATUS OF LEAF AT DIFFERENT PERIOD

Studies indicate that tissue composition undergoes changes as a result of growth and developmental processes throughout the season. Considerable work has been done on different fruits, on this aspect, which suggests that seasonal changes in the nutrient content of leaves can be separated into three distinct periods. First, there is high rate of influence in young leaves shortly thereafter when metabolic rates are high. Second, when the leaves undergo a period of changes as senescence approaches and the elements are withdrawn. Third, is a relatively stable intervening period of few weeks or months when mineral shifts are at the minimum. The fundamental idea behind the use of leaf analysis as the means of determining the nutritional requirements of tree has been clearly stated by Lundegarth (1943). He pointed out that "Leaf analysis is based on the functioning assimilating leaves as the central laboratories of nutrition".

In nutrition studies, importance of seasonal changes in nutrient elements have been emphasized by various workers. They found it desirable to determine the foliar concentration of different nutrient elements at various stages of leaves as an aid in diagnosing the nutritional abnormalities.

2.3.1 Nitrogen

The developing flowers and fruits contribute a part of driving force for nitrogen transport from perennial to annual (seasonal) parts of the crop size and level in leaves may both be correlated with the activity governing the transport of nitrogen constituent to annually growing parts of the tree (Oland, 1971).

Avilan (1971) reported analysis of mango Cv. 'Kent' leaves which showed that nitrogen level was the highest before period of flowering, fell during flowering and fruit formation and rose again during the ripening stage. Koo and Young (1972) reported stabilization of nitrogen in "Irwin" mango in 6 to 7 month old leaves. Gupta and Narasimhan (1975) reported that the peak nitrogen content in leaves was found in December and minimum in February after flowering in mango by analyzing leaf samples collected at monthly intervals from September to February.

Nitrogen content of 'Dashehari' mango leaves increased with the advancement of leaf age and were stabilized in 4 to 5 month old leaves. It was concluded that for nitrogen leaves should be sampled after 4 months (Pathak and Pandey, 1976; Pathak and Pandey, 1978_b). They further studied the changes in the nitrogen content of mango leaves in a great detail and at different stages of flowering and fruit growth and reported that nitrogen content of leaves showing significant depletion at different stages of flowering and fruit growth. Beside this there was a tendency to record the nitrogen level by rapid uptake as evidenced by higher nitrogen content prior to the onset of different stages. Kumar and Nauriyal (1979) found that the concentration of N in mango leaves increased with the advancement of age till the leaves become five months old. After this period, the N content was found to get stabilized.

Chadha *et al.* (1979) observed that nitrogen concentration decreased with advancing age of the leaves in Cv. 'Dashehari and Chausa'. Further, Chadha *et al.* (1980) reported that nitrogen content was stable in 6-7 months old leaves of mango Cv. 'Chausa'.

Awasthi *et al.* (1993) reported that highest leaf N content was observed in the top position followed by base and middle position of shoots in aonla Cv. 'Chakaiya'.

Interaction between period and position revealed that highest N content was recorded in May at the top position of shoot. The stability of nutrient was found at mid position of shoot in the month of July.

2.3.2 Phosphorus

Zidan and Maximos (1962) studied seasonal variations in nutrient status of two mango varieties namely "Paiiri" and "Alphanso" and found that P content decreased during summer and increased in winter followed by further decrease in spring. Avilan (1971) reported analysis of mango Cv. 'Kent' leaves which showed that phosphorus level was highest before flowering and fell during flowering and fruit formation and rose again during ripening stage. Work carried out in Florida by Koo and Young (1972) on mineral composition of mango leaves Cv. 'Irwin' revealed that as leaves increased in age, low P content was found. Singh and Singh (1973) found that a high level of P in shoots was favourable for the flower bud formation. During the month of August there is not much difference in the level of different potential flowering and non-flowering shoots of mango. As the time of flower bud initiation approached nearer, that is November-December, the level of phosphorus fractions except nucleic acid become quite high in flowering stems. The leaves from the flowering shoots also had a high level of phosphorus but differences were not so marked as in the case of stem.

Pathak and Pandey (1976) reported that the level of P in mango leaves Cv. 'Dashehari' decreased with the advancement of age. Studies were also conducted to follow the seasonal changes in phosphorus composition of leaves in mango Cv. 'Dashehari' during different stages of flowering and fruit growth by Pathak and Pandey (1978_b). They observed that the level of phosphorus was higher before

flowering and lower during flowering and fruit growth. Kumar and Nauriyal (1979) showed that phosphorus percentage in 'Dashehari' mango leaves registered a reduction in the second month and then exhibited a sharp increase in three, four and five month old leaves. Chadha *et al.* (1980) studied the effects of leaf age, leaf position on the shoot, sampling direction and sampling height of leaves of mango Cv. 'Chausa' on the mineral composition and found that phosphorus decreased significantly with advancing age of leaves. Phosphorus content was stable in 6-7 month-old leaves and varied with the sampling direction.

Awasthi *et al.* (1993) reported that leaf P content was found to be highest in the month of August in the leaves of aonla Cv. 'Chakaiya' at the basal shoot position. Stability of P content was found in the month of May to July at mid shoot position.

2.3.3 Potassium

Seasonal variations in the nutrient status of two mango Cv. "Pairi" and "Alphanso" were studied by Zidan and Maximos (1962). They reported that potassium content decreased in summer, but rose to maximum in winter and fell in spring. Avilan (1971) analyzed mango Cv. 'Kent' leaves and showed that potassium level was maximum before flowering and fruit formation and rose again during ripening. Potassium content in 'Irwin' mango leaves decreased with the advancement of leaf age (Koo and Young, 1972). Pathak and Pandey (1976) also reported the similar trend for potassium content in 'Dashehari' cultivar of mango. The periodical analysis of potassium constituent of mango leaves Cv. 'Dashehari' revealed that there was maximum accumulation of potassium before the fruit bud differentiation which gradually declined as the tree passed through the stage of bud development panicle elongation, fruit setting and fruit development (Pathak and Pandey, 1978_b).

Kumar and Nauriyal (1979) showed that potassium percentage decreased significantly from first to fifth month. The decrease was statistically significant and after that period it remained constant up to twelve month age.

Awasthi *et al.* (1993) revealed that K content of aonla branchlet Cv. 'Chakaiya' found higher in the month of June and July then after it was decreased from the month of September. K content was stabilized in the month of July to August in the mid shoot position.

2.3.4 Calcium

Calcium is considered to be the most abundant element in plant. It's concentration varies considerably in immature, mature leaves and also with the age of the plant. It also exhibits seasonal fluctuations. Early work carried out by several workers in stone fruits observed characteristic seasonal changes in the leaf calcium status. Avilan (1971) reported analyses of mango Cv. 'Kent' leaves and found that calcium level was low before flowering rose during fruit formation and fell subsequently. Koo and Young (1972) reported that calcium increased with both leaf age and position on shoot towards terminal end in 'Irwin' cultivar of mango.

Pathak and Pandey (1976) reported that calcium content increased with the advancement of leaf age in 'Dashehari' cultivar of mango. The seasonal changes in chemical composition of mango leaves Cv. 'Dashehari' were studied by Pathak and Pandey (1978_b) during different stages of flowering and fruit growth. They reported that calcium content, unlike other elements, appeared to show no definite trend. Chadha *et al.* (1980) while working on the standardization of leaf sampling technique in "Chausa" cultivar of mango observed that calcium level increased significantly with the advancement of age and remained statistically stable from 9 to 10 months.

Leaf calcium content of aonla leaves Cv. "Chakaiya" shown increasing trend from May to October, it was recorded highest in the month of September, while lowest in the month of June. Stability of nutrient for leaf Ca content was found in the month of July to August at mid shoot position (Awasthi *et al.*, 1993).

2.3.5 Magnesium

The course of change of magnesium content in foliage of fruit tree has been reported to follow almost the same pattern as calcium, although its levels remained much lower than the calcium. Pathak and Pandey (1976) reported that the level of magnesium content in 'Dashehari' mango leaves increased with the advancement of age of the leaf. They concluded that 2 months old leaves may be sampled for magnesium. Pathak and Pandey (1978_b) closely followed the changes in chemical composition of mango leaves at different stages of flowering and fruit growth during the on year and noticed that there was accumulation of magnesium before the fruit bud differentiation which gradually declined as the tree passed through the stages of bud development, panicle elongation and fruit development. Chadha *et al.* (1980) standardized the leaf sampling technique for mineral composition of leaves of mango Cv. 'Chausa' and found that magnesium content increased significantly with the advancement of leaf age.

Awasthi *et al.* (1993) observed that Mg content of branchlet of aonla Cv. 'Chakaiya' found highest in the month of July at the basal shoot position stability of nutrient was found in the month of August to October at middle position of shoot.

2.4 PERIOD AND STAGE FOR LEAF SAMPLING TECHNIQUE IN SOME FRUIT CROPS

Chadha *et al.* (1973) reported the 3rd pair of leaf from the apex portion of tree was sampled in the month of August/December was the best stage for leaf sampling as well as for proper nutritional diagnosis in guava. In pineapple, 4th leaf from the apex while $\frac{2}{3}$ th part of the leaf base of recently matured leaf should be collected for the leaf sampling technique (Rao *et al.*, 1977). Chadha *et al.* (1980) found that the vegetative shoot of 5 month old from middle leaf in the shoot when sampled from recently matured leaf is the best index tissue for nutritional diagnosis in mango.

Kotur *et al.* (1983) suggested that the leaf against the first open flower (6th leaf from the apex) may be used as an index tissue for leaf analysis in passion fruit. Bhargava and Sumner (1987) reported that the petiole should be taken as index tissue at the bud differentiation stage (5th petiole from the base for yield forecast) in grape for index tissue sampling technique for yield, while for quality, petiole taken as index tissue at the bloom stage (Bhargava, 1989). Bhargava and Dhandhar (1987) carried out investigation to examine the composition of pomegranate leaves in relation to their age and position on the shoot and reported that most of the nutrients were found stabilized in 8th leaf pair, from the growing tip. Sample picked in the month of April and August for the succeeding crop of February and June would be ideal.

Annapurna *et al.* (1988) suggested that the 10th leaf from the apex was the best index tissue when collected in the month of September for nutritional diagnosis in sapota. Tree of 3 to 5 months old leaves from June flush appeared to be best for nutritional diagnosis in acid lime (Singh *et al.*, 1989). Bhargava *et al.* (1989) reported

that 6th petiole from the apex was sampled after six month of planting in papaya for the proper nutritional diagnosis.

Leaf was taken as index tissue 2-month after the pruning (i.e. 6th leaf from the apex from the secondary or tertiary shoots) in ber for leaf analysis and proper nutritional diagnosis (Bhargava *et al.*, 1990). In aonla, 3-4 month old branchlets should be sampled from middle position of shoots for proper nutritional diagnosis (Awasthi *et al.*, 1993). Dhandar and Bhargava (1993) carried out an investigation to determine the tissues age of leaf for nutritional diagnosis in custard apple and reported the leaf at position five from apex side was found to be an ideal index tissue for nutritional diagnosis.

Kotur and Singh (1993) suggested that sampling the second pair of leaflets of litchi from tip of the terminal on autumn flush of 6-7 months, from all direction and at mid-height of the tree operated to be optimum for nutritional diagnosis. Kohli (1995) reported that 3-5 month old leaf from the new flush in June and 2nd leaf from the August to October months from the ambe bahar in mandarin was considered as an ideal index tissue for leaf nutrient analysis. Raghupathi *et al.* (1996) suggested that in fig sampled leaf in April for the August crop from the leaf at position nine from the apex for nutritional diagnosis.

In Phalsa, leaf sample was collected one month after pruning when leaf at position four from the apex for leaf nutritional diagnosis (Bhargava *et al.*, 1996). Bhargava and Reddy (1998) reported that petiole of third fully opened leaf was the best index tissue for nutritional diagnosis in banana.

2.5 CORRELATION STUDIES

Sinha *et al.* (1969) found a positive correlation of N fertilization with leaf N, P, K and Mg but level of a Ca remained unaffected. The fruit yield was positively correlated with N level in guava. Sahay and Ram (1970) observed a positive correlation of yield with leaf level of N content and none with other elements in mango.

A close correlation of N and K contents of the middle one-third portion of the leaf base sampled at fifth month of the plant growth was found to exist with fruit yield in "Kew" pineapple (Subramanian *et al.*, 1972).

Singh and Rajput (1981) correlated the nutrient status of leaves with the yield and suggested normal range for N (1.4-2 per cent), P (0.4-0.6 per cent), K (1.2-1.4 per cent), Ca (1.2-3.0 per cent) and Mg (0.25-0.68 per cent) in guava. Kohli *et al.* (1984) found a significant correlation between fruit yield and available nitrogen in leaf was observed at 16-leaf stage in Robusta banana.

Rao and Mukherjee (1987) in mango observed a direct correlation between leaf nutrient contents and fruit yield. Hariprakashrao *et al.* (1988) studied the correlation between leaf nutrients and fruit yield in passion fruit var. Purple and reported that there were significant correlations between petiole N and fruit yield and leaf K and fruit yield. The increased level of K₂O application significantly increased fruit yield. The intra correlation between different nutrients indicated that there were synergistic effect of N on P and Ca on Fe. Further, antagonistic effect of K on Mg and Ca on Mn were noticed.

Rybin *et al.* (1979) reported leaf N content in trees growing on derno-podzolic sandy soil was directly correlated with the amount of available N in the soil, but in

trees on fertile chernozem no such correlation was noted in apple. A positive correlation was found between leaf N content and the total length of annual shoot increment growth in apricot (Marinov, 1983). Bopaiah and Srivastava (1984) carried out an experiment on mango Cv. 'Dashehari' and found no significant correlation between soil and leaf N and K was observed, however, a significant correlation was noted between available P in the deeper soil levels (60-90 cm) and leaf P. No significant relationship between leaf nutrient contents and fruit yield was noted, except for a negative relationship with leaf N. Significant or mostly significant correlations were found between yield and Mg content in January or September. A negative correlation was observed between k content and yield. P and Ca contents were not significantly correlated with yield in citrus (Liu *et al.*, 1985). Vitanova (1986) carried out an experiment in plums and reported a positive correlation between N application rate and leaf N content. Rising N rates reduced leaf Mg content. Positive correlation were determined between leaf N, P, K and Ca contents and yield. A strong positive correlation was observed between leaf N, P and K contents and yield of *L. chinensis* at harvest in August (Hasan and Chattopadhyay, 1997).

Thus, it can be concluded that leaf analysis provides a guideline for fertilization in fruit crops, though it requires to standardized sampling of leaves at different period, position and age.



Material and Methods

CHAPTER – III

MATERIAL AND METHODS

The present investigation on the “studies on leaf nutrient status in relation to different period and position in aonla (*Emblica officinalis*, Gaertn) Cv. ‘Gujarat Aonla-1’ was carried out during the 2000-2001 at the Horticultural Research Farm, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand. The materials used and methodologies adopted for this investigation are presented in this chapter.

3.1 GENERAL

3.1.1 Location

Anand, where the present investigation was undertaken has an elevation of 4.51 meters above the mean sea level and is situated at 22°-35’ North latitude and 72°-55’ East longitude.

3.1.2 Climate and weather condition

Climate of Anand, middle Gujarat region is semi-arid and tropical with hot and dry summer with mild winter. October to May are sunny months, generally receiving more than eight hours sunshine per day. Hot weather commences by about mid February and ends by about middle of June. The temperature during these months ranges from 36.7°C to 46.7°C. Winter sets in the middle of October and continues till the middle of February. Monsoon is warm and moderately humid. It commence by the middle of June and ends by the middle of September. An average annual rainfall of this region is about 836 mm.

The observations of the meteorological parameters viz., average monthly maximum and minimum temperatures, relative humidity and rainfall during 2000-

2001 recorded at the Meteorological Observatory of the Gujarat Agricultural University, Anand Campus, Anand are presented in Appendix I.

3.1.3 Soil characteristics

Experimental field had even topography with a gentle slope. The soil of the experimental site is classified as typical sandy loam, locally known as 'Goradu', which is well drained and having fairly moisture retentive capacity. It responds well to manuring and irrigation. The physico-chemical properties of the experimental field are presented in Table 3.1.

Table 3.1 : Physico-chemical composition of soil (on air dry basis)

Sr. No.	Constituents	Soil depth range	
		0-15 (cm)	15-30 (cm)
1.	Coarse sand % (Piper, 1950)	0.42	0.46
2.	Fine sand % (Piper, 1950)	82.4	85.0
3.	Silt % (Piper, 1950)	10.6	9.7
4.	Clay % (Piper, 1950)	6.00	1.00
5.	Total salts % (Soil : Water, 1:5)	0.02	0.01
6.	Total nitrogen % (Kjeldahl, A.O.A.C., 1955)	0.045	0.034
7.	Readily available phosphorus ppm (Olsen's method, Jackson, 1973)	52.2	35.4
8.	Exchangeable K mg/100 g (Flame photometer, Jackson, 1973)	38.6	32.9
9.	Organic matter % (Walkaly and Black method, Jackson, 1973)	0.5	0.7
10.	pH (Soil : Water, 1:2.5) (Buckman pH meter, Jackson, 1973)	7.3	7.1
11.	Moisture %	1.2	1.1

3.2 EXPERIMENTAL MATERIAL

The experimental material consisted of 15 years old budded trees of aonla cultivar 'Gujarat Aonla-1' being most popular commercial cultivar of Middle Gujarat, tree was of large to medium in size, leaves were of dark green colour. Stem was of brown colour. Fruits are spherical in shape, skin was very smooth, thin and yellowish

in colour and transparent. Average fruit weight was 45 gm. It contains 815 mg Vitamin 'C' in 100 gm of fruit pulp and contain less fibre. Trees are regular in bearing with an higher yielding capacity. These trees are spaced at 8 m. Maximum care was taken in selecting the trees taking into consideration the size, vigour and uniformity in flowering. The experimental trees received uniform cultural practices for irrigation and plant protection measures etc. But as far as manure and fertilizer are concern nitrogen, phosphorus, potassium and FYM each at two levels were given as soil application before on set of monsoon during 2000 with 16 treatment combinations.

(1)	Nitrogen	(N ₁)	-	1000 g/tree
(2)	Nitrogen	(N ₂)	-	1500 g/tree
(3)	Phosphorus	(P ₀)	-	0 g/tree
(4)	Phosphorus	(P ₁)	-	750 g/tree
(5)	Potash	(K ₀)	-	0 g/tree
(6)	Potash	(K ₁)	-	750 g/tree
(7)	FYM	(F ₀)	-	0 kg/tree
(8)	FYM	(F ₁)	-	100 kg/tree

3.3 EXPERIMENTAL DETAILS

3.3.1 Method of collection of leaf samples

- (i) Selection of a vegetative terminal, unless otherwise specified.
- (ii) Samples were taken at the chest height to more than two meters height from the ground level.
- (iii) Collected a composite sample from the north, south, east, west and from the plant for purpose of analysis.
- (iv) Sample collected from the permanent sampling site to monitor the changes in the nutrient status based on the recommendation and/or modified practices.
- (v) Selection of leaves, which are fully exposed to the sunlight and avoided sampling the leaves, which are in shade.
- (vi) Samples were collected prior to irrigation.
- (vii) 500 leaves of aonla were made unit of sample.
- (viii) Soiled, diseased and insect or mechanically damaged plants were avoided for sampling.

- (ix) A plants growing within the areas having unusual features has also been avoided.
- (x) Do not sample, when the plants are under water and/or temperature stress.
- (xi) Avoid sample contamination.
- (xii) Sampling was carried out early in the morning.
- (xiii) The collected material has shifted immediately to the cool containers/place.
- (xiv) The samples were stored in a refrigerator at 5°C after the transport from the field for decontaminated. Samples covered with the soil particles should not be collected as far as possible or they should be cleaned using distilled water initially.

3.3.2 Treatments

Treatments : 16 treatment combination

T ₁	N ₁ P ₀ K ₀ F ₀
T ₂	N ₁ P ₀ K ₀ F ₁
T ₃	N ₁ P ₀ K ₁ F ₀
T ₄	N ₁ P ₀ K ₁ F ₁
T ₅	N ₁ P ₁ K ₀ F ₀
T ₆	N ₁ P ₁ K ₀ F ₁
T ₇	N ₁ P ₁ K ₁ F ₀
T ₈	N ₁ P ₁ K ₁ F ₁
T ₉	N ₂ P ₀ K ₀ F ₀
T ₁₀	N ₂ P ₀ K ₀ F ₁
T ₁₁	N ₂ P ₀ K ₁ F ₀
T ₁₂	N ₂ P ₀ K ₁ F ₁
T ₁₃	N ₂ P ₁ K ₀ F ₀
T ₁₄	N ₂ P ₁ K ₀ F ₁
T ₁₅	N ₂ P ₁ K ₁ F ₀
T ₁₆	N ₂ P ₁ K ₁ F ₁

Where, N₁ = 1000 g/tree P₀ = 0 g/tree K₀ = 0 g/tree F₀ = 0 kg/tree
N₂ = 1500 g/tree P₁ = 750 g/tree K₁ = 750 g/tree F₁ = 100 kg/tree

3.3.2.1 Position of leaf (Sample collected)

Treatments : Five different position.

- (i) Basal portion of the tree.
- (ii) Middle portion of tree
 - (a) Basal portion of the indeterminate branch (M_1).
 - (b) Middle portion of the indeterminate branch (M_2).
 - (c) Top portion of the indeterminate branch (M_3).
- (iii) Top portion of the tree.

3.3.2.2 Period of sampling

At bimonthly interval (From June, 2000 to April, 2001).

P_1 = June P_4 = December

P_2 = August P_5 = February

P_3 = October P_6 = April

Replication : 3 (Three)

Design : Randomized Block Design

3.3.3 Selection of sample

Leaf sample comprising of 400-500 leaves were collected from five different position viz., Basal, Middle (Basal, Middle, Top from indeterminate branch from middle portion of tree) and top, on current season growth from 48 trees of aonla Cv. Gujarat Aonla-1. The samples were collected at bimonthly interval (i.e. age of leaf) starting from June, 2000 to April, 2001 (i.e. June, August, October, December, February and April) and sample were analyzed for N, P, K, Ca and Mg content of leaf in per cent (on dry weight basis).

3.4 OBSERVATION RECORDED

1. Nutrient elements status in leaves (N, P, K, Ca and Mg) (%).
2. Plant height (m).
3. Stem girth (m).
4. Plant spread (East-west and North-south) (m).
5. Number of fruits per tree.
6. Yield (kg/tree).

3.5 DETAILED PROCEDURE OF RECORDING OBSERVATIONS

3.5.1 Nutrient element status in leaves

3.5.1.1 Preparation of sample for chemical analysis

In order to determine the nutrient status of experimental material under study, the leaf samples were collected early in the morning as and when required. The samples were put in polythene bags separately and immediately brought to laboratory, washed with tap water, rinsed in distilled water and surface water was allowed to evaporate in shade. The samples were placed in an electric oven at 65°C for drying.

The oven dried samples were weighed up to constant dry weight. The dried samples were powdered to 40 mesh. The plant sample were wet digested by di-acid for the determination of total P, K, Ca and Mg (A.O.A.C., 1980). 0.5 g dried samples were digested by adding 20 ml of (2:1, HNO₃ : HClO₄) di-acid mixture. The flasks were kept on hot plate at 180°C to 200°C until the residues in flask became milky white. After cooling, the distilled water was added and the contents were filtered. The final volume was made to 100 ml. This aliquot was used for the determination of nutrient contents. The nitrogen was estimated by employing micro-kjeldahl's method by Jackson (1973). The phosphorus was determined by ammonium metavanadate

colorimetric method (Jackson, 1973). Potassium was estimated by flame photometer (Chapman and Prett, 1961). Calcium and Magnesium were estimated by Versanate (EDTA) titration method (Cheng and Bray, 1951).

(N, P, K, Ca and Mg) calculated in percentage by following formula.

$$(a) \quad \text{Per cent N in plant material} = \frac{0.00007 \times T \times 100 \times 100}{10 \times 0.5}$$
$$= T \times 0.14 \%$$

where, T (Titration value) = Blank titration value – Sample titration value

$$(b) \quad \text{Percent phosphorus} = \frac{C}{\text{Weight of leaf sample (g)}} \times \frac{100}{\text{Aliquot (ml taken)}} \times \frac{\text{Volume of digest (ml)}}{10,000}$$

where,

Weight of leaf sample = 0.5 g
Aliquot (digest taken) = 5 ml
Volume of digest = 50 ml or 100 ml whatever,
Concentration of P in aliquot = C ppm
(obtained from standard curve)

$$(c) \quad \text{Per cent K} = C \text{ (ppm)} \times \frac{\text{Volume of digest}}{\text{Weight of sample}} \times \frac{100}{10,00,000}$$

where,

C ppm = Concentration of K in aliquot (obtained from standard curve)

$$(d) \quad \text{Per cent Ca} = \frac{\text{Volume of EDTA} \times \text{Normality of EDTA} \times \text{Equivalent weight of calcium}}{\text{ml of aliquot taken} \times 10}$$

$$(e) \quad \text{Ca}^{++} \text{ plus Mg}^{++} \text{ per cent} =$$

$$\frac{\text{Volume of EDTA used (ml)} \times \text{Normality of EDTA} \times \text{Equivalent weight of Ca}^{++} \text{ plus Mg}^{++}}{\text{ml of aliquot taken} \times 10}$$

Per cent Magnesium = Ca⁺⁺ plus Mg⁺⁺ per cent – Calcium per cent

3.5.2 Vegetative growth parameters

3.5.2.1 Plant height

Height of trees was measured from ground level to the farthest end of the highest branch with the help of a measuring pole in metres for each tree in the experiment.

3.5.2.2 Stem girth

Girth of the stem was measured with the help of the measure tap from 2 metre height from the ground for each tree in the experiment and expressed in metres.

3.5.2.3 Plant spread

North-south and East-west plant spread of the trees was also measured with a measuring pole and expressed in metres.

3.5.3 Yield parameters

3.5.3.1 Number of fruits/tree

The total number of fruits produced per tree was also recorded at the time of harvest.

3.5.3.2 Yield

For recording yield, total produce was weighed treatment-wise at harvest. The results were expressed in kilograms per tree.

3.6 STATISTICAL ANALYSIS

The experimental data of all the parameters were subjected to the statistical analysis for proper interpretation. A standard method of analysis of variance was used for analyzing the data appropriate to the design of the experiment. Significance of difference was tested by 'F' test at 5 per cent probability level (Panse and Sukhatme, 1967).

Correlation studies

With a view to determine the relationship between the characters under study, co-efficient of correlation was worked out between yield, number of fruits, vegetative growth parameters like plant height, stem girth and plant spread (East-west and North-south) with different leaf nutrient content like N, P, K, Ca and Mg in different period.

Results

CHAPTER - IV

RESULTS

The present investigation on the “Studies of leaf nutrient status in relation to different period and position in aonla (*Emblica officinalis*, Gaertn) Cv. Gujarat Aonla-1” consists of the leaf sampling at bimonthly interval throughout the year as well as nutritional status of leaves. It also include to find out the period of stability of nutrients with respect to different period, position on the shoot and correlate the different nutrients levels with vegetative growth parameter and yield.

4.1 NITROGEN

4.1.1 Effect of treatment on leaf level of N content

Effect of different treatments on the leaf level of N content at bimonthly interval was presented (Table 4.1 and 4.2). The results revealed that the mean leaf level of N content was found significantly higher (1.442 per cent) in treatment combination $N_2P_1K_1F_1$ (i.e. at higher level of nitrogen) as compared to rest of the treatments. While, it was lowest (0.634 per cent) in treatments $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$. It is clearly seen that higher level of nitrogen reflected higher mean leaf level of N content in most of the treatments. It is also seen that an application of nitrogen along with phosphorus, potassium and farm yard manure significantly increased mean leaf level of N content in treatment $N_1P_1K_1F_1$ (0.926 per cent) as compared to application of nitrogen alone in treatment $N_1P_0K_0F_0$ (0.634 per cent).

4.1.2 Effect of period on leaf level of N content

The results presented (Table 4.1) indicated that significant difference was observed with respect to leaf level of N content at different periods of bimonthly observations. The maximum mean leaf level of N content was recorded as 2.308 per cent in the month of August. While, it was minimum (0.238 per cent) in the month of

Table 4.1 : Leaf level of N content of different periods and treatments in aonla Cv.

Gujarat Aonla-1 on dry weight basis (%)

Treatment	Periods						Mean
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	
N ₁ P ₀ K ₀ F ₀	0.188	2.010	1.236	0.140	0.088	0.142	0.634
N ₁ P ₀ K ₀ F ₁	0.288	2.140	1.264	0.230	0.122	0.162	0.701
N ₁ P ₀ K ₁ F ₀	0.194	1.952	1.216	0.166	0.130	0.147	0.634
N ₁ P ₀ K ₁ F ₁	0.326	2.266	1.278	0.356	0.142	0.170	0.756
N ₁ P ₁ K ₀ F ₀	0.204	2.292	1.287	0.222	0.172	0.144	0.720
N ₁ P ₁ K ₀ F ₁	0.357	2.674	1.323	0.536	0.179	0.170	0.873
N ₁ P ₁ K ₁ F ₀	0.264	2.344	1.330	0.272	0.195	0.174	0.763
N ₁ P ₁ K ₁ F ₁	0.386	2.638	1.426	0.656	0.240	0.210	0.926
N ₂ P ₀ K ₀ F ₀	0.702	1.848	1.432	0.909	0.252	0.448	0.931
N ₂ P ₀ K ₀ F ₁	0.762	2.418	1.518	0.949	0.262	0.519	1.072
N ₂ P ₀ K ₁ F ₀	0.783	2.054	1.583	0.846	0.290	0.408	0.995
N ₂ P ₀ K ₁ F ₁	0.876	2.558	1.650	0.962	0.306	0.614	1.161
N ₂ P ₁ K ₀ F ₀	0.716	2.172	1.700	0.832	0.324	0.552	1.049
N ₂ P ₁ K ₀ F ₁	0.994	2.622	1.815	1.030	0.342	0.707	1.252
N ₂ P ₁ K ₁ F ₀	0.950	2.232	1.968	0.932	0.362	0.896	1.223
N ₂ P ₁ K ₁ F ₁	1.226	2.702	2.170	1.106	0.396	1.052	1.442
Mean	0.576	2.308	1.512	0.634	0.238	0.407	
		S.E.m.		C.D. (0.05)		C.V. (%)	
Treatment (T)		0.016		0.044			
Period (P)		0.027		0.081		1.99	
T x P		0.025		0.070			

Where,

N₁ = 1000 g N/treeN₂ = 1500 g N/treeP₀ = 0 g P/treeP₁ = 750 g P/treeK₀ = 0 g K/treeK₁ = 750 g K/treeF₀ = 0 kg FYM/treeF₁ = 100 kg FYM/tree

and period

P₁ = June P₄ = DecemberP₂ = August P₅ = FebruaryP₃ = October P₆ = April

Table 4.2 : Leaf level of N content of different position and treatments in aonla
Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatments	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
N ₁ P ₀ K ₀ F ₀	0.593	0.622	0.612	0.703	0.640	0.634
N ₁ P ₀ K ₀ F ₁	0.653	0.682	0.692	0.770	0.708	0.701
N ₁ P ₀ K ₁ F ₀	0.600	0.613	0.632	0.686	0.640	0.634
N ₁ P ₀ K ₁ F ₁	0.733	0.742	0.738	0.817	0.752	0.756
N ₁ P ₁ K ₀ F ₀	0.682	0.709	0.708	0.785	0.717	0.720
N ₁ P ₁ K ₀ F ₁	0.818	0.877	0.885	0.893	0.893	0.873
N ₁ P ₁ K ₁ F ₀	0.697	0.745	0.748	0.842	0.783	0.763
N ₁ P ₁ K ₁ F ₁	0.867	0.898	0.917	1.012	0.937	0.926
N ₂ P ₀ K ₀ F ₀	0.845	0.873	0.912	1.057	0.965	0.931
N ₂ P ₀ K ₀ F ₁	0.975	1.010	1.065	1.220	1.095	1.072
N ₂ P ₀ K ₁ F ₀	0.923	0.947	0.995	1.100	1.017	0.995
N ₂ P ₀ K ₁ F ₁	1.052	1.100	1.165	1.315	1.175	1.161
N ₂ P ₁ K ₀ F ₀	0.965	0.983	1.030	1.187	1.082	1.049
N ₂ P ₁ K ₀ F ₁	1.140	1.182	1.227	1.443	1.267	1.252
N ₂ P ₁ K ₁ F ₀	1.148	1.158	1.185	1.392	1.233	1.223
N ₂ P ₁ K ₁ F ₁	1.358	1.365	1.377	1.637	1.473	1.442
Mean	0.878	0.907	0.930	1.053	0.962	
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment (T)		0.016		0.044		
Position (P)		0.025		0.074		1.99
T x P		0.023		0.065		

Where, sample collected from

Base = Basal portion of the tree.

Middle = Middle portion of the tree.

(a) M₁ = Basal portion of indeterminate branch.

(b) M₂ = Middle portion of indeterminate branch.

(c) M₃ = Top portion of the indeterminate branch.

Top = Top portion of the tree.

February. An application of treatment was positively and directly reflected on mean leaf level of N content in the month of August as compared to June.

4.1.3 Interaction effect (Treatment x Period) on leaf level of N content

Looking to the interaction between treatment and period (Table 4.1) showed that significantly higher leaf level of N content (2.702 per cent) was recorded with treatment combination $N_2P_1K_1F_1$ in the month of August, while, it was recorded lowest (0.088 per cent) with treatment $N_1P_0K_0F_0$ in the month of February.

4.1.4 Effect of position on leaf level of nitrogen content

The result on effect of position on leaf level of N content (Table 4.2) revealed that significantly highest leaf level of N content (1.053 per cent) was recorded at M_3 position (i.e. top position of indeterminate branch from the middle portion of tree) followed by top position of tree, M_2 , M_1 and basal portion of the tree. It was observed lowest (0.878 per cent) at the basal position and it was statistically at par with M_1 and M_2 position.

4.1.5 Interaction effect (Treatment x Position) on leaf level of N content

Interaction between treatment and position over period was found significant for leaf level of nitrogen content. It was observed significantly higher (1.637) in M_3 position in the treatment $N_2P_1K_1F_1$ (i.e. all at higher level) where it was lowest (0.593 per cent) in basal position at treatment $N_1P_0K_0F_0$ (i.e. all at lower dose) (Table 4.2).

4.1.6 Interaction effect (Period x Position) on leaf level of N content

Significantly variation in leaf level of N content in aonla leaves was observed with respect to its period and position (Table 4.3 and Fig. 1). It was fluctuated throughout the year, highest leaf level of N content (2.590 per cent) was observed in M_3 position (i.e. top position of indeterminate branch from the middle portion of tree)

Table 4.3 : Leaf level of N content in different period and position in aonla Cv.

Gujarat Aonla-1 on dry weight basis (%)

Period	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
P ₁	0.517	0.537	0.542	0.723	0.562	0.576
P ₂	2.080	2.180	2.280	2.590	2.409	2.308
P ₃	1.490	1.478	1.478	1.620	1.496	1.512
P ₄	0.582	0.634	0.652	0.664	0.642	0.635
P ₅	0.204	0.222	0.234	0.274	0.254	0.238
P ₆	0.397	0.392	0.394	0.446	0.407	0.407
Mean	0.878	0.907	0.930	1.053	0.962	
		S.Em.		C.D. (0.05)		C.V. (%)
Period		0.027		0.081		
Position		0.025		0.074		1.99
Period x Position		0.003		0.008		

Where, period

P₁ = June P₄ = December
P₂ = August P₅ = February
P₃ = October P₆ = April

Where, sample collected from

Base = Basal portion of the tree.
Middle = Middle portion of the tree.
(a) M₁ = Basal portion of indeterminate branch.
(b) M₂ = Middle portion of indeterminate branch.
(c) M₃ = Top portion of the indeterminate branch.
Top = Top portion of the tree.

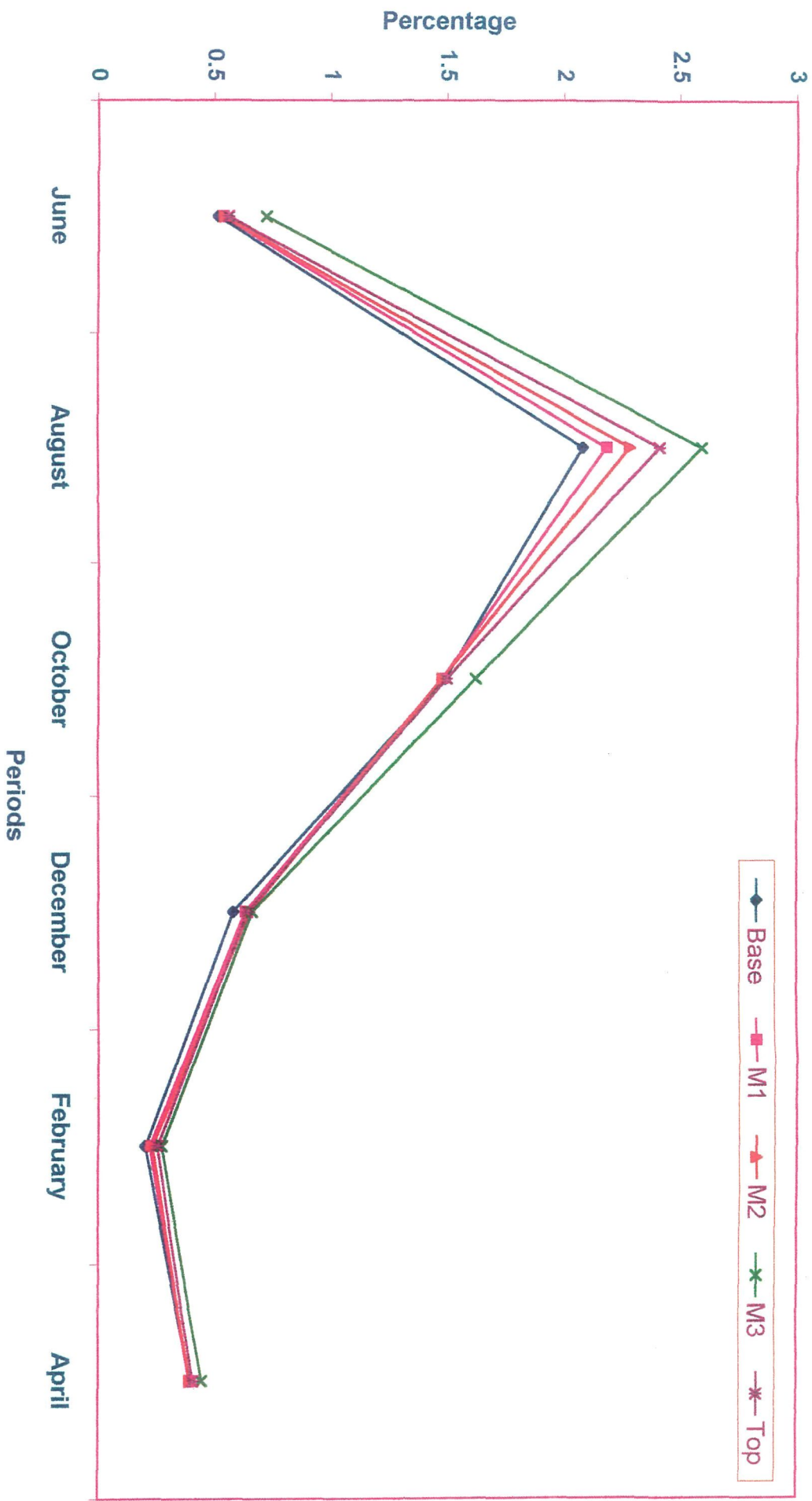


Fig. 1 : Leaf N content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1

followed by top, M₂, M₁ and Base. Interaction between period and position revealed that maximum leaf level of N content was recorded in the month of August at M₃ position of shoot, which tended to level of at top position of tree, M₂, M₁ and basal position during same month. It was found minimum in the month of February at basal position (0.204 per cent).

4.1.7 Interaction effect (Treatment x Period x Position) on leaf level of N content

Almost all interactions for leaf level of N content found significant and in consistent over period and different position (Table 4.4). Leaf level of N content (3.09 per cent) was found higher in the month of August at M₃ position with treatment N₂P₁K₁F₁ (i.e. all at higher dose) and it was statistically at par with N₂P₁K₀F₁ and N₂P₀K₁F₁ in same month and at the same position. It was observed lowest (0.08%) in the month of February at basal position with treatment N₁P₀K₀F₀ and it was at par in same month and same position with treatment N₁P₀K₁F₀ and N₁P₁K₀F₀.

4.2 PHOSPHORUS

4.2.1 Effect of treatment on leaf level of P content

The effect of different treatments on the mean leaf level of P content at bimonthly interval are presented (Table 4.5 and 4.6). The result indicated that the mean leaf level of phosphorus was found significantly higher due to treatment N₂P₁K₁F₁ (i.e. all at higher level) as compared to rest of the treatments, the value being as 0.532 per cent. While, it was recorded lower in treatment combination N₁P₀K₀F₀ and N₁P₀K₁F₀. The value recorded as 0.256 per cent for both the treatments.

Table 4.4 : Leaf level of N content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₁ P ₀ K ₀ F ₀	P ₁	0.15	0.16	0.14	0.30	0.19
	P ₂	1.90	1.96	1.97	2.20	2.02
	P ₃	1.20	1.24	1.21	1.29	1.24
	P ₄	0.10	0.14	0.13	0.18	0.15
	P ₅	0.08	0.09	0.08	0.10	0.09
	P ₆	0.13	0.14	0.14	0.15	0.15
N ₁ P ₀ K ₀ F ₁	P ₁	0.24	0.26	0.27	0.38	0.29
	P ₂	2.01	2.04	2.14	2.34	2.17
	P ₃	1.23	1.26	1.25	1.32	1.26
	P ₄	0.18	0.24	0.23	0.24	0.26
	P ₅	0.10	0.12	0.11	0.15	0.13
	P ₆	0.16	0.17	0.15	0.19	0.14
N ₁ P ₀ K ₁ F ₀	P ₁	0.15	0.14	0.18	0.34	0.16
	P ₂	1.88	1.92	1.96	2.01	1.99
	P ₃	1.22	1.21	1.20	1.24	1.21
	P ₄	0.14	0.16	0.18	0.17	0.18
	P ₅	0.09	0.11	0.13	0.17	0.15
	P ₆	0.12	0.14	0.14	0.19	0.15
N ₁ P ₀ K ₁ F ₁	P ₁	0.27	0.28	0.30	0.47	0.28
	P ₂	2.24	2.28	2.24	2.31	2.28
	P ₃	1.26	1.27	1.26	1.32	1.27
	P ₄	0.34	0.33	0.34	0.44	0.33
	P ₅	0.12	0.14	0.12	0.17	0.14
	P ₆	0.17	0.15	0.17	0.19	0.15
N ₁ P ₁ K ₀ F ₀	P ₁	0.17	0.18	0.16	0.37	0.14
	P ₂	2.21	2.26	2.25	2.42	2.32
	P ₃	1.29	1.28	1.27	1.30	1.29
	P ₄	0.17	0.24	0.26	0.23	0.21
	P ₅	0.11	0.15	0.18	0.22	0.20
	P ₆	0.14	0.14	0.13	0.17	0.14
N ₁ P ₁ K ₀ F ₁	P ₁	0.27	0.31	0.33	0.52	0.36
	P ₂	2.56	2.70	2.71	2.72	2.68
	P ₃	1.31	1.32	1.31	1.34	1.33
	P ₄	0.44	0.54	0.66	0.48	0.56
	P ₅	0.18	0.21	0.16	0.16	0.19
	P ₆	0.15	0.18	0.14	0.18	0.20
N ₁ P ₁ K ₁ F ₀	P ₁	0.22	0.22	0.21	0.44	0.23
	P ₂	2.12	2.29	2.34	2.50	2.47
	P ₃	1.33	1.31	1.32	1.37	1.32
	P ₄	0.22	0.26	0.29	0.29	0.30
	P ₅	0.13	0.20	0.19	0.23	0.22
	P ₆	0.16	0.19	0.14	0.22	0.16
N ₁ P ₁ K ₁ F ₁	P ₁	0.32	0.36	0.35	0.52	0.38
	P ₂	2.51	2.56	2.58	2.89	2.65
	P ₃	1.42	1.41	1.40	1.48	1.42
	P ₄	0.54	0.63	0.73	0.66	0.72
	P ₅	0.20	0.21	0.24	0.29	0.26
	P ₆	0.21	0.22	0.20	0.23	0.19

(Contd...)

(Contd...)

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₂ P ₀ K ₀ F ₀	P ₁	0.66	0.68	0.65	0.86	0.66
	P ₂	1.52	1.54	1.74	2.33	2.11
	P ₃	1.44	1.42	1.43	1.46	1.41
	P ₄	0.85	0.92	0.93	0.91	.93
	P ₅	0.20	0.22	0.26	0.30	0.28
	P ₆	0.40	0.46	0.46	0.48	0.40
N ₂ P ₀ K ₀ F ₁	P ₁	0.71	0.71	0.73	0.91	0.75
	P ₂	1.96	2.12	2.41	2.99	2.61
	P ₃	1.51	1.53	1.52	1.55	1.48
	P ₄	0.91	0.96	0.96	0.96	0.95
	P ₅	0.25	0.20	0.27	0.37	0.28
	P ₆	0.51	0.54	0.50	0.54	0.50
N ₂ P ₀ K ₁ F ₀	P ₁	0.72	0.74	0.76	0.92	0.78
	P ₂	1.76	1.87	2.01	2.41	2.22
	P ₃	1.58	1.56	1.57	1.62	1.59
	P ₄	0.82	0.83	0.86	0.88	0.84
	P ₅	0.24	0.28	0.37	0.33	0.29
	P ₆	0.42	0.40	0.40	0.44	0.38
N ₂ P ₀ K ₁ F ₁	P ₁	0.80	0.85	0.85	1.00	0.88
	P ₂	2.10	2.37	2.56	3.05	2.72
	P ₃	1.59	1.61	1.63	1.78	1.64
	P ₄	0.94	0.96	0.98	1.03	0.90
	P ₅	0.27	0.23	0.34	0.36	0.33
	P ₆	0.61	0.58	0.63	0.67	0.58
N ₂ P ₁ K ₀ F ₀	P ₁	0.65	0.64	0.70	.88	0.71
	P ₂	1.86	1.93	2.18	2.52	2.37
	P ₃	1.64	1.62	1.63	1.95	1.66
	P ₄	0.80	0.84	0.83	0.83	0.86
	P ₅	0.30	0.34	0.30	0.35	0.33
	P ₆	0.54	0.53	0.54	0.59	0.56
N ₂ P ₁ K ₀ F ₁	P ₁	0.90	0.94	0.96	1.20	0.97
	P ₂	2.20	2.41	2.63	3.06	2.81
	P ₃	1.72	1.74	1.75	2.11	1.76
	P ₄	0.98	1.03	1.01	1.14	0.99
	P ₅	0.32	0.29	0.35	0.39	0.36
	P ₆	0.72	0.68	0.66	0.76	0.71
N ₂ P ₁ K ₁ F ₀	P ₁	0.88	0.92	0.91	1.08	0.96
	P ₂	2.04	2.07	2.13	2.64	2.28
	P ₃	1.92	1.88	1.89	2.23	1.92
	P ₄	0.86	0.94	0.93	1.01	0.92
	P ₅	0.31	0.36	0.34	0.41	0.39
	P ₆	0.88	0.78	0.91	0.98	0.93
N ₂ P ₁ K ₁ F ₁	P ₁	1.17	1.20	1.16	1.38	1.22
	P ₂	2.43	2.51	2.64	3.09	2.84
	P ₃	2.18	1.98	2.00	2.56	2.13
	P ₄	1.02	1.12	1.11	1.18	1.10
	P ₅	0.36	0.40	0.36	0.45	0.41
	P ₆	0.99	0.98	0.99	1.16	1.14
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment x Period x Position		0.012		0.032		1.99

Table 4.5 : Leaf level of P content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatment	Periods						Mean
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	
N ₁ P ₀ K ₀ F ₀	0.104	1.144	0.084	0.062	0.038	0.102	0.256
N ₁ P ₀ K ₀ F ₁	0.194	1.214	0.162	0.138	0.096	0.166	0.328
N ₁ P ₀ K ₁ F ₀	0.112	1.142	0.084	0.062	0.038	0.096	0.256
N ₁ P ₀ K ₁ F ₁	0.161	1.193	0.176	0.152	0.116	0.180	0.330
N ₁ P ₁ K ₀ F ₀	0.158	1.224	0.174	0.146	0.086	0.144	0.322
N ₁ P ₁ K ₀ F ₁	0.220	1.276	0.242	0.208	0.146	0.206	0.383
N ₁ P ₁ K ₁ F ₀	0.166	1.180	0.176	0.134	0.082	0.142	0.313
N ₁ P ₁ K ₁ F ₁	0.324	1.234	0.294	0.258	0.180	0.294	0.431
N ₂ P ₀ K ₀ F ₀	0.170	1.136	0.148	0.118	0.082	0.145	0.300
N ₂ P ₀ K ₀ F ₁	0.230	1.170	0.192	0.164	0.116	0.183	0.342
N ₂ P ₀ K ₁ F ₀	0.154	1.130	0.116	0.086	0.048	0.126	0.277
N ₂ P ₀ K ₁ F ₁	0.236	1.200	0.208	0.170	0.100	0.220	0.356
N ₂ P ₁ K ₀ F ₀	0.248	1.212	0.212	0.170	0.124	0.236	0.367
N ₂ P ₁ K ₀ F ₁	0.308	1.270	0.310	0.252	0.168	0.320	0.438
N ₂ P ₁ K ₁ F ₀	0.352	1.200	0.302	0.246	0.152	0.488	0.457
N ₂ P ₁ K ₁ F ₁	0.431	1.278	0.392	0.316	0.174	0.600	0.532
Mean	0.223	1.200	0.204	0.168	0.109	0.228	
	S.E.m.		C.D. (0.05)			C.V. (%)	
Treatment (T)	0.004		0.010				
Period (P)	0.005		0.014			5.05	
T x P	0.005		0.014				

Where, N₁ = 1000 g N/tree K₀ = 0 g K/tree
 N₂ = 1500 g N/tree K₁ = 750 g K/tree
 P₀ = 0 g P/tree F₀ = 0 kg FYM/tree
 P₁ = 750 g P/tree F₁ = 100 kg FYM/tree

and period

P₁ = June P₄ = December
 P₂ = August P₅ = February
 P₃ = October P₆ = April

Table 4.6 : Leaf level of P content of different position and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatments	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
N ₁ P ₀ K ₀ F ₀	0.273	0.262	0.258	0.248	0.237	0.256
N ₁ P ₀ K ₀ F ₁	0.343	0.335	0.332	0.323	0.308	0.328
N ₁ P ₀ K ₁ F ₀	0.268	0.262	0.255	0.252	0.237	0.256
N ₁ P ₀ K ₁ F ₁	0.343	0.338	0.330	0.326	0.310	0.329
N ₁ P ₁ K ₀ F ₀	0.338	0.332	0.325	0.317	0.298	0.322
N ₁ P ₁ K ₀ F ₁	0.402	0.393	0.385	0.377	0.358	0.383
N ₁ P ₁ K ₁ F ₀	0.333	0.327	0.313	0.303	0.290	0.313
N ₁ P ₁ K ₁ F ₁	0.452	0.440	0.432	0.423	0.407	0.431
N ₂ P ₀ K ₀ F ₀	0.322	0.311	0.298	0.293	0.275	0.300
N ₂ P ₀ K ₀ F ₁	0.358	0.350	0.344	0.340	0.320	0.342
N ₂ P ₀ K ₁ F ₀	0.292	0.287	0.280	0.273	0.252	0.277
N ₂ P ₀ K ₁ F ₁	0.380	0.370	0.358	0.350	0.320	0.356
N ₂ P ₁ K ₀ F ₀	0.392	0.380	0.372	0.365	0.327	0.367
N ₂ P ₁ K ₀ F ₁	0.468	0.458	0.440	0.430	0.393	0.438
N ₂ P ₁ K ₁ F ₀	0.483	0.478	0.458	0.450	0.413	0.457
N ₂ P ₁ K ₁ F ₁	0.573	0.560	0.532	0.526	0.468	0.531
Mean	0.376	0.368	0.357	0.350	0.326	
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment (T)		0.004		0.010		
Position (P)		0.004		0.012		5.05
T x P		0.005		0.013		

Where, sample collected from

Base = Basal portion of the tree.

Middle= Middle portion of the tree.

(a) M₁ = Basal portion of indeterminate branch.

(b) M₂ = Middle portion of indeterminate branch.

(c) M₃ = Top portion of the indeterminate branch.

Top = Top portion of the tree.

4.2.2 Effect of period on leaf level of P content

The result presented (Table 4.6) revealed that significant difference was observed in mean leaf level of P content at bimonthly interval. The highest mean leaf level of P content (1.200 per cent) was recorded in P₂ period (in the month of August). While, it was found lowest as 0.109 per cent in P₅ period (i.e. in the month of February). The results indicated that mean leaf level of P content was decreased up to the month of February and then after it was increased in the month of April.

4.2.3 Interaction effect (Treatment x Period) on leaf level of P content

An interaction between treatment and period was found to be significant for leaf level of P content (Table 4.5). The result revealed that significantly highest leaf level of P content (1.278 per cent) was recorded in P₂ period (in the month of August) due to treatment N₂P₁K₁F₁ and it was statistically at par in the same month in treatment N₁P₁K₀F₁ and N₂P₁K₀F₁ the value recorded as 1.276 per cent and 1.270 per cent, respectively. Whereas, lowest leaf level of P content (0.038 per cent) was observed in P₅ (in the month of February) with treatment combination N₁P₀K₀F₀ (i.e. all the lower level) and N₁P₀K₁F₀.

4.2.4 Effect of position on leaf level of P content

The result (Table 4.6) indicated that significantly higher mean leaf level of P content was recorded at the basal position (0.376 per cent) and it was statistically at par with M₁ position (i.e. basal position of indeterminate branch) while, it was significantly lowest at the top position and value being as 0.326 per cent. It was clearly seen from the results that mean leaf level of P content decreased from base to the top position of shoot.

4.2.5 Interaction effect (Treatment x Position) on leaf level of P content

An interaction between treatment and position over period was found to be significant for leaf level of P content (Table 4.6). It was highest (0.573 per cent) due to treatment $N_2P_1K_1F_1$ (i.e. all at higher level) at basal position and which was at par with M_1 position (basal position of indeterminate branch) the value being recorded as 0.560 per cent whereas significantly lowest leaf level of P content (0.237 per cent) was recorded in top position at treatment combination $N_1P_0K_0F_0$ (i.e. all at lower level).

4.2.6 Interaction effect (Period x Position) on leaf level of P content

Period of sampling and position of leaf interacted significantly in respect to leaf level of P content and presented (Table 4.7 and Fig. 2). The highest (1.221 per cent) was noted in the month of August at basal position and it was statistically at par with $P_2 \times M_1$ interaction (1.215 per cent) (i.e. in the same month at basal position of indeterminate branch). While, it was lowest 0.097 per cent in the month of February at the top position ($P_5 \times Top$). The result also indicated that there was gradual decrease in leaf level of P content from base to top position throughout the year.

4.2.7 Interaction effect (Treatment x Period x Position) on leaf level of P content

The treatment, period and position interaction significantly for leaf level of P content (Table 4.8). Significantly highest leaf level of P content (1.32 per cent) was observed in the month of August at basal position due to treatment $N_2P_1K_1F_1$ and it was statistically at par in the same month at same position due to treatment $N_1P_1K_0F_1$ and $N_2P_1K_0F_1$. Lowest leaf level of P content (0.03 per cent) was found in the month

Table 4.7 : Leaf level of P content in different period and position in aonla Cv.

Gujarat Aonla-1 on dry weight basis (%)

Period	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
P ₁	0.237	0.231	0.224	0.218	0.205	0.223
P ₂	1.221	1.215	1.208	1.198	1.158	1.200
P ₃	0.226	0.217	0.211	0.205	0.163	0.204
P ₄	0.205	0.195	0.162	0.155	0.121	0.168
P ₅	0.123	0.114	0.109	0.101	0.097	0.109
P ₆	0.245	0.234	0.227	0.222	0.211	0.228
Mean	0.376	0.368	0.357	0.350	0.326	
		S.Em.		C.D. (0.05)		C.V. (%)
Period		0.005		0.014		
Position		0.004		0.012		5.05
Period x Position		0.003		0.007		

Where, period

P₁ = June P₄ = December
P₂ = August P₅ = February
P₃ = October P₆ = April

Where, sample collected from

Base = Basal portion of the tree.
Middle = Middle portion of the tree.
(a) M₁ = Basal portion of indeterminate branch.
(b) M₂ = Middle portion of indeterminate branch.
(c) M₃ = Top portion of the indeterminate branch.
Top = Top portion of the tree.

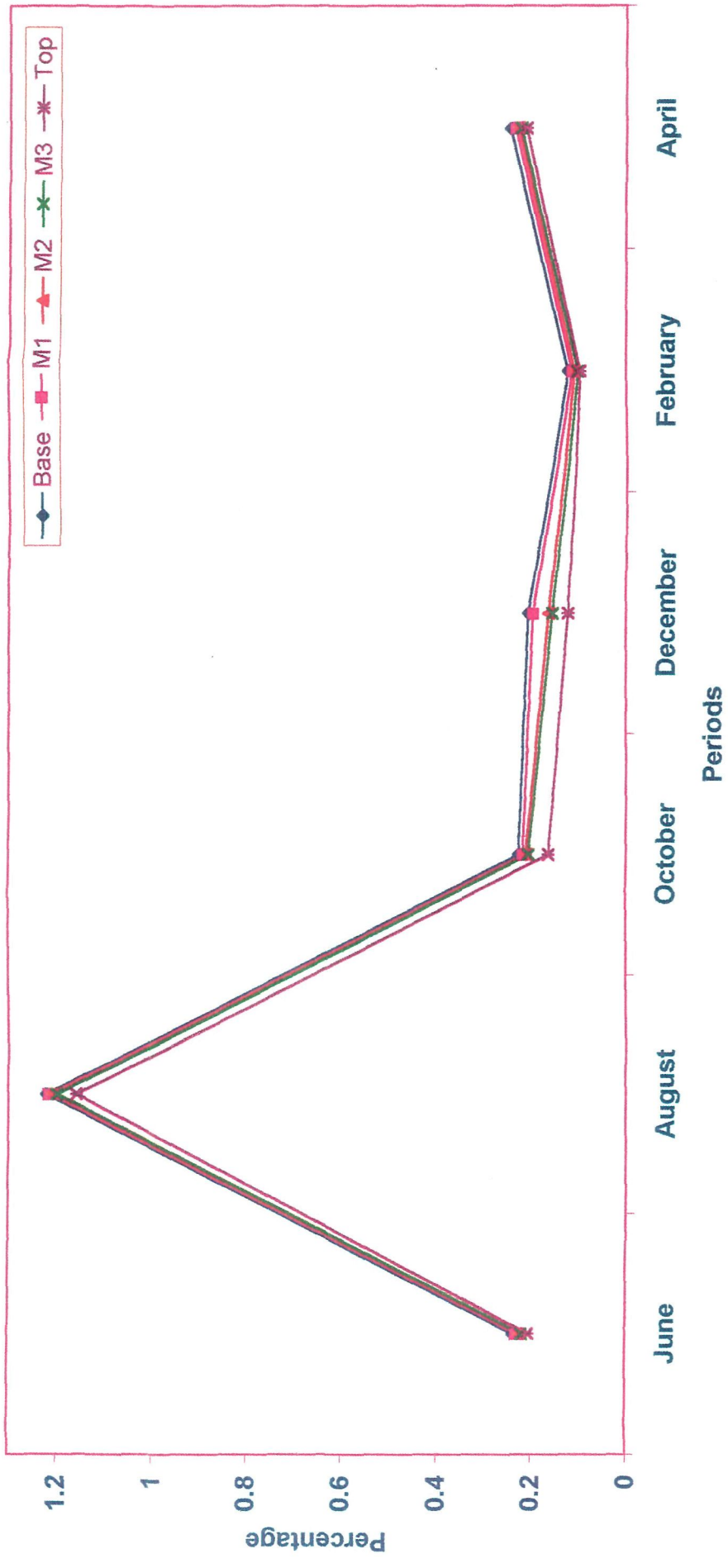


Fig. 2 : Leaf P content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1

Table 4.8 : Leaf level of P content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₁ P ₀ K ₀ F ₀	P ₁	0.13	0.11	0.11	0.09	0.08
	P ₂	1.16	1.15	1.15	1.14	1.12
	P ₃	0.10	0.09	0.09	0.08	0.06
	P ₄	0.08	0.07	0.06	0.06	0.04
	P ₅	0.04	0.04	0.04	0.04	0.03
	P ₆	0.13	0.11	0.10	0.09	0.08
N ₁ P ₀ K ₀ F ₁	P ₁	0.20	0.20	0.20	0.19	0.18
	P ₂	1.23	1.22	1.22	1.21	1.19
	P ₃	0.18	0.17	0.16	0.16	0.14
	P ₄	0.16	0.15	0.14	0.13	0.11
	P ₅	0.11	0.10	0.10	0.09	0.08
	P ₆	0.18	0.17	0.17	0.16	0.15
N ₁ P ₀ K ₁ F ₀	P ₁	0.12	0.12	0.11	0.11	0.10
	P ₂	1.16	1.15	1.15	1.14	1.11
	P ₃	0.10	0.09	0.08	0.08	0.07
	P ₄	0.08	0.07	0.06	0.06	0.04
	P ₅	0.04	0.04	0.04	0.04	0.03
	P ₆	0.11	0.10	0.10	0.06	0.08
N ₁ P ₀ K ₁ F ₁	P ₁	0.17	0.17	0.15	0.16	0.15
	P ₂	1.20	1.21	1.20	1.19	1.16
	P ₃	0.19	0.18	0.18	0.17	0.16
	P ₄	0.17	0.16	0.16	0.15	0.12
	P ₅	0.13	0.12	0.11	0.11	0.11
	P ₆	0.20	0.19	0.18	0.17	0.16
N ₁ P ₁ K ₀ F ₀	P ₁	0.17	0.17	0.16	0.15	0.14
	P ₂	1.24	1.24	1.23	1.21	1.20
	P ₃	0.19	0.18	0.18	0.17	0.15
	P ₄	0.17	0.16	0.15	0.15	0.10
	P ₅	0.10	0.09	0.09	0.08	0.07
	P ₆	0.16	0.15	0.14	0.14	0.13
N ₁ P ₁ K ₀ F ₁	P ₁	0.24	0.23	0.22	0.21	0.20
	P ₂	1.29	1.28	1.28	1.27	1.26
	P ₃	0.26	0.25	0.25	0.24	0.21
	P ₄	0.24	0.23	0.21	0.20	0.16
	P ₅	0.16	0.15	0.15	0.14	0.13
	P ₆	0.23	0.21	0.20	0.20	0.19
N ₁ P ₁ K ₁ F ₀	P ₁	0.19	0.17	0.17	0.15	0.15
	P ₂	1.20	1.20	0.18	1.17	1.15
	P ₃	0.20	0.20	0.17	0.16	0.15
	P ₄	0.16	0.15	0.14	0.13	0.09
	P ₅	0.10	0.09	0.08	0.07	0.07
	P ₆	0.15	0.15	0.14	0.14	0.13
N ₁ P ₁ K ₁ F ₁	P ₁	0.33	0.33	0.33	0.32	0.31
	P ₂	1.26	1.24	1.23	1.22	1.22
	P ₃	0.37	0.30	0.30	0.30	0.26
	P ₄	0.30	0.29	0.26	0.24	0.20
	P ₅	0.20	0.19	0.18	0.17	0.16
	P ₆	0.30	0.29	0.29	0.29	0.29

(Contd...)

(Contd...)

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₂ P ₀ K ₀ F ₀	P ₁	0.19	0.18	0.17	0.16	0.15
	P ₂	1.17	1.15	1.14	1.13	1.09
	P ₃	0.17	0.16	0.15	0.15	0.11
	P ₄	0.15	0.14	0.11	0.10	0.09
	P ₅	0.09	0.08	0.08	0.08	0.08
	P ₆	0.16	0.15	0.14	0.14	0.13
N ₂ P ₀ K ₀ F ₁	P ₁	0.24	0.24	0.23	0.22	0.22
	P ₂	1.19	1.18	1.18	1.17	1.13
	P ₃	0.21	0.20	0.19	0.19	0.17
	P ₄	0.19	0.18	0.17	0.16	0.12
	P ₅	0.13	0.12	0.12	0.11	0.10
	P ₆	0.19	0.18	0.17	0.19	0.18
N ₂ P ₀ K ₁ F ₀	P ₁	0.16	0.16	0.16	0.15	0.14
	P ₂	1.14	1.15	1.14	1.14	1.08
	P ₃	0.14	0.13	0.12	0.11	0.08
	P ₄	0.11	0.10	0.08	0.08	0.06
	P ₅	0.06	0.05	0.05	0.04	0.04
	P ₆	0.14	0.13	0.13	0.12	0.11
N ₂ P ₀ K ₁ F ₁	P ₁	0.25	0.24	0.24	0.23	0.22
	P ₂	1.23	1.22	1.21	1.20	1.14
	P ₃	0.23	0.22	0.22	0.21	0.16
	P ₄	0.21	0.20	0.16	0.16	0.12
	P ₅	0.12	0.11	0.10	0.09	0.08
	P ₆	0.24	0.23	0.22	0.21	0.20
N ₂ P ₁ K ₀ F ₀	P ₁	0.26	0.25	0.24	0.26	0.23
	P ₂	1.25	1.24	1.24	1.22	1.11
	P ₃	0.24	0.23	0.22	0.21	0.16
	P ₄	0.21	0.20	0.16	0.15	0.13
	P ₅	0.14	0.12	0.13	0.12	0.11
	P ₆	0.25	0.24	0.24	0.23	0.22
N ₂ P ₁ K ₀ F ₁	P ₁	0.33	0.32	0.31	0.30	0.28
	P ₂	1.30	1.29	1.28	1.27	1.21
	P ₃	0.34	0.33	.33	0.32	0.23
	P ₄	0.32	0.31	0.23	0.22	0.18
	P ₅	0.18	0.17	0.17	0.16	0.16
	P ₆	0.34	0.33	0.32	0.31	0.30
N ₂ P ₁ K ₁ F ₀	P ₁	0.36	0.36	0.36	0.35	0.33
	P ₂	1.21	1.22	1.21	1.20	1.16
	P ₃	0.33	0.32	0.32	0.32	0.22
	P ₄	0.32	0.31	0.22	0.21	0.17
	P ₅	0.17	0.16	0.15	0.14	0.14
	P ₆	0.51	0.50	0.49	0.48	0.46
N ₂ P ₁ K ₁ F ₁	P ₁	0.45	0.44	0.43	0.43	0.41
	P ₂	1.32	1.30	1.29	1.28	1.20
	P ₃	0.43	0.42	0.41	0.41	0.29
	P ₄	0.41	0.40	0.29	0.28	0.20
	P ₅	0.20	0.19	0.17	0.16	0.15
	P ₆	0.63	0.61	0.60	0.60	0.56
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment x Period x Position		0.010		0.029		5.05

of February in treatment combination $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$ at the top position and it was statistically at par with $N_2P_0K_1F_0$ in the same month and at the similar shoot position and again it was at par with treatment $N_1P_0K_0F_0$, $N_1P_0K_1F_0$ and $N_2P_0K_1F_0$ in the same month but with M_3 position (i.e. top position of indeterminate branch).

4.3 POTASSIUM

4.3.1 Effect of treatment on leaf level of K content

The effect of different treatments on mean leaf level of K content at bimonthly interval are presented (Table 4.9 and 4.10). The result indicated that mean leaf level of K content was found significantly higher due to treatment combination $N_2P_1K_1F_1$ (i.e. all at higher level) as compared to rest of the treatments and the value recorded as 0.954 per cent. While, it was lowest as 0.187 per cent in treatment $N_1P_0K_0F_0$ (i.e. all at lower level). It was also seen that K at higher level (i.e. K_1 750 g/tree) with FYM (F_1 100 kg/tree) with N and P combination, in most of cases recorded higher mean leaf level of K content than lower level.

4.3.2 Effect of period on leaf level of K content

The result (Table 4.9) revealed that significant differences was observed in respect to mean leaf level of K content at bimonthly interval. The highest mean leaf level of K content (0.753 per cent) was found in the month of June. While, it was lowest (0.336 per cent) in the month of April and it was statistically at par with mean leaf level of K content in August and February. The value being 0.346 and 0.351 per cent, respectively. It was also observed that the mean leaf level of K content did not show any specific pattern as it fluctuated throughout the year.

Table 4.9 : Leaf level of K content of different periods and treatments in aonla Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatment	Periods						Mean
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	
N ₁ P ₀ K ₀ F ₀	0.426	0.124	0.156	0.156	0.134	0.124	0.187
N ₁ P ₀ K ₀ F ₁	0.518	0.192	0.226	0.224	0.200	0.190	0.258
N ₁ P ₀ K ₁ F ₀	0.572	0.244	0.232	0.232	0.210	0.200	0.282
N ₁ P ₀ K ₁ F ₁	0.613	0.352	0.274	0.284	0.233	0.230	0.331
N ₁ P ₁ K ₀ F ₀	0.394	0.132	0.200	0.206	0.186	0.170	0.215
N ₁ P ₁ K ₀ F ₁	0.480	0.190	0.340	0.344	0.216	0.218	0.298
N ₁ P ₁ K ₁ F ₀	0.686	0.350	0.438	0.438	0.258	0.244	0.402
N ₁ P ₁ K ₁ F ₁	0.804	0.504	0.584	0.588	0.328	0.316	0.521
N ₂ P ₀ K ₀ F ₀	0.660	0.168	0.420	0.426	0.228	0.220	0.354
N ₂ P ₀ K ₀ F ₁	0.746	0.170	0.466	0.472	0.376	0.366	0.433
N ₂ P ₀ K ₁ F ₀	0.906	0.478	0.736	0.740	0.336	0.318	0.586
N ₂ P ₀ K ₁ F ₁	1.052	0.710	0.792	0.794	0.462	0.450	0.710
N ₂ P ₁ K ₀ F ₀	0.768	0.170	0.546	0.548	0.384	0.364	0.463
N ₂ P ₁ K ₀ F ₁	0.879	0.234	0.590	0.596	0.526	0.500	0.554
N ₂ P ₁ K ₁ F ₀	1.234	0.674	0.914	0.921	0.700	0.690	0.856
N ₂ P ₁ K ₁ F ₁	1.302	0.820	0.987	0.996	0.844	0.780	0.954
Mean	0.753	0.346	0.494	0.498	0.351	0.336	
		S.Em.		C.D. (0.05)		C.V. (%)	
Treatment (T)		0.007		0.019			
Period (P)		0.006		0.017		4.07	
T x P		0.009		0.025			

Where,

N₁ = 1000 g N/tree

N₂ = 1500 g N/tree

P₀ = 0 g P/tree

P₁ = 750 g P/tree

K₀ = 0 g K/tree

K₁ = 750 g K/tree

F₀ = 0 kg FYM/tree

F₁ = 100 kg FYM/tree

and period

P₁ = June P₄ = December

P₂ = August P₅ = February

P₃ = October P₆ = April

Table 4.10 : Leaf level of K content of different position and treatments in aonla
Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatments	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
N ₁ P ₀ K ₀ F ₀	0.170	0.175	0.180	0.210	0.198	0.187
N ₁ P ₀ K ₀ F ₁	0.235	0.243	0.257	0.282	0.275	0.258
N ₁ P ₀ K ₁ F ₀	0.258	0.268	0.277	0.307	0.298	0.282
N ₁ P ₀ K ₁ F ₁	0.300	0.311	0.327	0.361	0.357	0.331
N ₁ P ₁ K ₀ F ₀	0.185	0.198	0.207	0.245	0.238	0.215
N ₁ P ₁ K ₀ F ₁	0.282	0.285	0.297	0.318	0.308	0.298
N ₁ P ₁ K ₁ F ₀	0.378	0.390	0.402	0.425	0.417	0.402
N ₁ P ₁ K ₁ F ₁	0.497	0.508	0.513	0.545	0.540	0.521
N ₂ P ₀ K ₀ F ₀	0.332	0.342	0.350	0.375	0.370	0.354
N ₂ P ₀ K ₀ F ₁	0.410	0.418	0.432	0.457	0.447	0.433
N ₂ P ₀ K ₁ F ₀	0.563	0.573	0.588	0.602	0.602	0.586
N ₂ P ₀ K ₁ F ₁	0.682	0.688	0.705	0.742	0.733	0.710
N ₂ P ₁ K ₀ F ₀	0.423	0.435	0.452	0.513	0.493	0.463
N ₂ P ₁ K ₀ F ₁	0.518	0.527	0.548	0.598	0.579	0.554
N ₂ P ₁ K ₁ F ₀	0.807	0.813	0.838	0.920	0.900	0.856
N ₂ P ₁ K ₁ F ₁	0.885	0.907	0.932	1.052	0.997	0.954
Mean	0.433	0.443	0.456	0.497	0.485	
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment (T)		0.007		0.019		
Position (P)		0.001		0.003		4.07
T x P		0.004		0.012		

Where, sample collected from

Base = Basal portion of the tree.

Middle = Middle portion of the tree.

(a) M₁ = Basal portion of indeterminate branch.

(b) M₂ = Middle portion of indeterminate branch.

(c) M₃ = Top portion of the indeterminate branch.

Top = Top portion of the tree.

4.3.3 Interaction effect (Treatment x Period) on leaf level of K content

Looking to the interaction between treatment and period, which was significant for leaf level of K content (Table 4.9). Significantly highest leaf level of K content (1.302 per cent) was recorded in the month of June due to treatment $N_2P_1K_1F_1$. While, it was lowest as 0.124 per cent noted in the month of August and April in treatment combination of $N_1P_0K_0F_0$ (i.e. all at lower level) and it was statistically at par with treatment $N_1P_1K_0F_0$ (0.132 per cent) in the month of June.

4.3.4 Effect of position on leaf level of K content

The effect of different position on mean leaf level of K content was observed (Table 4.10). Significantly higher (0.497 per cent) in the M_3 position of shoot (i.e. top position of indeterminate branch). While, it was lower as 0.433 per cent in the basal position. Further, the results also showed that leaf level of K content was increased from basal position to top position of shoot of indeterminate branch.

4.3.5 Interaction effect (Treatment x Position) on leaf level of K content

Treatment and position of shoot interacted significantly over period for leaf level of K content (Table 4.10). It was recorded maximum in M_3 shoot position (1.052 per cent) due to $N_2P_1K_1F_1$ treatment and minimum was in treatment $N_1P_0K_0F_0$ (0.170 per cent) at basal position and again it was statistically at par with M_1 position (0.175 per cent) with same treatment.

4.3.6 Interaction effect (Period x Position) on leaf level of K content

Leaf level of K content of aonla branch has recorded at two month interval from different position of shoot are presented (Table 4.11 and Fig. 3). It was decreased abruptly in the month of August and remaining constant from October to December. It decreased significantly in February. However, significantly highest

Table 4.11: Leaf level of K content in different period and position in aonla Cv.

Gujarat Aonla-1 on dry weight basis (%)

Period	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
P ₁	0.698	0.723	0.746	0.802	0.795	0.753
P ₂	0.307	0.378	0.328	0.386	0.385	0.346
P ₃	0.469	0.473	0.488	0.531	0.507	0.494
P ₄	0.474	0.481	0.492	0.533	0.509	0.498
P ₅	0.333	0.338	0.349	0.373	0.363	0.351
P ₆	0.317	0.324	0.335	0.358	0.348	0.336
Mean	0.433	0.443	0.456	0.497	0.485	
		S.Em.		C.D. (0.05)		C.V. (%)
Period		0.006		0.017		
Position		0.001		0.003		4.07
Period x Position		0.003		0.008		

Where, period

P₁ = June P₄ = December
P₂ = August P₅ = February
P₃ = October P₆ = April

Where, sample collected from

Base = Basal portion of the tree.
Middle = Middle portion of the tree.
(a) M₁ = Basal portion of indeterminate branch.
(b) M₂ = Middle portion of indeterminate branch.
(c) M₃ = Top portion of the indeterminate branch.
Top = Top portion of the tree.

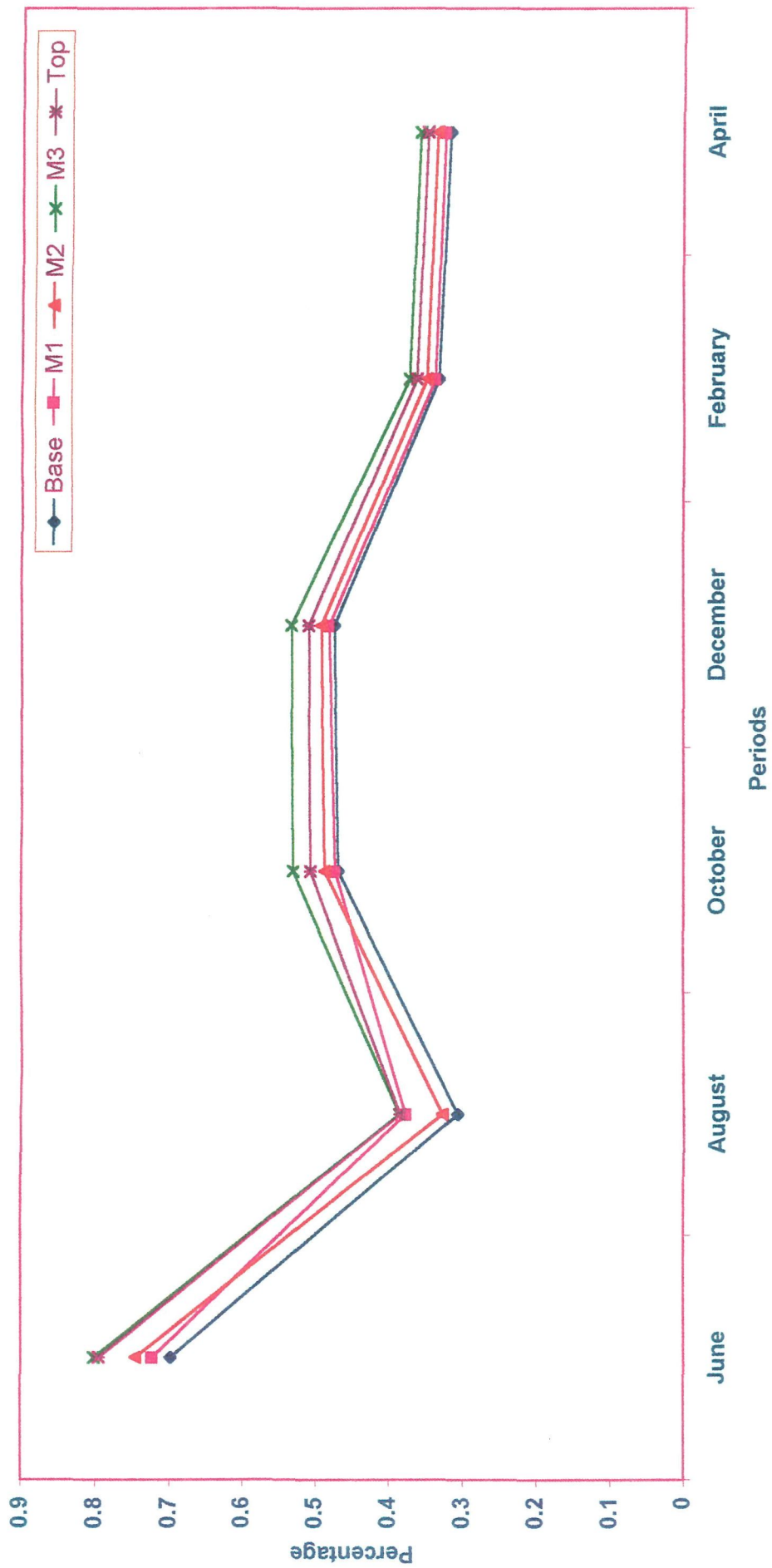


Fig. 3 : Leaf K content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1

value was estimated at M₃ position of shoot (i.e. top position of indeterminate branch) in the month of June (0.802 per cent) and it was statistically at par with top position of shoot in the same month (0.795 per cent). It was noted lowest in the month of August at basal position of shoot (0.307 per cent).

4.3.7 Interaction effect (Treatment x Period x Position) on leaf level of K content

The effect of all the three factors interacted significantly i.e. treatment, period and position are illustrated (Table 4.12). Significantly highest leaf level of K content was recorded in treatment N₂P₁K₁F₁ in the month of June at M₃ shoot position (1.41 per cent) and it was statistically at par with N₂P₁K₁F₁ in the same period at top position. While, it was lowest as (0.10 per cent) in the month of August due to treatment N₁P₁K₀F₀ at basal position and it was also at par with N₁P₀K₀F₀ in the month of August, February and April at basal position.

4.4 CALCIUM

4.4.1 Effect of treatment on leaf level of Ca content

The effect of different treatments in mean leaf level of Ca content at bimonthly interval are illustrated (Table 4.13 and 4.14). The results revealed that significantly higher (1.120 per cent) leaf level of Ca content was recorded in treatment combination N₂P₁K₁F₁ (i.e. all factors at higher level) as compared to rest of the treatment. While, significantly lower value was recorded (0.649 per cent) in treatment N₁P₀K₀F₀. It was also observed that nitrogen at higher level in combination with phosphorus, potassium and farm yard manure recorded the higher level of mean leaf Ca content as compared to lower levels.

Table 4.12 : Leaf level of K content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₁ P ₀ K ₀ F ₀	P ₁	0.39	0.40	0.66	0.46	0.46
	P ₂	0.11	0.14	0.16	0.13	0.13
	P ₃	0.14	0.13	0.41	0.19	0.17
	P ₄	0.14	0.14	0.42	0.19	0.16
	P ₅	0.12	0.13	0.23	0.15	0.14
	P ₆	0.12	0.11	0.22	0.14	0.13
N ₁ P ₀ K ₀ F ₁	P ₁	0.48	0.49	0.74	0.56	0.55
	P ₂	0.15	0.17	0.17	0.23	0.23
	P ₃	0.22	0.22	0.47	0.23	0.23
	P ₄	0.21	0.21	0.48	0.24	0.23
	P ₅	0.18	0.19	0.37	0.22	0.21
	P ₆	0.17	0.18	0.36	0.21	0.20
N ₁ P ₀ K ₁ F ₀	P ₁	0.53	0.55	0.91	0.61	0.60
	P ₂	0.19	0.21	0.47	0.31	0.31
	P ₃	0.23	0.23	0.74	0.24	0.22
	P ₄	0.23	0.23	0.75	0.23	0.23
	P ₅	0.19	0.20	0.34	0.23	0.22
	P ₆	0.18	0.19	0.32	0.22	0.21
N ₁ P ₀ K ₁ F ₁	P ₁	0.54	0.56	1.05	0.68	0.68
	P ₂	0.30	0.32	0.68	0.40	0.41
	P ₃	0.26	0.27	0.80	0.28	0.28
	P ₄	0.27	0.28	0.79	0.29	0.29
	P ₅	0.22	0.21	0.46	0.26	0.24
	P ₆	0.21	0.22	0.45	0.25	0.24
N ₁ P ₁ K ₀ F ₀	P ₁	0.32	0.34	0.76	0.48	0.47
	P ₂	0.10	0.12	0.18	0.16	0.16
	P ₃	0.18	0.19	0.52	0.22	0.21
	P ₄	0.19	0.20	0.51	0.22	0.22
	P ₅	0.17	0.18	0.38	0.20	0.19
	P ₆	0.15	0.16	0.36	0.19	0.18
N ₁ P ₁ K ₀ F ₁	P ₁	0.44	0.46	0.90	0.52	0.50
	P ₂	0.17	0.19	0.23	0.19	0.20
	P ₃	0.33	0.32	0.56	0.36	0.35
	P ₄	0.34	0.32	0.57	0.37	0.35
	P ₅	0.21	0.21	0.53	0.24	0.22
	P ₆	0.20	0.21	0.50	0.23	0.23
N ₁ P ₁ K ₁ F ₀	P ₁	0.64	0.69	1.20	0.71	0.71
	P ₂	0.31	0.33	0.62	0.39	0.38
	P ₃	0.42	0.42	0.91	0.46	0.45
	P ₄	0.43	0.41	0.92	0.46	0.44
	P ₅	0.24	0.25	0.69	0.27	0.27
	P ₆	0.23	0.24	0.69	0.26	0.25
N ₁ P ₁ K ₁ F ₁	P ₁	0.78	0.82	1.30	0.81	0.81
	P ₂	0.44	0.46	0.78	0.58	0.57
	P ₃	0.58	0.57	0.94	0.60	0.59
	P ₄	0.57	0.58	0.95	0.60	0.60
	P ₅	0.31	0.32	0.84	0.34	0.34
	P ₆	0.30	0.30	0.78	0.34	0.33

(Contd...)

(Contd...)

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₂ P ₀ K ₀ F ₀	P ₁	0.61	0.64	0.42	0.70	0.69
	P ₂	0.14	0.14	0.11	0.20	0.20
	P ₃	0.41	0.42	0.15	0.43	0.43
	P ₄	0.42	0.43	0.15	0.43	0.43
	P ₅	0.21	0.21	0.13	0.25	0.24
	P ₆	0.20	0.21	0.12	0.24	0.23
N ₂ P ₀ K ₀ F ₁	P ₁	0.74	0.74	0.51	0.76	0.75
	P ₂	0.15	0.15	0.18	0.19	0.19
	P ₃	0.44	0.45	0.23	0.49	0.48
	P ₄	0.43	0.46	0.23	0.50	0.49
	P ₅	0.36	0.36	0.20	0.40	0.39
	P ₆	0.34	0.35	0.19	0.40	0.38
N ₂ P ₀ K ₁ F ₀	P ₁	0.88	0.90	0.57	0.92	0.92
	P ₂	0.45	0.45	0.20	0.50	0.52
	P ₃	0.71	0.72	0.24	0.76	0.75
	P ₄	0.72	0.73	0.24	0.75	0.75
	P ₅	0.32	0.33	0.21	0.35	0.34
	P ₆	0.30	0.31	0.20	0.33	0.33
N ₂ P ₀ K ₁ F ₁	P ₁	0.98	1.02	0.60	1.11	1.10
	P ₂	0.66	0.66	0.33	0.78	0.77
	P ₃	0.78	0.78	0.28	0.80	0.80
	P ₄	0.79	0.78	0.29	0.80	0.80
	P ₅	0.45	0.45	0.23	0.48	0.47
	P ₆	0.43	0.44	0.23	0.47	0.46
N ₂ P ₁ K ₀ F ₀	P ₁	0.69	0.72	0.36	0.83	0.84
	P ₂	0.16	0.16	0.12	0.18	0.17
	P ₃	0.49	0.50	0.20	0.64	0.58
	P ₄	0.50	0.51	0.20	0.64	0.58
	P ₅	0.36	0.37	0.19	0.40	0.41
	P ₆	0.34	0.35	0.17	0.39	0.38
N ₂ P ₁ K ₀ F ₁	P ₁	0.84	0.87	0.48	0.90	0.88
	P ₂	0.21	0.21	0.20	0.26	0.26
	P ₃	0.53	0.54	0.34	0.68	0.64
	P ₄	0.54	0.55	0.34	0.68	0.64
	P ₅	0.51	0.52	0.20	0.54	0.53
	P ₆	0.48	0.47	0.22	0.53	0.52
N ₂ P ₁ K ₁ F ₀	P ₁	1.12	1.14	0.68	1.36	1.35
	P ₂	0.61	0.61	0.34	0.77	0.76
	P ₃	0.88	0.89	0.44	0.96	0.93
	P ₄	0.89	0.90	0.45	0.97	0.93
	P ₅	0.68	0.67	0.26	0.74	0.72
	P ₆	0.66	0.67	0.24	0.72	0.71
N ₂ P ₁ K ₁ F ₁	P ₁	1.18	1.22	0.80	1.41	1.40
	P ₂	0.76	0.76	0.47	0.90	0.90
	P ₃	0.90	0.92	0.58	1.16	1.00
	P ₄	0.91	0.96	0.59	1.15	1.01
	P ₅	0.80	0.81	0.33	0.89	0.88
	P ₆	0.76	0.77	0.31	0.80	0.79
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment x Period x Position		0.011		0.030		4.07

Table 4.13 : Leaf level of Ca content of different periods and treatments in aonla
Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatment	Periods						Mean
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	
N ₁ P ₀ K ₀ F ₀	0.346	0.854	0.920	0.762	0.620	0.392	0.649
N ₁ P ₀ K ₀ F ₁	0.390	0.948	0.968	0.806	0.636	0.426	0.696
N ₁ P ₀ K ₁ F ₀	0.350	0.914	1.000	0.752	0.596	0.376	0.665
N ₁ P ₀ K ₁ F ₁	0.402	0.940	1.048	0.822	0.672	0.436	0.720
N ₁ P ₁ K ₀ F ₀	0.372	1.000	1.038	0.844	0.624	0.398	0.713
N ₁ P ₁ K ₀ F ₁	0.440	1.060	1.087	0.825	0.664	0.449	0.754
N ₁ P ₁ K ₁ F ₀	0.462	1.042	1.090	0.886	0.640	0.422	0.757
N ₁ P ₁ K ₁ F ₁	0.506	1.120	1.142	0.904	0.706	0.510	0.818
N ₂ P ₀ K ₀ F ₀	0.468	1.106	1.149	1.044	0.665	0.486	0.820
N ₂ P ₀ K ₀ F ₁	0.530	1.162	1.198	1.082	0.700	0.550	0.870
N ₂ P ₀ K ₁ F ₀	0.562	1.144	1.218	1.120	0.698	0.665	0.901
N ₂ P ₀ K ₁ F ₁	0.628	1.222	1.260	1.134	0.725	0.820	0.965
N ₂ P ₁ K ₀ F ₀	0.588	1.202	1.258	1.164	0.758	0.704	0.946
N ₂ P ₁ K ₀ F ₁	0.664	1.260	1.348	1.182	0.820	0.743	1.003
N ₂ P ₁ K ₁ F ₀	0.762	1.277	1.410	1.172	0.874	0.762	1.043
N ₂ P ₁ K ₁ F ₁	0.908	1.306	1.494	1.202	0.970	0.792	1.120
Mean	0.524	1.097	1.164	0.981	0.711	0.558	
		S.Em.		C.D. (0.05)		C.V. (%)	
Treatment (T)		0.003		0.007			
Period (P)		0.002		0.007		2.42	
T x P		0.006		0.017			

Where,

N₁ = 1000 g N/tree

N₂ = 1500 g N/tree

P₀ = 0 g P/tree

P₁ = 750 g P/tree

K₀ = 0 g K/tree

K₁ = 750 g K/tree

F₀ = 0 kg FYM/tree

F₁ = 100 kg FYM/tree

and period

P₁ = June P₄ = December

P₂ = August P₅ = February

P₃ = October P₆ = April

Table 4.14 : Leaf level of Ca content of different position and treatments in aonla
Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatments	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
N ₁ P ₀ K ₀ F ₀	0.690	0.662	0.648	0.640	0.605	0.649
N ₁ P ₀ K ₀ F ₁	0.735	0.712	0.695	0.678	0.658	0.696
N ₁ P ₀ K ₁ F ₀	0.697	0.680	0.665	0.650	0.632	0.665
N ₁ P ₀ K ₁ F ₁	0.750	0.732	0.723	0.708	0.687	0.720
N ₁ P ₁ K ₀ F ₀	0.740	0.723	0.717	0.700	0.683	0.713
N ₁ P ₁ K ₀ F ₁	0.786	0.773	0.758	0.731	0.723	0.754
N ₁ P ₁ K ₁ F ₀	0.793	0.777	0.758	0.742	0.715	0.757
N ₁ P ₁ K ₁ F ₁	0.852	0.830	0.813	0.798	0.780	0.815
N ₂ P ₀ K ₀ F ₀	0.851	0.840	0.820	0.803	0.783	0.820
N ₂ P ₀ K ₀ F ₁	0.905	0.887	0.870	0.857	0.833	0.870
N ₂ P ₀ K ₁ F ₀	0.935	0.916	0.900	0.895	0.860	0.901
N ₂ P ₀ K ₁ F ₁	1.002	0.983	0.963	0.948	0.928	0.965
N ₂ P ₁ K ₀ F ₀	0.980	0.960	0.948	0.932	0.908	0.946
N ₂ P ₁ K ₀ F ₁	1.028	1.011	1.010	0.995	0.970	1.003
N ₂ P ₁ K ₁ F ₀	1.082	1.058	1.030	1.023	1.021	1.043
N ₂ P ₁ K ₁ F ₁	1.157	1.123	1.118	1.105	1.051	1.112
Mean	0.874	0.854	0.840	0.825	0.803	
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment (T)		0.003		0.007		
Position (P)		0.001		0.003		2.42
T x P		0.005		0.013		

Where, sample collected from

- Base = Basal portion of the tree.
 Middle = Middle portion of the tree.
 (a) M₁ = Basal portion of indeterminate branch.
 (b) M₂ = Middle portion of indeterminate branch.
 (c) M₃ = Top portion of the indeterminate branch.
 Top = Top portion of the tree.

4.4.2 Effect of period on leaf level of Ca content

The results on effect of different periods revealed that significant differences was found throughout the year for mean leaf level of Ca content (Table 4.13). The maximum value being (1.164 per cent) recorded in the month of October followed by August (1.097 per cent). It was clearly seen from the table that mean leaf level of Ca content starts declining from December to June. While, it was minimum (0.524 per cent) in the month of June followed by April (0.558 per cent).

4.4.3 Interaction effect (Treatment x Period) on leaf level of Ca content

The interaction between treatment and period was found to be significant for leaf level of Ca content (Table 4.13). Higher leaf level of Ca content (1.494 per cent) was recorded in the month of October due to treatment combination of $N_2P_1K_1F_1$. The result also revealed that maximum was in all the period in treatment combination $N_2P_1K_1F_1$. It was significantly lowest (0.346 per cent) in the month of June due to treatment $N_1P_0K_0F_0$ and it was statistically at par in the same month with treatment combination $N_1P_0K_1F_0$ (0.350 per cent).

4.4.4 Effect of position on leaf level of Ca content

The results regarding mean leaf level of Ca content from different position are presented (Table 4.14). The results showed that significant difference was found with different position. The maximum mean leaf level of Ca content (0.874 per cent) was recorded when leaf sample collected from the basal position. While, it was minimum (0.803 per cent) when leaf sample taken from top position. It is clearly seen from the result that the leaf level of Ca content was decreasing from basal position to top position.

4.4.5 Interaction effect (Treatment x Position) on leaf level of Ca content

The treatment and position interacted significantly in terms of leaf level of Ca content (Table 4.14). It was significantly higher (1.157 per cent) due to treatment $N_2P_1K_1F_1$ at the basal position. While, it was lowest (0.605 per cent) at the top position in treatment $N_1P_0K_0F_0$ (i.e. all factors at lower level).

4.4.6 Interaction effect (Period x Position) on leaf level of Ca content

The interaction effect of period x position was presented (Table 4.15 and Fig. 4). Leaf level of Ca content which indicated that significantly highest leaf level of calcium content (1.207 per cent) was noted in the month of October at basal position (i.e. P_3 x base). On the other hand, significantly lowest value (0.494 per cent) was obtained in the month of June at top position.

It was interested to note that increasing trend in Ca content from June to October, while it was in decreasing trend in respect to position from based to top.

4.4.7 Interaction effect (Treatment x Period x Position) on leaf level of Ca content

All the three factors interacted significantly for leaf level of Ca content which was inconsistent over period and different position in aonla (Table 4.16). Highest leaf level of Ca content (1.54 per cent) was recorded in the month of October at basal shoot position due to treatment of $N_2P_1K_1F_1$ (i.e. all at higher level). While, it was minimum (0.30 per cent) in the month of June at top position in treatment combination of $N_1P_0K_0F_0$ and it was statistically at par with treatment of $N_1P_0K_1F_1$ in the same month and at the same position.

Table 4.15: Leaf level of Ca content in different period and position in aonla Cv.

Gujarat Aonla-1 on dry weight basis (%)

Period	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
P ₁	0.555	0.540	0.521	0.508	0.494	0.524
P ₂	1.134	1.119	1.098	1.079	1.056	1.097
P ₃	1.207	1.176	1.168	1.151	1.119	1.164
P ₄	1.015	0.998	0.980	0.966	0.948	0.981
P ₅	0.745	0.724	0.712	0.702	0.669	0.711
P ₆	0.587	0.569	0.559	0.546	0.530	0.558
Mean	0.874	0.854	0.840	0.825	0.803	
		S.Em.		C.D. (0.05)		C.V. (%)
Period		0.002		0.007		
Position		0.001		0.003		2.42
Period x Position		0.003		0.008		

Where, period

P₁ = June P₄ = December
P₂ = August P₅ = February
P₃ = October P₆ = April

Where, sample collected from

Base = Basal portion of the tree.
Middle = Middle portion of the tree.
(a) M₁ = Basal portion of indeterminate branch.
(b) M₂ = Middle portion of indeterminate branch.
(c) M₃ = Top portion of the indeterminate branch.
Top = Top portion of the tree.

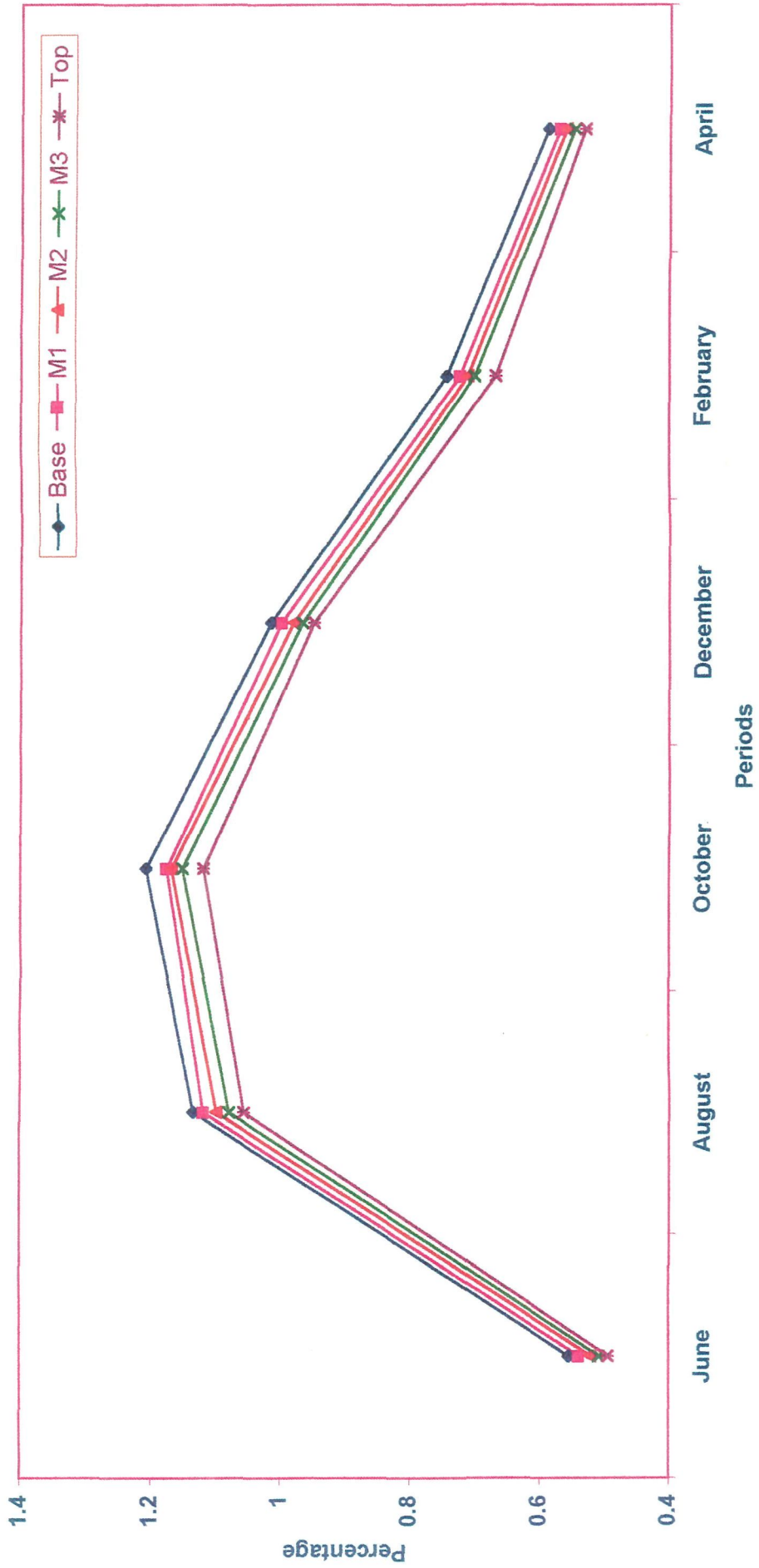


Fig. 4 : Leaf Ca content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1

Table 4.16 : Leaf level of Ca content (%) in different position and period with respect to different fertilizer treatments in aonla Cv. Gujarat Aonla-1

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₁ P ₀ K ₀ F ₀	P ₁	0.39	0.35	0.35	0.34	0.30
	P ₂	0.89	0.88	0.86	0.84	0.80
	P ₃	0.98	0.93	0.92	0.92	0.85
	P ₄	0.80	0.78	0.75	0.75	0.76
	P ₅	0.65	0.63	0.62	0.61	0.59
	P ₆	0.43	0.40	0.39	0.38	0.36
N ₁ P ₀ K ₀ F ₁	P ₁	0.42	0.40	0.39	0.38	0.36
	P ₂	1.00	0.98	0.94	0.92	0.90
	P ₃	1.02	0.98	0.96	0.95	0.93
	P ₄	0.84	0.82	0.80	0.79	0.78
	P ₅	0.67	0.65	0.65	0.62	0.59
	P ₆	0.46	0.44	0.43	0.41	0.39
N ₁ P ₀ K ₁ F ₀	P ₁	0.37	0.36	0.35	0.34	0.33
	P ₂	0.94	0.93	0.92	0.90	0.88
	P ₃	1.06	1.02	1.00	0.97	0.95
	P ₄	0.77	0.76	0.75	0.75	0.73
	P ₅	0.63	0.62	0.59	0.58	0.56
	P ₆	0.41	0.39	0.38	0.36	0.34
N ₁ P ₀ K ₁ F ₁	P ₁	0.44	0.42	0.40	0.39	0.36
	P ₂	0.96	0.95	0.94	0.93	0.92
	P ₃	1.08	1.06	1.06	1.04	1.00
	P ₄	0.85	0.83	0.82	0.81	0.80
	P ₅	0.70	0.68	0.68	0.66	0.64
	P ₆	0.47	0.45	0.44	0.42	0.40
N ₁ P ₁ K ₀ F ₀	P ₁	0.40	0.38	0.38	0.36	0.34
	P ₂	1.02	1.01	1.00	0.99	0.98
	P ₃	1.07	1.05	1.05	1.03	0.99
	P ₄	0.87	0.85	0.85	0.83	0.82
	P ₅	0.61	0.64	0.62	0.61	0.59
	P ₆	0.42	0.27	0.40	0.38	0.38
N ₁ P ₁ K ₀ F ₁	P ₁	0.46	0.45	0.44	0.42	0.42
	P ₂	1.10	1.08	1.06	1.04	1.02
	P ₃	1.12	1.10	1.09	1.06	1.07
	P ₄	0.86	0.85	0.83	0.80	1.79
	P ₅	0.69	0.68	0.67	0.65	0.63
	P ₆	0.48	0.48	0.46	0.42	0.40
N ₁ P ₁ K ₁ F ₀	P ₁	0.49	0.48	0.46	0.45	0.43
	P ₂	1.08	1.06	1.04	1.02	1.01
	P ₃	1.14	1.12	1.10	1.08	1.01
	P ₄	0.93	0.91	0.89	0.86	0.84
	P ₅	0.67	0.65	0.64	0.63	0.61
	P ₆	0.45	0.44	0.42	0.41	0.39
N ₁ P ₁ K ₁ F ₁	P ₁	0.54	0.52	0.50	0.49	0.48
	P ₂	1.16	1.14	1.12	1.10	1.08
	P ₃	1.19	1.16	1.14	1.12	1.10
	P ₄	0.94	0.92	0.91	0.89	0.86
	P ₅	0.74	0.72	0.70	0.69	0.68
	P ₆	0.54	0.52	0.51	0.50	0.48

(Contd...)

(Contd...)

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₂ P ₀ K ₀ F ₀	P ₁	0.50	0.48	0.47	0.45	0.44
	P ₂	1.14	1.13	1.11	1.09	1.06
	P ₃	1.17	1.18	1.16	1.14	1.10
	P ₄	1.08	1.06	1.04	1.02	1.02
	P ₅	0.70	0.68	0.66	0.65	0.63
	P ₆	0.52	0.51	0.48	0.47	0.45
N ₂ P ₀ K ₀ F ₁	P ₁	0.56	0.54	0.53	0.53	0.49
	P ₂	1.19	1.18	1.16	1.15	1.13
	P ₃	1.24	1.22	1.20	1.18	1.15
	P ₄	1.11	1.10	1.08	1.07	1.05
	P ₅	0.74	0.70	0.70	0.68	0.66
	P ₆	0.59	0.56	0.55	0.53	0.52
N ₂ P ₀ K ₁ F ₀	P ₁	0.59	0.58	0.57	0.55	0.52
	P ₂	1.18	1.17	1.15	1.12	1.10
	P ₃	1.26	1.23	1.22	1.20	1.18
	P ₄	1.15	1.14	1.12	1.11	1.08
	P ₅	0.73	0.70	0.68	0.74	0.64
	P ₆	0.70	0.67	0.66	0.65	0.64
N ₂ P ₀ K ₁ F ₁	P ₁	0.66	0.64	0.63	0.61	0.60
	P ₂	1.26	1.25	1.22	1.20	1.18
	P ₃	1.30	1.28	1.26	1.24	1.22
	P ₄	1.17	1.15	1.13	1.12	1.10
	P ₅	0.76	0.74	0.72	0.73	0.68
	P ₆	0.86	0.84	0.62	0.79	0.79
N ₂ P ₁ K ₀ F ₀	P ₁	0.62	0.60	0.59	0.58	0.55
	P ₂	1.24	1.22	1.21	1.19	1.15
	P ₃	1.29	1.26	1.27	1.25	1.22
	P ₄	1.20	1.18	1.16	1.15	1.13
	P ₅	0.79	0.78	0.76	0.74	0.72
	P ₆	0.74	0.72	0.70	0.68	0.68
N ₂ P ₁ K ₀ F ₁	P ₁	0.70	0.68	0.66	0.65	0.63
	P ₂	1.30	1.28	1.26	1.24	1.22
	P ₃	1.40	1.34	1.36	1.34	1.30
	P ₄	1.22	1.20	1.18	1.16	1.15
	P ₅	1.86	0.84	0.82	0.80	0.78
	P ₆	0.69	0.73	0.78	0.78	0.74
N ₂ P ₁ K ₁ F ₀	P ₁	0.80	0.84	0.70	0.69	0.78
	P ₂	1.32	1.31	1.28	1.26	1.22
	P ₃	1.46	1.38	1.41	1.41	1.39
	P ₄	1.21	1.19	1.17	1.16	1.13
	P ₅	0.90	0.89	0.88	0.86	0.84
	P ₆	0.80	0.74	0.74	0.76	0.77
N ₂ P ₁ K ₁ F ₁	P ₁	0.94	0.92	0.91	0.90	0.87
	P ₂	1.36	1.34	1.30	1.28	1.25
	P ₃	1.54	1.50	1.50	1.48	1.45
	P ₄	1.24	1.22	1.20	1.19	1.16
	P ₅	1.03	0.96	1.01	0.99	0.86
	P ₆	0.83	0.80	0.79	0.79	0.75
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment x Period x Position		0.012		0.033		2.42

4.5 MAGNESIUM

4.5.1 Effect of treatment on leaf level of Mg content

The effect of different treatment on mean leaf level of Mg content at bimonthly interval are presented (Table 4.17 and 4.18). It was found to be significantly higher (0.560 per cent) due to treatment combination of $N_2P_1K_1F_1$ as compared to rest of the treatment. While, it was lower (0.271 per cent) in treatment of $N_1P_0K_0F_0$ and was at par with treatment combination of $N_1P_0K_1F_0$ (0.278 per cent). Further to add that the higher leaf level of Mg content was found in almost all the treatment when nitrogen was applied at higher level alongwith phosphorus, potassium and farm yard manure as compared to lower level of nitrogen.

4.5.2 Effect of period on leaf level of Mg content

The results presented in Table 4.17 revealed that significantly higher mean leaf level of Mg content (1.020 per cent) was found in the month of August. While, it was significantly lower (0.225 per cent) in the month of October. There was no any specific trend was observed for mean leaf level of Mg content.

4.5.3 Interaction effect (Treatment x Period) on leaf level of Mg content

Looking to the interaction between treatment and period for leaf level of Mg content are illustrated (Table 4.17). It was significantly higher (1.258 per cent) due to treatment $N_2P_1K_1F_1$ in the month of August, whereas it was lowest (0.094 per cent) in treatment combination $N_1P_0K_0F_0$ in the month of June.

Table 4.17 : Leaf level of Mg content of different periods and treatments in aonla
Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatment	Periods						Mean
	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	
N ₁ P ₀ K ₀ F ₀	0.094	0.790	0.128	0.208	0.150	0.255	0.271
N ₁ P ₀ K ₀ F ₁	0.126	0.812	0.150	0.236	0.194	0.286	0.301
N ₁ P ₀ K ₁ F ₀	0.134	0.774	0.138	0.202	0.184	0.236	0.278
N ₁ P ₀ K ₁ F ₁	0.155	0.850	0.168	0.238	0.216	0.292	0.320
N ₁ P ₁ K ₀ F ₀	0.168	0.862	0.150	0.230	0.250	0.238	0.316
N ₁ P ₁ K ₀ F ₁	0.194	0.868	0.196	0.272	0.265	0.296	0.348
N ₁ P ₁ K ₁ F ₀	0.206	0.930	0.150	0.232	0.180	0.288	0.331
N ₁ P ₁ K ₁ F ₁	0.242	0.972	0.236	0.314	0.260	0.362	0.398
N ₂ P ₀ K ₀ F ₀	0.254	1.092	0.206	0.264	0.256	0.336	0.401
N ₂ P ₀ K ₀ F ₁	0.270	1.134	0.270	0.282	0.290	0.378	0.437
N ₂ P ₀ K ₁ F ₀	0.294	1.154	0.242	0.320	0.225	0.366	0.434
N ₂ P ₀ K ₁ F ₁	0.298	1.170	0.292	0.366	0.293	0.390	0.468
N ₂ P ₁ K ₀ F ₀	0.332	1.196	0.272	0.300	0.263	0.412	0.463
N ₂ P ₁ K ₀ F ₁	0.342	1.220	0.320	0.404	0.304	0.432	0.504
N ₂ P ₁ K ₁ F ₀	0.366	1.236	0.322	0.436	0.358	0.436	0.526
N ₂ P ₁ K ₁ F ₁	0.394	1.258	0.356	0.479	0.406	0.466	0.560
Mean	0.242	1.020	0.225	0.299	0.256	0.342	
		S.Em.		C.D. (0.05)		C.V. (%)	
Treatment (T)		0.003		0.009			
Period (P)		0.005		0.014		4.92	
T x P		0.006		0.017			

Where,

N₁ = 1000 g N/tree

N₂ = 1500 g N/tree

P₀ = 0 g P/tree

P₁ = 750 g P/tree

K₀ = 0 g K/tree

K₁ = 750 g K/tree

F₀ = 0 kg FYM/tree

F₁ = 100 kg FYM/tree

and period

P₁ = June P₄ = December

P₂ = August P₅ = February

P₃ = October P₆ = April

Table 4.18 : Leaf level of Mg content of different position and treatments in aonla
Cv. Gujarat Aonla-1 on dry weight basis (%)

Treatments	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
N ₁ P ₀ K ₀ F ₀	0.305	0.278	0.269	0.258	0.243	0.271
N ₁ P ₀ K ₀ F ₁	0.332	0.307	0.303	0.290	0.272	0.301
N ₁ P ₀ K ₁ F ₀	0.308	0.290	0.282	0.265	0.245	0.278
N ₁ P ₀ K ₁ F ₁	0.352	0.332	0.322	0.305	0.288	0.320
N ₁ P ₁ K ₀ F ₀	0.342	0.333	0.323	0.303	0.280	0.316
N ₁ P ₁ K ₀ F ₁	0.393	0.360	0.349	0.333	0.307	0.348
N ₁ P ₁ K ₁ F ₀	0.360	0.340	0.335	0.378	0.302	0.331
N ₁ P ₁ K ₁ F ₁	0.448	0.410	0.398	0.375	0.357	0.398
N ₂ P ₀ K ₀ F ₀	0.438	0.415	0.403	0.382	0.365	0.401
N ₂ P ₀ K ₀ F ₁	0.480	0.453	0.442	0.413	0.398	0.437
N ₂ P ₀ K ₁ F ₀	0.465	0.444	0.443	0.418	0.397	0.434
N ₂ P ₀ K ₁ F ₁	0.512	0.490	0.477	0.434	0.428	0.468
N ₂ P ₁ K ₀ F ₀	0.497	0.483	0.465	0.443	0.425	0.463
N ₂ P ₁ K ₀ F ₁	0.557	0.527	0.502	0.470	0.465	0.504
N ₂ P ₁ K ₁ F ₀	0.567	0.543	0.535	0.510	0.473	0.526
N ₂ P ₁ K ₁ F ₁	0.605	0.569	0.557	0.548	0.520	0.560
Mean	0.435	0.411	0.400	0.379	0.360	
		S.Em.			C.D. (0.05)	C.V. (%)
Treatment (T)		0.003			0.009	
Position (P)		0.001			0.003	4.92
T x P		0.005			0.013	

Where, sample collected from

Base = Basal portion of the tree.

Middle = Middle portion of the tree.

(a) M₁ = Basal portion of indeterminate branch.

(b) M₂ = Middle portion of indeterminate branch.

(c) M₃ = Top portion of the indeterminate branch.

• Top = Top portion of the tree.

4.5.4 Effect of position on leaf level of Mg content

The results presented for the effect of position revealed that significant difference was found between all the position for mean leaf level of Mg content (Table 4.18). The maximum mean leaf level of Mg content (0.435 per cent) was recorded at basal shoot position. While, it was minimum (0.360 per cent) when leaf sample collected from top position. The results also revealed that the decreasing trend for mean leaf Mg content from base to the top position.

4.5.5 Interaction effect (Treatment x Position) on leaf level of Mg content

The results regarding interaction between treatment and position are presented (Table 4.17) for leaf level of Mg content. It was revealed that significantly higher leaf level of Mg content (0.605 per cent) was noted due to treatment $N_2P_1K_1F_1$ at the basal position of shoot followed by $N_2P_1K_1F_0$ at the same position (0.567 per cent). While, it was lowest (0.243 per cent) in treatment combination of $N_1P_0K_0F_0$ at the top position and it was statistically at par with treatment $N_1P_0K_1F_0$ (0.245 per cent) at the same position.

4.5.6 Interaction effect (Period x Position) on leaf level of Mg content

The period and position interacted significantly in respect to leaf level of Mg content (Table 4.19 and Fig. 5). The results indicated that maximum leaf level of Mg content (1.069 per cent) was recorded in the month of August at basal position and it also indicated that leaf level of Mg content was decreasing from basal to top position in the same month. While, it was found minimum (0.184 per cent) at the top position in the month of June.

Table 4.19: Leaf level of Mg content in different period and position in aonla Cv.

Gujarat Aonla-1 on dry weight basis (%)

Period	Shoot position					Mean
	Base	Middle			Top	
		M ₁	M ₂	M ₃		
P ₁	0.291	0.269	0.262	0.203	0.184	0.242
P ₂	1.069	1.034	1.015	1.004	0.978	1.020
P ₃	0.252	0.231	0.227	0.216	0.198	0.225
P ₄	0.334	0.311	0.302	0.279	0.268	0.299
P ₅	0.288	0.266	0.256	0.244	0.226	0.256
P ₆	0.377	0.356	0.340	0.329	0.308	0.342
Mean	0.435	0.411	0.400	0.379	0.360	
		S.Em.		C.D. (0.05)		C.V. (%)
Period		0.005		0.014		
Position		0.001		0.003		4.92
Period x Position		0.003		0.008		

Where, period

P₁ = June P₄ = December
P₂ = August P₅ = February
P₃ = October P₆ = April

Where, sample collected from

Base = Basal portion of the tree.
Middle = Middle portion of the tree.
(a) M₁ = Basal portion of indeterminate branch.
(b) M₂ = Middle portion of indeterminate branch.
(c) M₃ = Top portion of the indeterminate branch.
Top = Top portion of the tree.

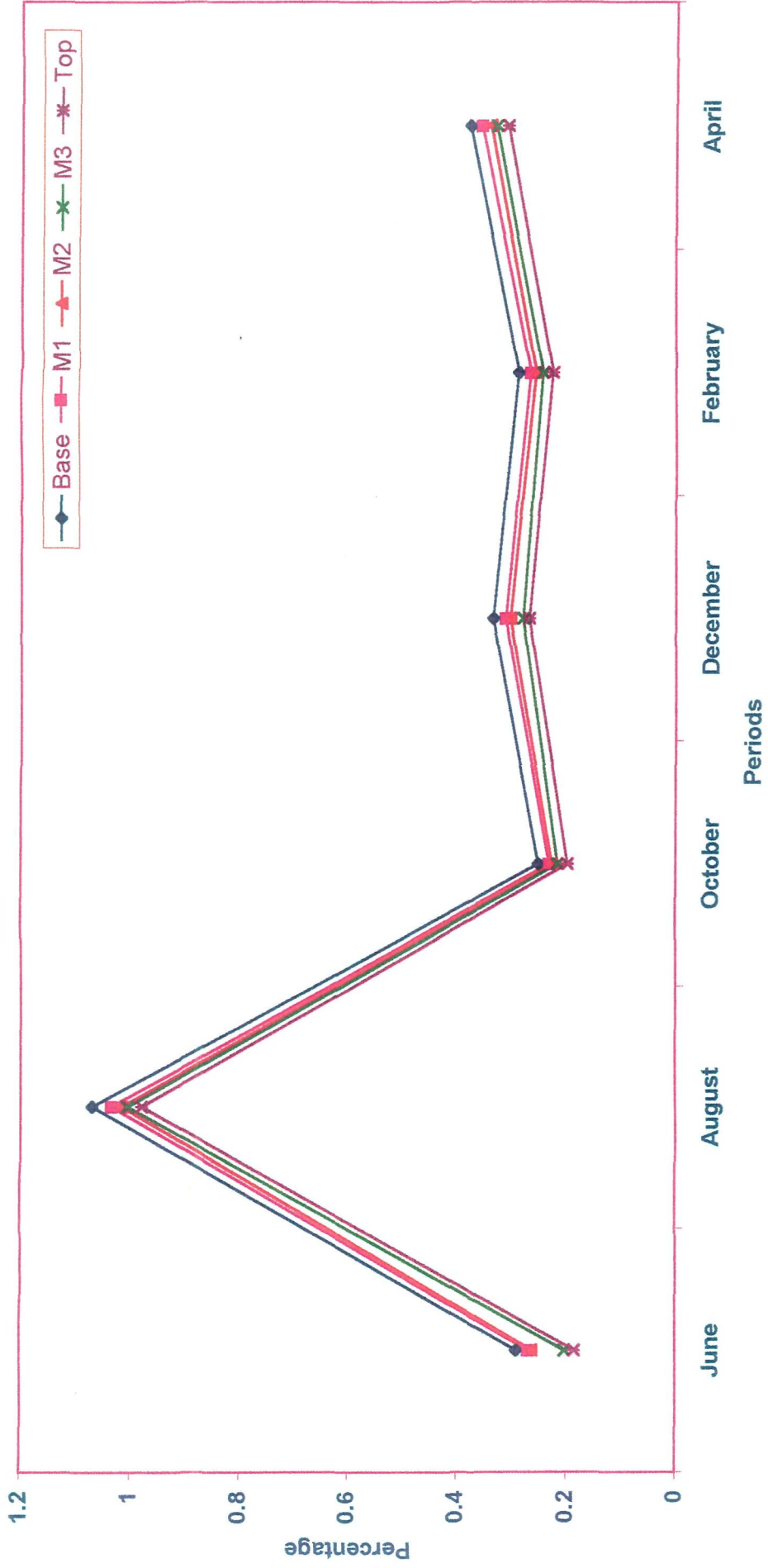


Fig. 5 : Leaf Mg content (%) in different position over treatment in aonla Cv. Gujarat Aonla-1

4.5.7 Interaction effect (Treatment x Period x Position) on leaf level of Mg content

All factors under studied interacted significantly viz., treatment, period and position for the leaf level of Mg content (Table 4.20). Significantly highest leaf level of Mg content (1.32 per cent) was found in the treatment combination $N_2P_1K_1F_1$ in the month of August at the basal position and it was statistically at par with $N_2P_1K_1F_0$ (1.29 per cent) in the same month and at same position. It was significantly lowest (0.07 per cent) due to treatment $N_1P_0K_0F_0$ in the month of June at top position and it was found statistically at par with treatment $N_1P_0K_0F_1$ (0.09 per cent), $N_1P_0K_1F_0$ (0.08 per cent) and $N_1P_0K_1F_1$ (0.10 per cent) in the same month and at similar position.

4.6 PERFORMANCE OF VEGETATIVE GROWTH AND YIELD IN AONLA Cv. GUJARAT AONLA-1

Effect of different nutrients (16 treatment combinations) on vegetative growth parameters and yield in aonla are presented (Table 4.21). Plant spread (East-West), stem girth, number of fruits/tree and fruit yield (kg/tree) were significantly influenced by different levels of N, P, K and FYM. While these were non-significant on plant height and plant spread (North-South). Fruit yield (kg/tree) was found highest due to treatment $N_2P_1K_1F_1$ (217 kg/tree) and it was statistically at par with treatment $N_1P_1K_1F_1$ (204 kg/tree) and lowest was found (143.333 kg/tree) with treatment $N_1P_1K_0F_0$. Number of fruits per tree was also significantly maximum at $N_2P_1K_1F_1$ (7036.667 fruits/tree) treatment and again it was at par with $N_1P_1K_1F_1$ (6909.333 fruits/tree). While, it was lowest (6388.333 fruits/tree) in treatment $N_1P_1K_0F_0$. Stem girth and plant spread (East-West) were also maximum at $N_2P_1K_1F_1$ treatment

Table 4.20 : Leaf level of Mg content (%) in different position and period in different fertilizer treatments in aonla Cv. Gujarat Aonla-1

Treatment	Period	Shoot position				
		Base	Middle			Top
			M ₁	M ₂	M ₃	
N ₁ P ₀ K ₀ F ₀	P ₁	0.11	0.10	0.10	0.09	0.07
	P ₂	0.85	0.80	0.78	0.77	0.75
	P ₃	0.15	0.13	0.13	0.12	0.11
	P ₄	0.24	0.22	0.21	0.19	0.18
	P ₅	0.19	0.15	0.14	0.14	0.13
	P ₆	0.29	0.27	0.25	0.24	0.22
N ₁ P ₀ K ₀ F ₁	P ₁	0.16	0.14	0.14	0.10	0.09
	P ₂	0.87	0.82	0.80	0.79	0.78
	P ₃	0.17	0.15	0.15	0.15	0.13
	P ₄	0.26	0.24	0.24	0.24	0.20
	P ₅	0.22	0.20	0.20	0.18	0.17
	P ₆	0.31	0.29	0.29	0.28	0.26
N ₁ P ₀ K ₁ F ₀	P ₁	0.18	0.16	0.15	0.10	0.08
	P ₂	0.82	0.79	0.77	0.76	0.73
	P ₃	0.16	0.14	0.13	0.13	0.13
	P ₄	0.23	0.21	0.21	0.19	0.17
	P ₅	0.20	0.19	0.19	0.18	0.16
	P ₆	0.26	0.25	0.24	0.23	0.20
N ₁ P ₀ K ₁ F ₁	P ₁	0.21	0.18	0.16	0.12	0.10
	P ₂	0.88	0.86	0.85	0.84	0.82
	P ₃	0.19	0.17	0.16	0.16	0.16
	P ₄	0.27	0.25	0.24	0.22	0.21
	P ₅	0.24	0.23	0.22	0.21	0.18
	P ₆	0.32	0.30	0.30	0.28	0.26
N ₁ P ₁ K ₀ F ₀	P ₁	0.20	0.21	0.20	0.13	0.10
	P ₂	0.86	0.88	0.87	0.86	0.84
	P ₃	0.18	0.16	0.15	0.14	0.12
	P ₄	0.26	0.24	0.23	0.22	0.20
	P ₅	0.28	0.26	0.25	0.24	0.22
	P ₆	0.27	0.25	0.24	0.23	0.20
N ₁ P ₁ K ₀ F ₁	P ₁	0.24	0.20	0.19	0.18	0.16
	P ₂	0.94	0.86	0.86	0.85	0.83
	P ₃	0.24	0.22	0.21	0.18	0.13
	P ₄	0.30	0.29	0.28	0.26	0.23
	P ₅	0.30	0.28	0.26	0.25	0.23
	P ₆	0.34	0.31	0.29	0.28	0.26
N ₁ P ₁ K ₁ F ₀	P ₁	0.28	0.24	0.23	0.16	0.12
	P ₂	0.96	0.94	0.93	0.92	0.90
	P ₃	0.17	0.15	0.15	0.15	0.13
	P ₄	0.25	0.24	0.24	0.22	0.21
	P ₅	0.18	0.17	0.18	0.19	0.18
	P ₆	0.32	0.30	0.28	0.27	0.27
N ₁ P ₁ K ₁ F ₁	P ₁	0.36	0.28	0.27	0.19	0.17
	P ₂	1.10	0.96	0.94	0.94	0.92
	P ₃	0.26	0.24	0.24	0.22	0.22
	P ₄	0.34	0.32	0.32	0.30	0.29
	P ₅	0.29	0.28	0.26	0.25	0.22
	P ₆	0.40	0.38	0.36	0.35	0.32

(Contd...)

(Contd...)

Treatment	Period	Shoot position				Top
		Base	Middle			
			M ₁	M ₂	M ₃	
N ₂ P ₀ K ₀ F ₀	P ₁	0.32	0.29	0.28	0.20	0.18
	P ₂	1.14	1.10	1.08	1.08	1.06
	P ₃	0.24	0.21	0.20	0.20	0.18
	P ₄	0.29	0.28	0.26	0.24	0.23
	P ₅	0.28	0.26	0.26	0.24	0.24
	P ₆	0.36	0.35	0.34	0.33	0.30
N ₂ P ₀ K ₀ F ₁	P ₁	0.34	0.31	0.30	0.19	0.21
	P ₂	1.19	1.14	1.12	1.12	1.10
	P ₃	0.29	0.27	0.27	0.27	0.25
	P ₄	0.32	0.30	0.29	0.26	0.24
	P ₅	0.32	0.30	0.29	0.28	0.26
	P ₆	0.42	0.40	0.38	0.36	0.33
N ₂ P ₀ K ₁ F ₀	P ₁	0.36	0.32	0.31	0.26	0.22
	P ₂	1.15	1.18	1.16	1.15	1.13
	P ₃	0.26	0.24	0.26	0.24	0.21
	P ₄	0.36	0.34	0.33	0.29	0.28
	P ₅	0.26	0.21	0.24	0.22	0.20
	P ₆	0.40	0.38	0.36	0.35	0.34
N ₂ P ₀ K ₁ F ₁	P ₁	0.35	0.34	0.34	0.21	0.25
	P ₂	1.24	1.19	1.17	1.14	1.11
	P ₃	0.32	0.31	0.29	0.28	0.26
	P ₄	0.40	0.38	0.38	0.34	0.33
	P ₅	0.32	0.31	0.29	0.27	0.28
	P ₆	0.44	0.41	0.39	0.37	0.34
N ₂ P ₁ K ₀ F ₀	P ₁	0.36	0.36	0.35	0.32	0.27
	P ₂	1.22	1.22	1.20	1.18	1.16
	P ₃	0.30	0.28	0.28	0.26	0.24
	P ₄	0.35	0.32	0.29	0.26	0.28
	P ₅	0.30	0.29	0.26	0.25	0.22
	P ₆	0.45	0.43	0.41	0.39	0.38
N ₂ P ₁ K ₀ F ₁	P ₁	0.39	0.38	0.37	0.27	0.30
	P ₂	1.28	1.24	1.22	1.20	1.17
	P ₃	0.36	0.34	0.32	0.30	0.28
	P ₄	0.46	0.42	0.39	0.36	0.39
	P ₅	0.36	0.32	0.29	0.29	0.26
	P ₆	0.49	0.46	0.42	0.40	0.39
N ₂ P ₁ K ₁ F ₀	P ₁	0.42	0.39	0.39	0.34	0.29
	P ₂	1.29	1.28	1.24	1.22	1.15
	P ₃	0.34	0.32	0.34	0.32	0.29
	P ₄	0.49	0.44	0.45	0.40	0.40
	P ₅	0.40	0.39	0.36	0.34	0.30
	P ₆	0.46	0.44	0.43	0.44	0.41
N ₂ P ₁ K ₁ F ₁	P ₁	0.43	0.40	0.41	0.39	0.34
	P ₂	1.32	1.28	1.26	1.24	1.19
	P ₃	0.40	0.36	0.35	0.34	0.33
	P ₄	0.52	0.48	0.46	0.48	0.45
	P ₅	0.46	0.42	0.40	0.38	0.37
	P ₆	0.50	0.47	0.46	0.46	0.44
		S.Em.		C.D. (0.05)		C.V. (%)
Treatment x Period x Position		0.011		0.031		4.92

Table 4.21 : Effect of different treatments on vegetative growth and yield in aonla

Cv. Gujarat Aonla-1

Sr. No.	Treatment	Plant height (cm)	Plant spread		Stem girth (m)	No. of fruits/tree	Fruit yield/tree (kg)
			E-W (m)	N-S (m)			
1.	N ₁ P ₀ K ₀ F ₀	6.700	7.000	7.467	0.637	6547.333	162.667
2.	N ₁ P ₀ K ₀ F ₁	7.367	7.133	7.633	0.687	6758.667	185.333
3.	N ₁ P ₀ K ₁ F ₀	6.667	6.767	7.067	0.690	6574.667	168.000
4.	N ₁ P ₀ K ₁ F ₁	7.033	7.133	6.667	0.743	6528.333	160.667
5.	N ₁ P ₁ K ₀ F ₀	6.767	7.133	7.567	0.683	6388.333	143.333
6.	N ₁ P ₁ K ₀ F ₁	7.100	7.600	7.567	0.793	6487.000	154.000
7.	N ₁ P ₁ K ₁ F ₀	6.167	6.667	7.633	0.687	6422.333	146.000
8.	N ₁ P ₁ K ₁ F ₁	7.233	7.467	6.967	0.827	6909.333	204.000
9.	N ₂ P ₀ K ₀ F ₀	6.433	6.867	7.000	0.703	6497.667	157.667
10.	N ₂ P ₀ K ₀ F ₁	6.967	7.167	7.100	0.767	6613.000	171.667
11.	N ₂ P ₀ K ₁ F ₀	7.033	6.900	6.667	0.653	6460.667	149.667
12.	N ₂ P ₀ K ₁ F ₁	7.333	7.100	7.367	0.717	6561.667	167.333
13.	N ₂ P ₁ K ₀ F ₀	6.767	6.867	7.000	0.710	6576.000	161.667
14.	N ₂ P ₁ K ₀ F ₁	7.233	7.233	7.233	0.780	6724.667	180.333
15.	N ₂ P ₁ K ₁ F ₀	6.967	7.700	6.333	0.817	6736.667	184.667
16.	N ₂ P ₁ K ₁ F ₁	7.233	8.033	7.767	0.900	7036.667	217.000
	S.Em. ±	0.24	0.20	0.38	0.03	66.40	7.73
	C.D. at 5%	NS	0.57	NS	0.10	191.74	22.32
	C.V. %	6.03	4.80	9.24	8.20	1.74	7.89

(0.900 m and 8.033 m, respectively) and both were at par with $N_2P_1K_1F_0$ and $N_1P_1K_1F_1$ level of treatment (0.817 m and 7.700 m, respectively). While, stem girth was observed lowest (0.637 m) in treatment $N_1P_0K_0F_0$. Similarly, plant spread (East-West) was found significantly lowest (6.667 m) due to treatment $N_1P_1K_1F_0$.

4.7 CORRELATION BETWEEN YIELD, NUMBER OF FRUITS PER TREE AND LEAF LEVEL OF NUTRIENTS IN DIFFERENT PERIOD IN AONLA CV. GUJARAT AONLA-1

The data related to correlation between yield, number of fruit per tree and leaf level of nutrient in different period are presented (Table 4.22).

The yield (kg/tree) was significantly and positively correlated with number of fruits/tree, leaf level of nitrogen content (%) of August, October and April; per cent leaf level of phosphorus content of June, October, December, February and April; Leaf level of potassium content (%) of all period except in the month of December; leaf level of calcium content (%) of June and February and leaf level of magnesium content of October, December, February and April. The number of fruits per tree showed significant and positive relationship with leaf level of nitrogen content (per cent) of August, October and April; per cent leaf level of phosphorus content in all the period; leaf level of potassium content (per cent) in all month except December; leaf level of calcium content (per cent) of June, October and February and leaf level of magnesium content (per cent) in all the period except June and August.

Correlation between vegetative growth and leaf level of nutrient content in different periods in aonla cv. Gujarat Aonla-1 are presented (Table 4.23).

Table 22 : Correlation between yield, number of fruits per tree and leaf level of nutrient in different periods in aonla cv. Gujarat Aonla-1

	Y ₁	Y ₂	N ₁	N ₂	N ₃	N ₄	N ₅	N ₆	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	K ₁	K ₂
Y ₁	1.000*															
Y ₂	0.995*	1.000														
N ₁	0.474	0.485	1.000													
N ₂	0.542*	0.545*	0.426	1.000												
N ₃	0.577*	0.599*	0.932*	0.447	1.000											
N ₄	0.407	0.414	0.951*	0.469	0.827*	1.000										
N ₅	0.431	0.454	0.944*	0.433	0.927*	0.929*	1.000									
N ₆	0.546*	0.554*	0.962*	0.395	0.975*	0.866*	0.923*	1.000								
P ₁	0.795*	0.815*	0.744*	0.705*	0.844*	0.712*	0.799*	0.800*	1.000							
P ₂	0.471	0.508*	0.281	0.831*	0.400	0.259	0.347	0.320	0.697*	1.000						
P ₃	0.701*	0.726*	0.657*	0.773*	0.762*	0.634*	0.726*	0.707*	0.967*	0.820*	1.000					
P ₄	0.706*	0.728*	0.609*	0.811*	0.704*	0.606*	0.679*	0.651*	0.954*	0.842*	0.994*	1.000				
P ₅	0.646*	0.670*	0.512*	0.798*	0.581*	0.563*	0.593*	0.533*	0.888*	0.831*	0.943*	0.966*	1.000			
P ₆	0.767*	0.783*	0.731*	0.588*	0.879*	0.626*	0.753*	0.835*	0.951*	0.625*	0.916*	0.885*	0.780*	1.000		
K ₁	0.592*	0.593*	0.880*	0.382	0.909*	0.800*	0.889*	0.902*	0.793*	0.239	0.686*	0.635*	0.509*	0.817*	1.000	
K ₂	0.556*	0.542*	0.605*	0.399	0.676*	0.514*	0.623*	0.640*	0.656*	0.235	0.584*	0.550*	0.400	0.714*	0.876*	1.000
K ₃	0.511*	0.521*	0.882*	0.421	0.899*	0.838*	0.922*	0.874*	0.789*	0.272	0.693*	0.644*	0.523*	0.782*	0.976*	0.855*
K ₄	0.328	0.339	0.908*	0.289	0.901*	0.804*	0.887*	0.911*	0.653*	0.197	0.569*	0.502*	0.359	0.711*	0.922*	0.755*
K ₅	0.663*	0.674*	0.887*	0.508*	0.966*	0.771*	0.887*	0.952*	0.890*	0.452	0.817*	0.767*	0.636*	0.931*	0.941*	0.772*
K ₆	0.655*	0.663*	0.887*	0.510*	0.962*	0.778*	0.889*	0.952*	0.890*	0.445	0.816*	0.768*	0.643*	0.929*	0.946*	0.774*
Ca ₁	0.600*	0.620*	0.924*	0.473	0.991*	0.826*	0.926*	0.962*	0.862*	0.411	0.785*	0.729*	0.599*	0.889*	0.935*	0.739*
Ca ₂	0.460	0.473	0.932*	0.527*	0.891*	0.932*	0.969*	0.899*	0.825*	0.402	0.773*	0.735*	0.647*	0.760*	0.883*	0.649*
Ca ₃	0.481	0.502*	0.946*	0.471	0.958*	0.898*	0.984*	0.952*	0.840*	0.404	0.781*	0.732*	0.633*	0.832*	0.916*	0.673*
Ca ₄	0.391	0.340	0.956*	0.321	0.887*	0.942*	0.967*	0.906*	0.672*	0.202	0.581*	0.530*	0.460	0.623*	0.833*	0.517*
Ca ₅	0.650*	0.675*	0.888*	0.532*	0.965*	0.788*	0.898*	0.938*	0.915*	0.534*	0.866*	0.822*	0.717*	0.946*	0.892*	0.695*
Ca ₆	0.432	0.449	0.924*	0.425	0.922*	0.866*	0.931*	0.910*	0.725*	0.302	0.625*	0.573*	0.478	0.699*	0.890*	0.660*
Mg ₁	0.427	0.453	0.945*	0.423	0.938*	0.927*	0.996*	0.927*	0.798*	0.341	0.725*	0.676*	0.595*	0.760*	0.884*	0.605*
Mg ₂	0.350	0.369	0.956*	0.353	0.892*	0.954*	0.980*	0.910*	0.708*	0.227	0.621*	0.574*	0.506*	0.653*	0.851*	0.543*
Mg ₃	0.620*	0.638*	0.951*	0.559*	0.940*	0.905*	0.930*	0.939*	0.864*	0.442	0.772*	0.738*	0.667*	0.814*	0.880*	0.618*
Mg ₄	0.636*	0.651*	0.911*	0.601*	0.957*	0.833*	0.911*	0.928*	0.899*	0.513*	0.844*	0.802*	0.690*	0.902*	0.924*	0.763*
Mg ₅	0.557*	0.565*	0.864*	0.633*	0.881*	0.833*	0.884*	0.894*	0.889*	0.564*	0.860*	0.835*	0.740*	0.881*	0.808*	0.623*
Mg ₆	0.580*	0.603*	0.948*	0.482	0.945*	0.921*	0.953*	0.931*	0.846*	0.372	0.756*	0.716*	0.655*	0.797*	0.892*	0.615*

(Contd...)

Y₁ = Yield kg/tree; Y₂ = No. of fruits/tree and [N₁ = June, N₂ = August, N₃ = October, N₄ = December, N₅ = February and N₆ = April - for leaf level of nitrogen content in per cent. Similarly, for, Phosphorus = P₁ to P₆, Potassium = K₁ to K₆, Calcium = Ca₁ to Ca₆ and Magnesium = Mg₁ to Mg₆].

(Contd...)

	K ₃	K ₄	K ₅	K ₆	Ca ₁	Ca ₂	Ca ₃	Ca ₄	Ca ₅	Ca ₆	Mg ₁	Mg ₂	Mg ₃	Mg ₄	Mg ₅	Mg ₆
Y ₁																
Y ₂																
N ₁																
N ₂																
N ₃																
N ₄																
N ₅																
N ₆																
P ₁																
P ₂																
P ₃																
P ₄																
P ₅																
P ₆																
K ₁																
K ₂																
K ₃	1.000															
K ₄	0.929*	1.000														
K ₅	0.905*	0.887*	1.000													
K ₆	0.910*	0.890*	0.999*	1.000												
Ca ₁	0.929*	0.911*	0.974*	0.970*	1.000											
Ca ₂	0.919*	0.870*	0.884*	0.890*	0.903*	1.000										
Ca ₃	0.928*	0.912*	0.943*	0.944*	0.959*	0.963*	1.000									
Ca ₄	0.862*	0.877*	0.810*	0.812*	0.873*	0.924*	0.934*	1.000								
Ca ₅	0.871*	0.849*	0.976*	0.972*	0.966*	0.877*	0.951*	0.819*	1.000							
Ca ₆	0.908*	0.905*	0.865*	0.869*	0.914*	0.885*	0.915*	0.935*	0.843*	1.000						
Mg ₁	0.917*	0.888*	0.889*	0.890*	0.936*	0.960*	0.985*	0.968*	0.905*	0.931*	1.000					
Mg ₂	0.882*	0.877*	0.828*	0.832*	0.885*	0.946*	0.950*	0.996*	0.837*	0.929*	0.980*	1.000				
Mg ₃	0.880*	0.848*	0.915*	0.918*	0.934*	0.923*	0.935*	0.916*	0.920*	0.936*	0.932*	0.922*	1.000			
Mg ₄	0.926*	0.876*	0.962*	0.964*	0.961*	0.923*	0.944*	0.839*	0.956*	0.901*	0.908*	0.855*	0.942*	1.000		
Mg ₅	0.818*	0.796*	0.906*	0.908*	0.881*	0.905*	0.924*	0.797*	0.925*	0.772*	0.875*	0.823*	0.876*	0.904*	1.000	
Mg ₆	0.898*	0.846*	0.901*	0.903*	0.945*	0.924*	0.951*	0.939*	0.920*	0.933*	0.965*	0.950*	0.976*	0.922*	0.846*	1.000

Critical value (1 - TAIL, 0.5) = + or -0.427; Critical value (2 - TAIL, 0.5) = + or -0.496*

Y₁ = Plant height (m); Y₂ = Stem girth (m); Y₃ = Plant spread (East-West) (m); Y₄ = Plant spread (North-South) (m) and [N₁ = June, N₂ = August, N₃ = October, N₄ = December, N₅ = February and N₆ = April - for leaf level of nitrogen content in per cent. Similarly, for, Phosphorus = P₁ to P₆, Potassium = K₁ to K₆, Calcium = Ca₁ to Ca₆ and Magnesium = Mg₁ to Mg₆].

The plant height was significantly and positively-correlated with plant spread (East-West); leaf level of nitrogen content of August; leaf level of phosphorus content of June, August, December and February; leaf level of magnesium content of October and December.

Stem girth was significant positive correlation with plant spread (East-West) and leaf level of N, P, K, Ca and Mg content in all the period except K in the month of October, Ca in the month of December and April and Mg in the month of August.

The plant spread (East-West) was significantly and positively correlated with leaf level of N content of August, October and April; P for all the period; K, Ca and Mg in all the period except K in the month of December, Ca in the month of December and April and Mg in the month of June and August.

The plant spread (North-South) was non-significantly correlated with all the leaf level of nutrients content in all periods.

Correlation among different nutrients content in leaf in different period revealed that leaf level of nitrogen content of June was positively correlated with leaf nitrogen content of October, December, February and April. Similarly leaf level of phosphorus content in all the period except in the month of August while potassium, calcium and magnesium leaf content were positively correlated with nitrogen content of June in all the periods. Same trend has also been observed for nitrogen content of October, December, February and April with phosphorus, potassium, calcium and magnesium in all the period. While, leaf nitrogen content (per cent) of August was positively correlated with phosphorus throughout the year; potassium in the month of February and April; calcium of August and February and magnesium of October, December and February.

Table 4.23 : Correlation coefficient among vegetative growth parameters and different leaf nutrient content in different periods in aonla cv. Gujarat Aonla-I

	Y ₁	Y ₂	Y ₃	Y ₄	Y ₅	N ₁	N ₂	N ₃	N ₄	N ₅	N ₆	P ₁	P ₂	P ₃	P ₄	P ₅	P ₆	K ₁	K ₂	
Y ₁	1.000																			
Y ₂	0.471	1.000																		
Y ₃	0.609*	0.876*	1.000																	
Y ₄	0.001	-0.027	0.069*	1.000																
Y ₅	0.380	0.565*	0.479	-0.204	1.000															
N ₁	0.757*	0.759*	0.760*	0.205	0.426	1.000														
N ₂	0.346	0.645*	0.607*	-0.146	0.932*	0.932*	1.000													
N ₃	0.362	0.569*	0.426	-0.278	0.951*	0.469	0.827*	1.000												
N ₄	0.282	0.596*	0.455	-0.245	0.944*	0.433	0.927*	0.909*	1.000											
N ₅	0.316	0.621*	0.556*	-0.175	0.962*	0.395	0.975*	0.866*	0.866*	1.000										
N ₆	0.515*	0.905*	0.815*	-0.030	0.744*	0.705*	0.843*	0.712*	0.712*	0.799*	1.000									
P ₁	0.548*	0.712*	0.713*	0.398	0.281	0.831*	0.400	0.259	0.347	0.320	0.697*	1.000								
P ₂	0.486	0.921*	0.826*	0.064	0.657*	0.773*	0.762*	0.634*	0.634*	0.726*	0.967*	0.820*	1.000							
P ₃	0.525*	0.931*	0.836*	0.068	0.609*	0.811*	0.704*	0.606*	0.606*	0.679*	0.954*	0.842*	0.994*	1.000						
P ₄	0.525*	0.896*	0.767*	-0.025	0.512*	0.798*	0.581*	0.563*	0.563*	0.533*	0.888*	0.831*	0.943*	0.966*	1.000					
P ₅	0.430	0.872*	0.848*	-0.055	0.731*	0.588*	0.879*	0.626*	0.626*	0.753*	0.951*	0.625*	0.916*	0.885*	0.885*	1.000				
P ₆	0.357	0.626*	0.529*	-0.288	0.880*	0.382	0.909*	0.800*	0.800*	0.889*	0.902*	0.793*	0.239	0.686*	0.635*	0.509*	1.000			
K ₁	0.402	0.568*	0.558*	-0.163	0.605*	0.399	0.676*	0.514*	0.514*	0.623*	0.640*	0.656*	0.235	0.854*	0.550*	0.400	0.817*	1.000		
K ₂	0.356	0.605*	0.529*	-0.262	0.882*	0.421	0.899*	0.838*	0.838*	0.922*	0.874*	0.789*	0.272	0.693*	0.644*	0.523*	0.782*	0.976*	0.855*	
K ₃	0.257	0.465	0.436	-0.201	0.908*	0.289	0.901*	0.804*	0.804*	0.887*	0.911*	0.653*	0.197	0.569*	0.502*	0.359	0.711*	0.922*	0.755*	
K ₄	0.395	0.748*	0.680*	-0.133	0.887*	0.508*	0.966*	0.771*	0.771*	0.887*	0.952*	0.890*	0.452	0.817*	0.767*	0.636*	0.931*	0.941*	0.772*	
K ₅	0.401	0.752*	0.682*	-0.165	0.887*	0.510*	0.962*	0.778*	0.778*	0.889*	0.952*	0.890*	0.445	0.816*	0.768*	0.643*	0.929*	0.946*	0.774*	
K ₆	0.345	0.678*	0.620*	-0.106	0.924*	0.473	0.911*	0.826*	0.826*	0.926*	0.962*	0.862*	0.411	0.785*	0.729*	0.599*	0.889*	0.935*	0.739*	
Ca ₁	0.341	0.665*	0.531*	-0.180	0.932*	0.527*	0.891*	0.932*	0.932*	0.969*	0.899*	0.825*	0.402	0.773*	0.735*	0.647*	0.760*	0.883*	0.649*	
Ca ₂	0.302	0.676*	0.550*	-0.228	0.946*	0.471	0.958*	0.898*	0.898*	0.984*	0.952*	0.840*	0.404	0.781*	0.732*	0.633*	0.832*	0.916*	0.673*	
Ca ₃	0.254	0.430	0.308	-0.278	0.956*	0.321	0.887*	0.942*	0.942*	0.906*	0.906*	0.672*	0.202	0.581*	0.530*	0.460	0.623*	0.833*	0.517*	
Ca ₄	0.400	0.781*	0.705*	-0.139	0.888*	0.532*	0.965*	0.788*	0.788*	0.898*	0.938*	0.915*	0.534*	0.866*	0.822*	0.717*	0.946*	0.892*	0.695*	
Ca ₅	0.411	0.463	0.406	-0.206	0.924*	0.425	0.922*	0.866*	0.866*	0.931*	0.910*	0.725*	0.302	0.625*	0.573*	0.478	0.699*	0.890*	0.660*	
Ca ₆	0.260	0.595*	0.461	-0.251	0.945*	0.423	0.938*	0.927*	0.927*	0.996*	0.927*	0.798*	0.341	0.725*	0.676*	0.595*	0.760*	0.884*	0.605*	
Mg ₁	0.253	0.488	0.346	-0.290	0.956*	0.353	0.892*	0.954*	0.954*	0.980*	0.910*	0.708*	0.227	0.621*	0.574*	0.506*	0.653*	0.851*	0.543*	
Mg ₂	0.532*	0.661*	0.590*	-0.175	0.951*	0.559*	0.940*	0.908*	0.908*	0.930*	0.939*	0.864*	0.442	0.772*	0.738*	0.667*	0.814*	0.880*	0.618	
Mg ₃	0.510*	0.736*	0.707*	-0.151	0.911*	0.601*	0.957*	0.833*	0.833*	0.911*	0.928*	0.899*	0.513*	0.844*	0.802*	0.690*	0.902*	0.924*	0.763	
Mg ₄	0.408	0.821*	0.751*	-0.100	0.864*	0.633*	0.880*	0.833*	0.833*	0.883*	0.894*	0.889*	0.564*	0.860*	0.835*	0.740*	0.881*	0.808*	0.623*	
Mg ₅	0.401	0.646*	0.521*	-0.243	0.948*	0.482	0.945*	0.921*	0.921*	0.953*	0.931*	0.846*	0.372	0.756*	0.716*	0.655*	0.797*	0.892*	0.615	

(Contd...)

Y₃ = Plant height (m); Y₄ = Stem girth (m); Y₅ = Plant spread (East-West) (m); Y₆ = Plant spread (North-South) (m) and [N₁] = June, [N₂] = August, [N₃] = October, [N₄] = December, [N₅] = February and [N₆] = April - for leaf level of nitrogen content in per cent. Similarly, for, Phosphorus = P₁ to P₆, Potassium = K₁ to K₆, Calcium = Ca₁ to Ca₆ and Magnesium = Mg₁ to Mg₆.

Results

(Contid...)	K ₃	K ₄	K ₅	K ₆	Ca ₁	Ca ₂	Ca ₃	Ca ₄	Ca ₅	Ca ₆	Mg ₁	Mg ₂	Mg ₃	Mg ₄	Mg ₅	Mg ₆
Y ₃	1.000															
Y ₄	0.929*															
Y ₅	0.905*															
Y ₆	0.910*															
N ₁	0.929*															
N ₂	0.919*															
N ₃	0.928*															
N ₄	0.862*															
N ₅	0.871*															
N ₆	0.871*															
P ₁	0.908*															
P ₂	0.916*															
P ₃	0.882*															
P ₄	0.880*															
P ₅	0.926*															
P ₆	0.818*															
K ₁	0.898*															
K ₂	0.898*															
K ₃	1.000															
K ₄	0.929*	1.000														
K ₅	0.905*	0.887*	1.000													
K ₆	0.910*	0.890*	0.999*	1.000												
Ca ₁	0.929*	0.911*	0.974*	0.970*	1.000											
Ca ₂	0.919*	0.870*	0.884*	0.890*	0.903*	1.000										
Ca ₃	0.928*	0.912*	0.943*	0.944*	0.959*	0.963*	1.000									
Ca ₄	0.862*	0.877*	0.810*	0.812*	0.873*	0.924*	0.934*	1.000								
Ca ₅	0.871*	0.849*	0.976*	0.972*	0.966*	0.877*	0.951*	0.819*	1.000							
Ca ₆	0.908*	0.905*	0.865*	0.865*	0.914*	0.885*	0.915*	0.935*	0.843*	1.000						
Mg ₁	0.916*	0.888*	0.889*	0.890*	0.936*	0.960*	0.985*	0.968*	0.905*	0.931*	1.000					
Mg ₂	0.882*	0.877	0.828*	0.832*	0.885*	0.946*	0.950*	0.996*	0.837*	0.929*	0.980*	1.000				
Mg ₃	0.880*	0.848*	0.915*	0.918*	0.934*	0.923*	0.935*	0.916*	0.920*	0.936*	0.932*	0.922*	1.000			
Mg ₄	0.926*	0.876*	0.962*	0.965*	0.961*	0.923*	0.944*	0.839*	0.956*	0.901*	0.908*	0.855*	0.942*	1.000		
Mg ₅	0.818*	0.796*	0.906*	0.908*	0.881*	0.905*	0.924*	0.797*	0.925*	0.772*	0.875*	0.823*	0.876*	0.904*	1.000	
Mg ₆	0.898*	0.846*	0.901*	0.903*	0.945*	0.924*	0.951*	0.939*	0.920*	0.933*	0.965*	0.950*	0.976*	0.922*	0.846*	1.000

Critical value (1 - TAIL, 0.5) = + or -0.427; Critical value (2 - TAIL, 0.5) = + or -0.496*

Discussion

CHAPTER - V

DISCUSSION

Aonla (*Emblica officinalis*, Gaertn) is an important arid fruit crop in terms of yield, economic and medicinal values. The demand of its fruits and products is continuously rising, but faulty nutrition management practices make the production uncertain. Among the different methods to judge requirements of nutrients leaf analysis has already proved as powerful tool. It has been well documented that the composition of various elements in aonla changes throughout the year in the leaf (Garg and Khanduja, 1976; Awasthi *et al.*, 1993). In order to understand present status of knowledge in aonla tree, the present investigation entitled "Studies on leaf nutrient status in relation to different period and position in aonla (*Emblica officinalis* Gaertn) cultivar Gujarat Aonla-1" was planned to assess the leaf nutritional status of the Gujarat Aonla-1 cultivar of aonla right from June, 2000 to April, 2001 at bimonthly interval from the different positions, periods and treatments were studied. This has provided some useful information. The silent features of these observation alongwith their significant findings and correlation to each other factors have been discuss in following pages.

5.1 NITROGEN

5.1.1 Effect of treatment on leaf level of N content

Results of analysis of mean leaf level of N content in aonla leaves as influenced by the application of N, P, K and FYM each at 2 levels in 16 treatments combinations at bimonthly interval are given (Table 4.1 and 4.2).

The results revealed that mean leaf level of N content was recorded significantly higher due to treatment $N_2P_1K_1F_1$ (1.442 per cent) as compared to rest of treatments. It may be due to application of all the fertilizer N, P, K and FYM given at

higher level (i.e. N at 1500 g/tree, P 750 g/tree, K 750 g/tree and FYM 100 kg/tree) to the tree as basal application which was reflected in high uptake and in higher mean leaf N. These results are in agreement with the findings of Bansal and Motiramani (1968), Samra *et al.* (1978), Rajput *et al.* (1981) in mango; Randhawa (1973) and Kohli *et al.* (1984) in Robusta, banana; Wagh and Mahajan (1988) and Tassar *et al.* (1989) in guava and Sarooshi *et al.* (1991) in Valencia orange. The results also indicated that significantly lower mean leaf N content (0.634 per cent) in treatment $N_1P_0K_0F_0$ and $N_1P_0K_1F_1$. It may be due to alone application of nitrogen at lower dose (N 1000 g/tree alone).

5.1.2 Effect of period on leaf level of N content

The result (Table 4.1) revealed that significant difference was found in mean leaf N content at different period (i.e. at bimonthly interval). It was maximum as 2.308 per cent in the month of August and minimum as 0.238 per cent in the month of February. An application of fertilizer treatment is positively and directly reflected on mean leaf level of N content in the month of August as compared to the month of June may be due to nitrogen was absorbed more quickly by plant after its application and it reflected on leaf N content in the month of August. Fruit development starts from this month and nitrogen was more utilized during this period and reached at low level in February i.e. after harvest of fruits. It was also seen that decreasing trend in mean leaf level of N content observed in relation to fruit development in the month of October and December. This results are in consonance with the findings of Pathak and Pandey (1976), Pathak and Pandey (1978_b) in mango and Awasthi *et al.* (1993) in aonla.

5.1.3 Interaction effect (Treatment x Period) on leaf level of N content

Treatment and period interacted significantly (Table 4.1). The higher level of N content was noted due to treatment combination $N_2P_1K_1F_1$ in the month of August. It may be due to more readily and quickly availability of all these nutrients to the plant in the month of August. It was lowest due to treatment $N_1P_0K_0F_0$ in the month of June. Because, June is dormancy period for aonla crop after fertilization. So there are two reason of low N content one is reserved N was utilized in flowering and in new growth. Second is the application of low dose of N in this combination. This results are in line of work with Subramanian *et al.* (1974) in 'Kew' pineapple and Samara *et al.* (1978) in mango.

5.1.4 Effect of position on leaf level of N content

The results presented (Table 4.2) showed that significantly higher (1.053 per cent) leaf level of N content in M_3 shoot position (i.e. top position of indeterminate branch), while it was lowest as 0.878 per cent at the basal position. The higher leaf level of N content was recorded in the M_3 (top position of indeterminate branch) may be due the highly mobile nature of nitrogen element from base to the top (i.e. towards the younger leaves). Koo and Young (1972) and Pathak and Pandey (1976) who found more nitrogen at top position than basal position in mango leaves. These results are also in line with the findings of Emmert (1954), Poulsen and Hansen (1965) and Kumar and Pandey (1979) who observed more amount of nitrogen in top shoot position in mango and Awasthi *et al.* (1993) in aonla.

5.1.5 Interaction effect (Treatment x position) on leaf level of N content

The interaction between treatment and position was found significant for leaf level of N content (Table 4.2). The highest (1.637 per cent) was recorded in the M_3

shoot position due to treatment $N_2P_1K_1F_1$ whereas it was lowest (0.593 per cent) in basal position in treatment $N_1P_0K_0F_0$. This is due to translocation of N towards the growing point as the mobile nature of this element. These results are in consonance with the work of Tassar *et al.* (1989) in guava and Bhargava and Reddy (1998) in banana.

5.1.6 Interaction effect (Period x Position) on leaf level of N content

Significant interaction in leaf N content was found with respect to different period (Table 4.3 and Fig. 1). Maximum leaf level of N content (2.590 per cent) was recorded in the month of August at M_3 position (i.e. top position of indeterminate branch) while, it was minimum in the month of February in basal position. In general, leaf N content was higher in M_3 position followed by top, M_2 , M_1 and base. Stability of nutrient was considered at M_2 position of shoot (i.e. middle portion of the indeterminate branch) in the month of August to October. Similar fluctuating trend was observed by Awasthi *et al.* (1993) in aonla; Badyal and Kar (1985) in plum; Menzel *et al.* (1987) and Sanyal and Mitra (1990_a) in guava; Sanyal and Mitra (1990_b) in litchi and Kher (1996) in young leaves of mango.

Highest status of leaf N content recorded in M_3 position due to its translocation from older to younger shoot because of its highly mobile nature. It was found lowest in the month of February at basal position, most probable due to more number of older leaves in the base and they becomes in the senescent stage.

5.1.7 Interaction effect (Treatment x Period x Position) on leaf level of N content

Almost all interactions for leaf level of N content found significant and inconsistent over period and different positions (Table 4.4). Maximum (3.09 per cent)

was noted in the month of August at M₃ position due to treatment N₂P₁K₁F₁ and it was statistically at par with N₂P₁K₀F₁ and N₂P₀K₁F₁ in the same month and at the same position. This might be due to in all three treatments having same level of N and FYM which was directly reflected on leaf N content. While, it was minimum (0.08 per cent) in the month of February at basal position due to treatment N₁P₀K₀F₀. It was at par in same month and in same position with treatment N₁P₀K₁F₀ and N₁P₁K₀F₀. It may be due to no mobility of N from top to bottom position and also the month of February was the senescent phase after harvesting of fruits in aonla as no utilization. These results are in consonance with the investigation of Awasthi *et al.* (1993) and Shukla and Pathak (1999) in aonla; Singh *et al.* (1989) in acid lime; Bhargava *et al.* (1990) in ber and Bhargava and Reddy (1998) in banana.

5.2 PHOSPHORUS

5.2.1 Effect of treatment on leaf level of P content

The effect of different treatments on the mean leaf level of P content at bimonthly interval are presented (Table 4.5 and 4.6). The result indicated that the mean leaf level of P content was significantly higher due to treatment N₂P₁K₁F₁ (i.e. all at higher level) as compared to rest of the treatments, the value being 0.532 per cent. While, it was lowest in treatment N₁P₀K₀F₀ and N₁P₀K₁F₀. The value recorded as 0.256 per cent for both the treatment. This effect may be due to the soil application of phosphatic fertilizer as basal dose (750 g/tree) which reflected directly on the P content of leaf. It means application is directly and positively correlated on mean leaf level of P content. The present findings are in line with the observations of Bansal and Motiramani (1968), Wagh and Mahajan (1988) in guava; Subramanian *et al.* (1974) in 'Kew' variety of pineapple; Rajput *et al.* (1981) in Deshehari mango;

Hariprakashrao *et al.* (1988) in passion fruit var. Purple and Sarooshi *et al.* (1991) in Valencia orange.

5.2.2 Effect of period on leaf level of P content

It is obvious from the result that significant difference was found in respect to mean leaf level of P content at bimonthly interval (Table 4.5). It was maximum (1.200 per cent) in the month of August while, lowest (0.109 per cent) in the month of February. The results also indicated that mean leaf P content was decreased after August month. It may be due to utilization of P for fruit development from August and lowest in the month of February may be due to after fruit harvesting stage and most of the reserved leaf P utilized during fruit growth, development and up to maturity stage till the December month. These results are in confirmity with the findings of Thakur *et al.* (1981) in mango and Awasthi *et al.* (1993) in aonla.

5.2.3 Interaction effect (Treatment x Period) on leaf level of P content

Interaction of treatment and period was found to be significant for leaf P content (Table 4.5). It was highest (1.278 per cent) in the month of August with treatment $N_2P_1K_1F_1$. It may be due to the application of fertilizer treatment at on set of monsoon as basal dose which reflected in the month of August. Whereas lowest (0.038 per cent) in the month of February in treatment combination $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$. It may be because the most of the leaf P content was utilized during fruit growth and development stage and also up to fruit maturity stage. These results are in agreement with the findings of Subramanian *et al.* (1974) in Kew pineapple and Hariprakashrao *et al.* (1988) in Passion fruit var. Purple.

5.2.4 Effect of position on leaf level of P content

The results revealed (Table 4.6) that significantly higher mean leaf level of P content was recorded at the basal position (0.376 per cent) and it was statistically at par with M₁ position (i.e. basal position of indeterminate branch) whereas lowest (0.326 per cent) at the top position. The decreasing pattern from base to top was found. It may be due to the partial and poor mobility of phosphorus element from base to the top position. These results are in consonance with the findings of Koo and Young (1972), Pathak and Pandey (1978_a), Kumar and Pandey (1979), Thakur *et al.* (1981) in different mango cultivar and Awasthi *et al.* (1993) in aonla.

5.2.5 Interaction effect (Treatment x Position) on leaf level of P content

Interaction effect between treatment and position was found to be significant for leaf level of P content (Table 4.6). It was maximum (0.573 per cent) due to treatment N₂P₁K₁F₁ at basal position and which was at par with M₁ shoot position (basal position of indeterminate branch) with same treatment. Whereas, it was minimum (0.237 per cent) in top position in treatment N₁P₀K₀F₀. The results indicates the partial mobility of phosphorus from base to top position and soil application of N, P, K and FYM level caused significant effect. These results are in agreement with the research work of Hariprakashrao *et al.* (1988) in Passion fruit and Sarooshi *et al.* (1991) in Valencia orange.

5.2.6 Interaction effect (Period x Position) on leaf level of P content

Significant variation in P content of aonla leaves was observed in respect to different period and position (Table 4.7 and Fig. 2). It was fluctuated throughout the year. Highest leaf level of P content in the month of August at the basal position (1.221 per cent) and it was statistically at par in the same month at M₁ position of

shoot (i.e. basal position of indeterminate branch). It was decreased abruptly in the month of October to February at top position of shoot (0.097 per cent). It was also found that highest was recorded in the basal while, lowest in the top and average value at middle position of shoot, thus, stability of P in branchlet from August to October at M_2 position (i.e. middle portion of the indeterminate branch). An increased in leaf level of P in August was possibly due to poor shoot growth and tendency of nutrients accumulation needed for the growth and development of fruit. A continuous in significant decrease in leaf P content from base to top indicated its partial mobility. These results are also in line with the findings of Emmert (1957), Poulsen and Hansen (1965) in apple; Koo and Young (1972), Chadha *et al.* (1980), Thakur *et al.* (1980) and Kher (1996) in mango; Sanyal *et al.* (1990) in papaya and Awasthi *et al.* (1993) in aonla.

5.2.7 Interaction effect (Treatment x Period x Position) on leaf level of P content

Interaction among treatment, period and position of leaf level of P content was also found significant (Table 4.8). It was maximum (1.32 per cent) with treatment combination $N_2P_1K_1F_1$ in the month of August at basal position, which was statistically at par with treatments $N_1P_1K_0F_1$ and $N_2P_1K_0F_1$ in the same month and at the similar position. It showed the poor mobility of phosphorus element from base to top position. Minimum was noted (0.03 per cent) due to treatment $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$ in the month of February at the top position of tree and it was statistically at par with $N_2P_0K_1F_0$ in the same month and at similar position. It may be because there is no supply of phosphorus for this treatment combination and which caused lower level of P in the leaf. This results are in agreement with Garg and Khanduja (1976),

Awasthi *et al.* (1993) and Shukla and Pathak (1999) in aonla and Kohli (1995) in mandarin.

5.3 POTASSIUM

5.3.1 Effect of treatment on leaf level of K content

The effect of different treatments on mean leaf level of K at bimonthly interval are presented (Table 4.9 and 4.10). The results showed that significantly higher K content (0.954 per cent) was found due to treatment combination of $N_2P_1K_1F_1$ (i.e. all fertilizer applied at higher level) as compared to rest of the treatments. It may be because the basal application of all fertilizers were given at higher level which were reflected in leaf level of K. The application of K at 750 g/tree was directly and positively correlated with leaf K content of treatment. These results are in consonance with the investigation of Randhawa *et al.* (1973) in Robusta banana; Subramanian *et al.* (1974) in Kew pineapple; Singh and Rajput (1976) in guava; Rajput *et al.* (1981) in mango; Hariprakashrao *et al.* (1988) in passion fruit and Sarooshi *et al.* (1991) in Valencia orange. While, it was lowest (0.187 per cent) in treatment $N_1P_0K_0F_0$ (i.e. all at lower level). The results also indicated that both the K 750 g/tree and FYM 100 kg/tree at higher levels alongwith N and P combination recorded higher mean leaf level of K content over lower level.

5.3.2 Effect of period on leaf level of K content

The results (Table 4.9) revealed that significant differences were observed in respect to mean leaf level of K at bimonthly interval. It was maximum (0.753 per cent) in the month of June. This may be due to the application of potassic fertilizer and farm yard manure as a soil application. While, it was lowest (0.336 per cent) in the month of April, which was at par with mean leaf level of K in August and

February. It may be due to translocation of K towards the fruit growth and development during August, while in the month of February the leaves were at senescent stage. These results are in agreement with the work of Zidan and Maximos (1962), Koo and Young (1972), Pathak and Pandey (1978_b) in different cultivar of Mango and Awasthi *et al.* (1993) in aonla.

5.3.3 Interaction effect (Treatment x Period) on leaf level of K content

The interaction between treatment and period was found to be significant for leaf K content (Table 4.9). It was highest (1.302 per cent) due to treatment $N_2P_1K_1F_1$ in the month of June. It may be due to soil application of potassic fertilizer which was quickly available to the plant and directly reflected on leaf content. These results are in confirmation with the findings of Singh and Rajput (1976) in guava and Subramanian *et al.* (1974) in Kew pineapple. While, it was lowest (0.124 per cent) in the month of August and April with treatment $N_1P_0K_0F_0$. It may be due to the no application of potassic fertilizer and translocation of K for fruit growth and development during August, while in the month of April, K was found lowest. It may be because it was utilized for the development of flowering shoot.

5.3.4 Effect of position on leaf level of K content

The effect of different position on mean leaf level of K content was observed (Table 4.10) significantly higher (0.497 per cent) at M_3 position (i.e. top portion of indeterminate branch) while, it was lowest (0.433 per cent) at the basal position. The results also reflected for increasing mean leaf K content from basal position to top position of shoot of indeterminate branch. It showed the highly mobile nature of the potassium element. These observations are in line of work with Poulsen and Hansen

(1965) in apple; Sanyal and Mitra (1990_a), Menzel *et al.* (1987) in litchi and Awasthi *et al.* (1993) in aonla.

5.3.5 Interaction effect (Treatment x Position) on leaf level of K content

Interaction between treatment and position was found to be significant for leaf level of K content (Table 4.10). It was maximum (1.052 per cent) due treatment $N_2P_1K_1F_1$ at the M_3 position of shoot (i.e. top position of indeterminate branch). While, it was minimum (0.170 per cent) in treatment $N_1P_0K_0F_0$ at basal position and it was at par with same treatment combination at M_1 position of shoot (i.e. basal position of indeterminate branch). The result indicated that the leaf K content was increased from base to top position, it may be due to highly mobile nature of this element and recorded highest in $N_2P_1K_1F_1$ because it was given at higher level. These results are in agreement with findings of Poulsen and Hansen (1965) in apple and Menzel *et al.* (1987) in litchi.

5.3.6 Interaction effect (Period x Position) on leaf level of K content

The interaction between leaf level of K content of different period and position are illustrated (Table 4.11 and Fig. 3). It was decreased abruptly in the month of August while it remaining constant from October to December though it was decreased in the month of February. However, significantly highest leaf level of K content (0.802 per cent) was estimated in the month of June at the M_3 shoot position (i.e. top position of indeterminate branch) and lowest in the month of August at basal position (0.307 per cent). It may be due to the movement of leaf K towards the top position of shoot. Interaction between period and position indicated that there was no definite trend of K content in position. It was stabilized during the month of June to August in mid position while, increased during the month of June indicated its better

absorption and translocation which was needed for vegetative growth phase. Abrupt decrease in the month of August may be due to its better absorption required for the utilization in developing fruit. These results were supported by Moon and Hymas (1964) in apple; Koo and Young (1972), Pathak and Pandey (1978a), Thakur *et al.* (1981) and Kher (1996) in mango; Badiyal and Kar (1985) in plum; Sanyal *et al.* (1990) in papaya and Awasthi *et al.* (1993) in aonla.

5.3.7 Interaction effect (Treatment x Period x Position) on leaf level of K content

Interaction effect among different treatment, period and position on leaf K content are found to be significantly differed (Table 4.12). Highest (1.41 per cent) was noted due to treatment $N_2P_1K_1F_1$ in the month of June at M_3 position of shoot (i.e. top position of indeterminate branch) and it was akin with same treatment in the same month at top position of shoot. This showed mobility of element from base to top position. Lowest leaf K content (0.10 per cent) was observed in treatment $N_1P_1K_0F_0$ in the month of August at basal position and it was found at par with treatment $N_1P_0K_0F_0$ in the month of August, February and April at the similar position. This might be due to highly mobile nature of K and application of fertilizer and farm yard manure. This results are in consonance with Rao *et al.* (1977) in pine apple; Kamboj (1987) in pear; Kher (1996) in mango and Awasthi *et al.* (1993), Shukla and Pathak (1999) in aonla.

5.4 CALCIUM

5.4.1 Effect of treatment on leaf level of Ca content

The effect of different treatments on mean leaf level of Ca at bimonthly interval (Table 4.13) indicated that significantly higher (1.120 per cent) was noted due to treatment combination of $N_2P_1K_1F_1$ as compared to rest of the treatments. While,

lower value being recorded as 0.649 per cent in treatment $N_1P_0K_0F_0$. The results also showed that nitrogen at higher level (i.e. 1500 g N/tree) in presence of phosphorus, potassium and farm yard manure recorded the higher Ca content as compared to their lower levels. The increase may be due to the soil application of N, P, K and FYM fertilizers. These results are in agreement with the finding of Ramaswamy (1971) in Robusta banana; Wagh and Mahajan (1988) in guava.

5.4.2 Effect of period on leaf level of Ca content

Significant difference was observed throughout the year at bimonthly interval for mean leaf level of Ca content are presented (Table 4.13). It was maximum (1.164 per cent) in the month of October followed by August (1.097 per cent), while it was clearly seen from the results that mean leaf Ca content starts declining from December to April. It may be because during this period, the leaves were at senescent stage and also it was utilized in the flowering stage (i.e. in the month of March and April). While minimum (0.524 per cent) was in the month of June. These results are in confirmation with work of Avilan (1971), Koo and Young (1972), Pathak and Pandey (1976) in different mango cultivar and Awasthi *et al.* (1993) in aonla.

5.4.3 Interaction effect (Treatment x Period) on leaf level of Ca content

An interaction between treatment and period found to be significant in respect to leaf level of Ca content. It was highest (1.494 per cent) due to treatment combination $N_2P_1K_1F_1$ in the month of October. It may be due soil application of N, P, K and FYM while, it was lowest (0.346 per cent) in treatment combination $N_1P_0K_0F_0$ in the month of June and it was akin with treatment $N_1P_0K_1F_0$ in the same month. It was evident from the data that leaf Ca content starts decreasing from December to April in all the treatments as the deciduous nature of the tree and most of

leaf Ca content utilized during flowering by flowering shoot in the month of March. These results are in line of work with Avilan (1971) in mango and Wagh and Mahajan (1988) in guava.

5.4.4 Effect of position on leaf level of Ca content

The results regarding mean leaf level of Ca content from different position are illustrated (Table 4.14). Significant different was found due to different position for mean leaf level of Ca content. It was maximum (0.874 per cent) when leaf samples were collected from the basal position and minimum (0.803 per cent) was noted when leaf sample taken from top position. It is clearly seen from the result that leaf Ca content was decreasing from basal position to top position. It may be due to immobile nature of this element from base to top position. The findings with calcium trend are in conformity with those of Young and Koo (1971), Pathak and Pandey (1976), Kumar and Pandey (1979) in mango and Awasthi *et al.* (1993) in aonla.

5.4.5 Interaction effect (Treatment x Position) on leaf level of Ca content

The interaction between different treatments and position for leaf level of Ca content (Table 4.14) was found significantly higher (1.157 per cent) due to treatment $N_2P_1K_1F_1$ from basal position. It may be due to soil application of all fertilizers and immobility of the calcium from base to top position. These results are in consonance with findings of Young and Koo (1971), Pathak and Pandey (1976) and Kher (1996) in mango. While, significantly lowest (0.605 per cent) in treatment $N_1P_0K_0F_0$ at the top position may be due to alone application of nitrogen does not much affect on leaf Ca content at the top position.

5.4.6 Interaction effect (Period x Position) on leaf level of Ca content

Interaction between different periods and positions (Table 4.15 and Fig. 4) was shown an increasing trend from June to October and then after decreased from December to April. As regards to its position, a decreasing pattern was observed from base to top revealing an average value at middle position. Interaction effect indicated that significantly higher leaf Ca content (1.207 per cent) was observed in the month of October at basal position. While, it was lowest (0.494 per cent) in the month of June at top position. It becomes all most static in October to December at the middle position. Accumulation of leaf Ca content in basal position may be due to immobile nature of this nutrients within the plant. This results are in conformity with Koo and Young (1972), Pathak and Pandey (1976), Kumar and Pandey (1979), Chadha (1980) and Kher (1996) in mango; Sanyal and Mitra (1990) in guava and Awasthi *et al.* (1993) in aonla.

5.4.7 Interaction effect (Treatment x Period x Position) on leaf level of Ca content

Almost all interactions for leaf Ca content found to be significant and inconsistent over period and different position (Table 4.16). Highest leaf Ca content (1.54 per cent) was recorded with fertilizer treatment of $N_2P_1K_1F_1$ in the month of October at basal position. While, the minimum (0.30 per cent) was noted in the month of June at the top position in treatment combination $N_1P_0K_0F_0$ and it was barring with treatment $N_1P_0K_1F_0$ in the same month and at the similar position. Similar trend was observed by Bhargava *et al.* (1990) in ber; Bhargava and Raghupathi (1993) in custard apple; Raghupathi *et al.* (1996) in fig and Awasthi *et al.* (1993) in aonla.

5.5 MAGNESIUM

5.5.1 Effect of treatment on leaf level of Mg content

The effect of different treatments on mean leaf level of Mg content at bimonthly interval (Table 4.17 and 4.18) was found significantly higher (0.560 per cent) due to treatment combination $N_2P_1K_1F_1$ as compared to all other treatments. While, it was lowest (0.271 per cent) in treatment $N_1P_0K_0F_0$ and it was statistically at par with treatment $N_1P_0K_1F_0$ (0.278 per cent). The results also indicated that higher mean leaf level of Mg content was found in almost all the treatment when nitrogen was applied at higher level in presence of P, K and FYM as compared to their respective lower levels. These results are in agreement with the findings of Ramaswamy (1971) in Robusta banana and Wagh and Mahajan (1988) in guava.

5.5.2 Effect of period on leaf level of Mg content

The results regarding effect of different period (Table 4.17) revealed that significantly higher mean leaf level of Mg content (1.020 per cent) was found in the month of August. While, lowest (0.225 per cent) was noted in the month of October. There was no any specific trend for mean leaf Mg content, as it was fluctuated throughout the year. These results are in consonance with the findings of Pathak and Pandey (1978_b) in mango and Awasthi *et al.* (1993) in aonla.

5.5.3 Interaction effect (Treatment x Period) on leaf level of Mg content

The interaction between different treatment and period for leaf Mg content (Table 4.17) were significantly highest (1.258 per cent) due to treatment $N_2P_1K_1F_1$ in the month of August. While, it was lowest (0.094 per cent) in treatment combination $N_1P_0K_0F_0$ in the month of June. The increase in leaf Mg content may be due to the soil

application of N, P, K and FYM fertilizers. These results are in line with the work of Wagh and Mahajan (1988) in guava and Awasthi *et al.* (1993) in aonla.

5.5.4 Effect of position on leaf level of Mg content

Effect of different position (Table 4.18) was found significant for mean leaf level of Mg content. It was maximum (0.435 per cent) at basal position. While, it was minimum (0.360 per cent) when leaf samples were collected from top position. The results are revealed that the mean Mg was decreased from base to the top position may be possibly due to less mobile nature of this element. These results are in confirmation with investigation of Chadha *et al.* (1980) in Chausa cultivar of mango and Awasthi *et al.* (1993) in aonla.

5.5.5 Interaction effect (Treatment x Position) on leaf level of Mg content

The results regarding interaction between different treatments and position (Table 4.18) for leaf level of Mg content indicated significantly (0.605 per cent) was recorded due to treatment $N_2P_1K_1F_1$ at the basal position. It showed the partial mobility of these element from base to top. It was found lowest (0.243 per cent) in treatment combination $N_1P_0K_0F_0$ at the top position and it was akin with treatment $N_1P_0K_1F_0$ (0.245 per cent) at the same position. It may be due to soil application of N, P, K and FYM fertilizers. These results are in agreement with the findings of Chadha *et al.* (1986) in mango Cv. Chausa; Wagh and Mahajan (1988) in guava and Awasthi *et al.* (1993) in aonla.

5.5.6 Interaction effect (Period x Position) on leaf level of Mg content

Significant interaction in leaf level of Mg content was found with respect to different period and position (Table 4.19 and Fig. 5). Maximum Mg content (1.069 per cent) was noted in the month of August at basal position and minimum (0.184 per

cent) in the month of June at top position. The period between August to October was found to be stabilized duration for leaf Mg content when samples were collected from middle shoot. The lower percentage of Mg obtained in June indicated its more utilization in active growth during this period. The results are in conformity with Chadha *et al.* (1980) and Kher (1996) in mango; Sanyal and Mitra (1990) in litchi; Awasthi *et al.* (1993) in aonla and Bhargava and Reddy (1998) in banana.

5.5.7 Interaction effect (Treatment x Period x Position) on leaf level of Mg content

Interaction between treatment, period and position for leaf level of Mg content are given (Table 4.20). Significantly higher (1.32 per cent) was found due to treatment $N_2P_1K_1F_1$ in the month of August at basal position. It might be due to the partial mobility of Mg from base to top and also soil application of N, P, K and FYM fertilizers. While, it was at par with $N_2P_1K_1F_0$ (1.29 per cent) in the same month and at the same position. Whereas, it was lowest (0.07 per cent) in treatment $N_1P_0K_0F_0$ in the month of June at top position and it was akin with treatment $N_1P_0K_0F_1$ (0.09 per cent, $N_1P_0K_1F_0$ (0.08 per cent) and $N_1P_0K_1F_1$ (0.10 per cent) in the same month and at the similar position. It may be because in the month of June aonla crop was in active vegetative phase of growth and it was utilized by plant. This results are in consonance with Annapurna (1988) in sapota; Kher (1996) in mango; Awasthi *et al.* (1993) and Shukla and Pathak (1999) in aonla.

5.6 PERFORMANCE OF VEGETATIVE GROWTH AND YIELD IN AONLA Cv. GUJARAT AONLA-1

Effect of different nutrients (16 treatment combinations) on vegetative growth parameters and yield in aonla are showed (Table 4.21). The stem girth, plant spread (East-West), number of fruits/tree and fruit yield kg/tree were significantly influenced by different levels of N, P, K and FYM. While there was non-significant different of these treatments in plant height and plant spread (North-South). Fruit yield kg/tree was recorded highest due to treatment $N_2P_1K_1F_1$ (i.e. all at higher level) and it was statistically at par with treatment $N_1P_1K_1F_1$. These results are in consonance with the work of Ramaswamy (1971) in guava; Randhawa *et al.* (1973) in Robusta banana and Tassar *et al.* (1983) in guava. Number of fruits per tree was significantly maximum in $N_2P_1K_1F_1$ treatment and again it was at par with $N_1P_1K_1F_1$. Stem girth and plant spread (East-West) were also recorded highest due to $N_2P_1K_1F_1$ treatment and both were at par with $N_2P_1K_1F_0$ and $N_1P_1K_1F_1$ level of treatments. This might be due to the soil application of N, P, K and FYM to plant. These results are in confirmation with line of work of Tassar *et al.* (1983) in guava.

5.7 CORRELATION

The data pertaining to correlation coefficient are tabulated (Table 4.22 and 4.23).

The correlation between leaf N content of December and February was non-significantly related with yield, this may be due to the fact that during December content of leaf N was diverted towards fruits as it was at maturity stage, while during February due to its deciduous nature there was a defoliation time. Leaf phosphorus content of August was also non-significantly related, it might be due to better

absorption at required for the utilization in developing fruits. Leaf calcium content of August and October and magnesium of August were also found non-significantly related with yield because in these months nutrients were diverted towards fruit growth and development. More or less same trend was also been observed between number of fruits per tree with said mineral nutrients. Significant positive correlation coefficient was found between plant spread (East-West) and nitrogen content of leaf in August, October; leaf phosphorus content of all the period; while, potassium of all most all the periods except December and April. Whereas, magnesium content of October to April which might be due to direct exposure to sunlight.

This results were akin with Subramanian *et al.* (1972) in Kew pineapple; Marinov (1983) in apricot; Bopaiah and Shrivastava (1984) in mango; Liu *et al.* (1985) in citrus; Vitanova (1986) in plum; Rybin *et al.* (1987) in apple; Sanyal and Mitra (1990) in guava and Hasan and Chattopadhyay (1997) in litchi.

Summary and Conclusion

CHAPTER - VI

SUMMARY AND CONCLUSION

The present investigation on “Studies on leaf nutrient status in relation to different period and position in aonla Cv. Gujarat Aonla-1” was carried during the year 2000-2001 at Horticultural Research Farm, B.A. College of Agriculture, Gujarat Agricultural University, Anand Campus, Anand. Leaf was chosen as an index tissue and it was collected from five different position viz., (i) Base of the tree, (ii) Middle portion of the tree, (a) Basal portion of indeterminate branch, (b) Middle portion of indeterminate branch, (c) top portion of the indeterminate branch and (iii) top portion of the tree at bimonthly interval (i.e. June, August, October, December, February and April). Starting from June, 2000 to April, 2001 and leaf samples were analyzed for the nitrogen, phosphorus, potassium, calcium and magnesium content of leaves on dry weight basis. The experimental tree received uniform cultural practices for irrigation and plant protection measures but N, P, K and FYM were given as per treatments each at two levels (16 treatment combinations) at one set of monsoon. Vegetative growth in terms of plant height, stem girth, plant spread (East-West) and (North-South) and yield as number of fruits/tree and yield kg/tree were also recorded for different 16 treatment combinations. All the collected data were subjected to statistically analyzed which were summarized and final conclusion was drawn in this chapter.

6.1 NITROGEN

Mean leaf level of N content was found significantly higher due to treatment $N_2P_1K_1F_1$ as compared to rest of the treatments. While, it was lowest in treatment combination $N_1P_0K_0F_0$ and $N_1P_0K_1F_1$.

Significantly highest mean leaf level of N content was recorded in the month of August (after an application of manures and fertilizers) and found lowest in the month of February.

Treatment and period interacted significantly. Maximum leaf level of N content was noted due to treatment combination $N_2P_1K_1F_1$ in the month of August and minimum was recorded with treatment $N_1P_0K_0F_0$ in the month of June.

Leaf level of N content was observed significantly higher in M_3 shoot position (i.e. top portion of indeterminate branch) when leaf sample collected from middle of the tree, it was found lower when sample collected at basal portion of the tree.

Treatment $N_2P_1K_1F_1$ at M_3 shoot position recorded significantly higher leaf level of N content and lower was found in treatment $N_1P_0K_0F_0$ at basal portion of the tree in interaction between treatment and position.

Interaction of period and position showed a significant variation. The maximum leaf level of N content was noted in the month of August at M_3 position of shoot. While, it was minimum in the month of February at the basal position.

Almost all interactions for leaf level of N content were found to be significant and inconsistent over period and different positions. Maximum leaf level of N content was observed in treatment $N_2P_1K_1F_1$ in the month of August at the M_3 shoot position and minimum was in $N_1P_0K_0F_0$ treatment in the month of February at basal position.

6.2 PHOSPHORUS

Treatment $N_2P_1K_1F_1$ was recorded significantly higher mean leaf level of P content as compared to rest of the treatments. It was found lowest in treatment $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$.

Mean leaf level of P content was found significantly higher in the month of August while, it was lowest in the month of February.

Interaction between treatment and period found significant for leaf level of P content. It was maximum in treatment $N_2P_1K_1F_1$ in the month of August. Whereas, minimum in treatment $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$ in the month of February.

Significantly higher mean leaf level of P content was observed at the basal position of tree whereas lowest at the top position of the tree.

Treatment $N_2P_1K_1F_1$ at basal position recorded significantly higher mean leaf level of P content. While, it was lowest due to treatment $N_1P_0K_0F_0$ at the top position of tree.

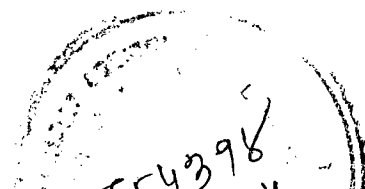
Significant difference was observed for leaf level of P content for period and position interaction. Maximum was in the month of August at basal position. While, it was minimum in the month of February at the top position of tree.

Interaction among treatment, period and position was showed significantly higher leaf level of P content in treatment combination $N_2P_1K_1F_1$ in the month of August at the basal position of tree. Whereas, it was noted lowest due to treatment $N_1P_0K_0F_0$ and $N_1P_0K_1F_0$ in the month of February at top position of tree.

6.3 POTASSIUM

Mean leaf level of K content was found to be significantly higher in treatment combination of $N_2P_1K_1F_1$ whereas it was lowest in treatment $N_1P_0K_0F_0$.

Significantly higher mean leaf level of K was recorded in the month of June while, it was lowest in the month of April.



Treatment and period interacted significantly. Maximum leaf level of K content was found due to treatment $N_2P_1K_1F_1$ in the month of June whereas, it was minimum in treatment $N_1P_0K_0F_0$ in the month of August and April.

Top portion of indeterminate branch (M_3 shoot position) when samples were collected from the middle portion of the tree showed significantly higher leaf level of K content whereas lowest was noted at basal position of tree.

Interaction between treatment and position found significant for leaf level of K content. Maximum was observed in $N_2P_1K_1F_1$ treatment at M_3 shoot position and minimum in treatment $N_1P_0K_0F_0$ at basal position.

Period and position interaction showed significant effect in higher leaf level of K content in the month of June at M_3 position of shoot and lowest in the month of August at basal position.

Interaction effect between treatment, period and position on leaf level of K content was found to be significantly differed. Highest was found due to treatment $N_2P_1K_1F_1$ in the month of June at M_3 position of shoot, while, lowest in treatment $N_1P_1K_0F_0$ in the month of August at basal position.

6.4 CALCIUM

Mean leaf level of Ca content was recorded significantly higher in treatment $N_2P_1K_1F_1$ as compared to rest of the treatments. Whereas, lowest was noted in treatment $N_1P_0K_0F_0$.

Significantly higher leaf level of Ca content was observed in the month of October followed by August whereas it was lower in the month of June.

Treatment and period interacted significantly for leaf level of Ca content. Maximum was recorded in treatment $N_2P_1K_1F_1$ in the month of October while, it was minimum in $N_1P_0K_0F_0$ in the month of June.

Significantly higher mean leaf level of Ca content was recorded when leaf sample collected from basal position and lowest was noted in top position.

Interaction between treatment and position showed significant effect. Higher leaf level of Ca content was recorded in the treatment $N_2P_1K_1F_1$ at basal position, while it was lowest in $N_1P_0K_0F_0$ treatment at the top position.

Interaction effect between period and position indicated significantly higher leaf level of Ca content in the month of October at basal position whereas it was lowest in the month of June at top position.

Almost all interactions for leaf level of Ca content found to be significant and inconsistent over periods and different positions. Maximum leaf level of Ca content was recorded with treatment $N_2P_1K_1F_1$ in the month of October at basal position. While, it was minimum in treatment $N_1P_0K_0F_0$ in the month of June at top position.

6.5 MAGNESIUM

Mean leaf level of Mg content was significantly higher in treatment combination $N_2P_1K_1F_1$ as compared to all other treatments. While, lowest was observed in treatment $N_1P_0K_0F_0$.

An effect of different period revealed that significantly higher mean leaf level of Mg content was found in the month of August. While, it was noted lowest in the month of October.

Interaction between treatment and period showed significant difference for leaf level of Mg content. It was recorded maximum due to treatment $N_2P_1K_1F_1$ in the month of June whereas minimum in treatment $N_1P_0K_0F_0$ in the month of June.

An effect of position was found to be significant for mean leaf level of Mg content. It was maximum at basal position and minimum was at the top position.

An interaction between treatment and position indicated that significantly higher leaf level of Mg content in treatment $N_2P_1K_1F_1$ at basal position, while, it was lowest in treatment combination $N_1P_0K_0F_0$ at top position.

Significant interaction in leaf level of Mg content was found with respect to different period and position. Maximum was observed in the month of August at basal position and minimum in the month of June at top position.

An interaction between different treatment, period and position for leaf level of Mg content indicated that significantly higher in treatment $N_2P_1K_1F_1$ in the month of August at basal position. While, it was lowest in treatment $N_1P_0K_0F_0$ in the month of June at top position.

6.6 PERFORMANCE OF VEGETATIVE GROWTH AND YIELD IN AONLA Cv. GUJARAT AONLA-1

Significant effect of different treatments were found on plant spread (East-west), stem girth, number of fruits/tree and fruit yield (kg/tree). Fruit yield was recorded highest in treatment $N_2P_1K_1F_1$ and it was at par with $N_1P_1K_1F_1$. While, it was noted lowest in treatment $N_1P_1K_0F_0$.

6.7 CORRELATION STUDIES

The yield (kg/tree) was significantly and positively correlated with number of fruits/tree, leaf level of N, P, K, Ca and Mg in different periods except the correlation

between leaf level of N content of December and February, P content of August, Ca content of August and October and Mg content of August which was found non-significant. More or less same trend was observed between number of fruits per tree with the said nutrients. Significant correlation coefficient was found between plant spread (East-west) and leaf level of N content in August and October; P content of all the periods; K content of all the period except December and April; whereas Mg content of October to April. There was significant positive relationship between different nutrients content in leaf and in different periods.

CONCLUSION

Despite the marked fluctuation of leaf nutrients throughout the year in aonla cv. Gujarat Aonla-1, stability period for nitrogen, phosphorus and magnesium were noted in the month of August to October. Potassium content of leaf stabilized during June to August and calcium in October to December. All these nutrients were found stabilized at middle position of indeterminate branch when sample collected from middle position of tree. To assess N, P, K, Ca and Mg status of an aonla tree leaf sample should be collected from middle position of the tree at their respective stabilized period. Besides these, aonla trees requires to be applied N, P, K along with FYM for higher yield.

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* Original not seen.

Appendix

Appendix I : Meteorological data for the period of study (June, 2000-April, 2001)

Month	Temperature (°C)		RH (%)	RF (mm)
	Maximum	Minimum		
June, 2000	36.85	27.35	64.40	49.50
July, 2000	32.03	25.69	78.82	222.2
August, 2000	32.88	25.50	78.19	809.0
September, 2000	34.23	24.25	68.87	9.000
October, 2000	37.35	21.01	59.13	0.000
November, 2000	34.34	15.88	53.26	0.000
December, 2000	30.95	10.96	55.23	4.300
January, 2001	27.89	10.29	52.45	0.000
February, 2001	31.00	11.14	54.03	0.000
March, 2001	35.10	17.41	46.90	0.000
April, 2001	30.08	14.09	40.25	0.000