

**Effect Of Factorial Combination Of Nitrogen, Phosphorus
And Potassium On The Fruit Bud Differentiation, Yield
And Quality In Himrod Cv. Of Grape**

BY

K. U. SANGHANI

**A Thesis submitted to the
Punjab Agricultural University
Ludiana, Punjab.**

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

HORTICULTURE

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Dedicated
To
Late Dr. G.S. Cheema

**EFFECT OF FACTORIAL COMBINATIONS OF NITROGEN, PHOSPHORUS AND
POTASSIUM ON THE FRUIT BUD DIFFERENTIATION, YIELD AND
QUALITY IN HEMROD Cv. OF GRAPE**

By

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**Dissertation submitted to the Punjab Agricultural University
in partial fulfilment of the requirements for the degree of:**

DOCTOR OF PHILOSOPHY

in

HORTICULTURE

**College of Agriculture
Punjab Agricultural University
Ludhiana**

1974

V I T A

The author was born at village Utran, Jalgaon district, Maharashtra, on January 30, 1942. He passed the matriculation examination in 1959 from New English School, Nashirabad (Maharashtra). He obtained the B.Sc. (Agri.) degree with Honours from University of Poona in 1961. He stood first in M.Sc. (Agri.) degree in University of Poona, obtaining first class. During his B.Sc. (Agri.) and M.Sc. (Agri.) studies, he was awarded Shri Manakchandji Senghani scholarship.

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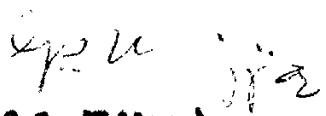
He has eight years of service experience upto date. The author was deputed for course of Ph.D. in November, 1970, by Mahatma Phule Krishi Vidyapeeth, Rahuri, in the capacity of Assistant Professor of Horticulture. During the course of present studies, he was selected as Reader of Horticulture. He had sixteen research and popular articles at his credit.

He married Miss Pustpalata in 1967 and they have two children, Sanjay and Sapana.

CERTIFICATE I

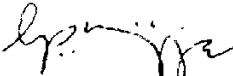
This is to certify that this dissertation entitled "Effect of factorial combinations of nitrogen, phosphorus and potassium on the fruit bud differentiation, yield and quality in Emerald Gr. of grape" submitted for the degree of Doctor of Philosophy in Agriculture (Horticulture) of the Punjab Agricultural University is a bonafide research work carried out by Shri K. U. Sanghera under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.



(G.S. Nijjar)
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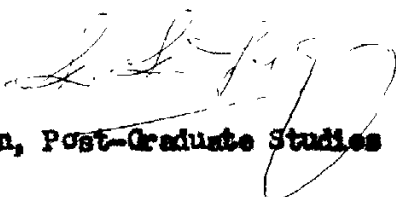
CERTIFICATE II

This is to certify that the dissertation entitled "Effect of factorial combinations of nitrogen, phosphorus and potassium on the fruit bud differentiation, yield and quality in Hamrod Cv. of grape" submitted by Shri K.U. Sanghani in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Agriculture (Horticulture) has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with an external examiner.


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Beneghanvi
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✓ (K.U. Sanghavi)
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Chapter I

I N T R O D U C T I O N

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Chapter I

INTRODUCTION

There has been a keen interest, in recent years, towards the development of grape cultivation in India. About 8,000 hectares have been put under the choicest cultivars of grapes, particularly in the states of Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu. The grape industry is also springing up in North India especially in the Punjab and Haryana.

The principal cultivars grown in India are Anab-e-Shahi, Thompson Seedless, Bhokari, Chona Sahibi, Bangalore Him, Muscat and Perlette. The cultivar Himrod has recently been introduced in India. It has several merits such as good vine vigour, high prolificity and early ripening. It bears large, well filled bunches with greenish yellow, medium sized berries and excels in taste containing 19-20 per cent sugar. The berries are seedless. An important characteristic of this variety is its resistance to diseases and insects which is very significant under Punjab conditions. Because of these virtues, this cultivar is becoming popular with the growers.

The management practices play an important role in commercial vineyards. These practices include fertilisation, irrigation, plant protection, pruning etc. Amongst these, judicious fertilisation plays a key role in determining yield and quality of the crop.

Nitrogen, phosphorus and potassium are important for profitable crop production. Grape vines remove these elements from the soil in large amounts. Chessa *et al.* (1954) reported that a 5 ton crop per acre of fresh grapes removed 33 lb of N, 9 lb of P_2O_5 , 27 lb of K_2O , 71 lb of lime and 360 lb of magnesia. Removal of the nutrients through pruning wood is in addition to these quantities. Replacement of these huge quantities of nutrients in the soil is, therefore, necessary to keep it in a good fertile condition and to have bumper crops in the following years.

Despite the fact that the grape industry in the Punjab has been growing at a rapid rate, much attention has not so far been given to various aspects of viticulture including nutrition.

There is a vast disparity amongst the growers in various regions of India with regard to quantities and types of fertilisers applied. The fruit growers, at present, are following manual practices based either on common experience in their localities or on the results of research conducted in foreign countries.

A few fertilizer trials, however, have been carried out in India in the recent past. Mathava Rao and Mukherjee (1970) and Narsya *et al.* (1970), under Delhi and Tamil Nadu conditions respectively, have shown that vine nutrition has great bearing on fruit-bud differentiation. Under Punjab condition, Hijjar and Ghani (1969) and Hijjar and Ram (1969) reported that high yield and better quality of Anab-e-Shahi grapes was obtained by the application of 1 kg of N per vine combined with 1 to 1.5 kg of P_2O_5 . Similarly, Hassan (1969) obtained best results with 3 lb of K_2O per vine as far as yield and quality of Anab-e-Shahi grape was concerned.

Keeping in view the importance of fertilization and in the light of observations of above mentioned workers, it is considered desirable to conduct the studies to investigate the influence of N, P and K on flower bud differentiation, yield and quality of Himrod cultivar of grapes.

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Chapter II

REVIEW OF LITERATURE

Chapter XI

REVIEW OF LITERATURE

The work done in India on the effects of N, P and K fertilizers on the fruit bud differentiation, vigour, yield and quality of grapes is meagre. On the other hand, voluminous literature has been published abroad on this aspect. An attempt has been made here to review the work done on this aspect at home and abroad under the appropriate sub-headings.

NITROGEN

Effect on growth

Nitrogen application has been reported to increase the vigour of the vines by Ismail *et al.* (1957), Cheban (1963) and Sandvad (1964). Bensen *et al.* (1957) reported that 60 lb of N per acre was not sufficient to maintain good vine vigour whereas 100 lb of N per acre greatly increased it. Similarly, Vega *et al.* (1957), Agulhon *et al.* (1964) and Sparks and Larsen (1966) reported that increased N application resulted in greater vegetative growth. El-Shourbagy and Ismail (1961), however, observed that the vines treated with 90 g N recorded heaviest weights of prunings as compared

with those which were given 100 or 150 g of N per year. Williams (1945), however, found that shoot growth did not significantly increase by N application to the vines.

Effect on fruit bud differentiation

According to Manivel (1967) and Srinivasan (1968) N promoted earlier initiation of leaf primordia. A rapid reduction in the N content was associated with the time of flower bud differentiation (Malanta, 1967).

Effect on bunch size and weight

Shaulis (1984) reported that the N promoted the size and compactness of grape bunches. The vines receiving 80 g inorganic N produced more and heavier clusters than those receiving 20 or 100 g (Ragab and Habeeb, 1981).

Effect on berry size and weight

The berry size was not affected or possibly was increased very slightly by N application as noted by Williams (1945, 1946). Large berries, as judged by length to width ratio were, however, obtained from the vines which received 80 g of N each (Ismail *et al.*, 1984). An increase in berry weight was obtained by Agulhon *et al.* (1984) with the application of 400 kg N per hectare.

Effect on yield

Nitrogen deficiency has been considered to be the chief limiting factor in grape production. Many workers have reported an

increase in grape yield with the application of nitrogen (Ulrich, 1952; Ballatore, 1958; Hansen *et al.*, 1957; Vergenes, 1959; Aguilon *et al.*, 1964; Sandvad, 1964; Hernandez and Mendiala, 1965 and Cheben, 1968). The rate at which the N is to be applied to get an increase in yields depends upon the type of soil (Brenas and Vergenes, 1961), and the time of its application (Winkler, 1962). Wellington and Collison (1945) noted that the application of 52 lb of N per acre increased grape yield approximately by 1,400 lb. Similarly, El-Shourbagy and Ismail (1961) reported that 120 g N per vine significantly increased the number of clusters and crop weight. Hopkins and Gouley (1930), on the other hand, obtained no significant increase in yield by N application. In a four-year experiment, Ballatore (1958) obtained significant yield increase only in one year by the application of N. Excessive application of N depressed the yields by production of luxuriant vegetative growth and flower shatter at the expense of berry production (Glore, 1958; Christensen and Kasimatis, 1964). Sparks and Larsen (1965) also did not get yield increase with N application.

Effect on fruit quality

Hedrick and Glavin (1914), Ulrich (1952) and Cheben (1968) showed that N improved fruit quality in grapes. On the other hand, Gouley and Hopkins (1929) observed that the total sugars were somewhat higher in the control and low in the grapes borne by the N-treated vines. Partridge (1951) compared vines of equal production and found that the unfertilized vines were consistently higher in

the total solids than the vines receiving N either alone or in NPK combination. Boynton and Snook (1944) also reported that differential doses of N had no marked effect on soluble solids in the fruits. Williams (1945, 1946) reported that juice acidity increased and sugar content decreased with N application. Vergnes (1959) obtained high T.S.S. from control plants than those treated with the different N fertilisers. Arutyunyan *et al.* (1964) and Hernandez *et al.* (1964) reported that juice acidity increased and sugar content decreased with N application. Sparks and Larsen (1966), however, found no direct effect of N on soluble solids in grapes.

Effect on nutritional status of vines

The per cent dry weight of an element present in grape leaves or in leaf petioles is considered to be the most dependable criterion for diagnosing its deficient or toxic levels. Legata and Masse (1927) working on nutrition of grapes in France were the first to set down the sampling technique and the basis for the interpretation of results.

Beattie and Furshey (1954) sampled 85 Concord vineyards in Ohio and found a significant correlation between petiole-N value and fruit yield. These workers concluded from their survey data that a petiole-N level of 0.77 per cent in mid-July was required for an intermediate yield in Concord grapes. Shaulis and Kimball (1956) surveyed 18 vineyards and conducted N-trials in three Concord vineyards. They concluded that a late-June petiole-N level of less

than 1.5 per cent almost always resulted in low vine vigour, that values of over 2.0 per cent were mostly associated with high vine vigour and that grape yields were reduced when the N level was less than 1.6 per cent.

Marked increase in N content of petioles by increasing the doses of N was observed by Ulrich (1952), Kosma and Polyak (1964) and Abdalla and Sefiek (1965).

Nijjar (1972) reported the results of two experiments on Anab-e-Shahi cultivar of grape. In the first experiment three doses each of N, P and K (0.5, 1.0 and 1.5 kg N, 0.5, 1.0 and 1.5 kg K_2O and 0.75, 1.50 and 2.25 kg P_2O_5) were factorially combined and in second experiment three doses each of N and P (0.5, 1.0 and 1.5 kg each of N and P_2O_5) were factorially combined. In these experiments, he observed that with an increase in soil N, there were no significant differences in the N, P, K, Mg, Na, B and Zn content of leaf but there were significant differences in Ca, Mn and Fe content of the leaf.

PHOSPHORUS

Effect on growth

The deficiency of P resulted in reduced growth, dull grey green leaves and pre-mature defoliation (Chandler, 1955). Vines were found to be more vigorous when P was applied (Randolph, 1944; Fleming, 1961, and Cheben, 1965). However, Gladrin (1958)

after a 25-year trial, reported that P was of doubtful value so far as vine growth was concerned.

Effect on fruit bud differentiation

Hroyasu (1965) found that lack of P between March and July reduced the yield in Black Queen grape grown in sand and solution culture. Omission of P during the rest of the year did not produce a detrimental effect. Manaya (1966) showed that application of P after 30-40 days of pruning of Anab-e-Shahi vines was helpful in promoting fruitfulness as that was a crucial period when fruit buds were laid down in the leaf axils. Analysis of nucleic acid contents of buds at different stages indicated a higher rate of RNA synthesis at the time of flower bud formation and higher RNA/DNA ratio at the 6th bud which was the fruitful region in Anab-e-Shahi. These data of Madhava Rao and Srinivasan (1971) lend credence to the need for P nutrition at the time of flower bud formation.

Effect on bunch size and weight

Arumakov (1966) reported that spraying the vines with 1 per cent potassium phosphate at the beginning and again at the end of July increased the bunch size.

Effect on berry size and weight

Akopjan and Kassarjan (1966) observed that the berry size was increased with organic fertiliser plus P.

Effect on yield

Randolph (1944) found that the treatments containing P significantly increased the total yield and more so when P applications were raised from 15 to 31 to 47 lb per acre. Uphall *et al.* (1949) reported that the application of superphosphate gave the best response in increasing the yield. Many other workers have also reported the increase in the yield of grapes by the addition of P (Liwant, 1954; Dragash, 1957 and Kobayashi *et al.*, 1961). Arutjunjan (1959) noted that the yield was more with the combined application of superphosphate and organic manure than was the sum of increases resulting from the application of superphosphate and manure separately. Sakyanarayana (1972) conducting nutritional experiments and surveying various vineyards in Andhra Pradesh concluded that Anab-e-Shahi responded well to P application giving higher yields with better quality fruits.

Glabrin (1956) was of the view that P had a doubtful value as far as yield of grapes was concerned. Similarly, Walters (1949) reported that P did not increase the yield of grapes. Williams (1945) observed that P tended to depress the effect of N and in no case had statistically significant difference in yield.

Effect on fruit quality

Ariev (1954) found that the foliar spray of P increased the sugar content of the juice and also improved the juiciness of berries. Chema *et al.* (1954), Dragash (1957) and Jacob and Von Usankul

(1953) reported better ripening and increased sugar content with P application. The combined application of organic manure and P fertilizers gave the highest increase in sugar content (Arutjunjan, 1964 and Skopjan and Hesarjan, 1965). Abdalla and Sefick (1965) and Skopjan and Hesarjan (1965) showed that the application of P reduced the grape-juice acidity.

Effect on nutritional status of vines

The reference level of Lugatu and Mame (1954) is 0.22 per cent P for four growth stages ranging from 0.26 per cent at the beginning of bloom to 0.12 per cent at fruit maturity.

Beattie and Forshey (1954) surveyed 85 Concord vineyards and concluded that no vineyard producing 3.5 tons per acre necessary for profitable grape production showed less than 0.14 per cent P in leaf petioles.

Shadlis and Kimball (1956) in five field experiments on Concord grapes found no indication of vine response to added P. Similarly, Larsen et al. (1955, 1958 and 1959) in extensive vineyard surveys and intensive fertilizer trials did not get response to P application.

Kosma and Polyak (1964) reported that the P application always increased P content of all the organs while Abdalla and Sefick (1965) reported that the P content of leaf petioles was not altered by the application of phosphatic fertilizer.

Dev *et al.* (1970) conducted an experiment on the uptake of radioactive P by three grape cultivars viz. Beauty Seedless, Badana and Himrod. They observed that Himrod cultivar contained significantly higher P than those of Beauty Seedless and Badana. This differential behaviour of cultivars for content of P revealed that Himrod vines were more efficient in absorbing P under similar soil and climatic conditions than other two cultivars and thus the Himrod cultivar may be able to satisfy its requirements even under relatively lower P environments. Hijjar (1972) reported that with increase in P application to Anab-e-Shahi grapevines, there was no significant increase in leaf content of N, P, Ca, Mg, Mn and B. However, the leaf content of K, Zn and Fe were significantly increased with an increase in soil P.

POTASSIUM

Effect on growth

Manson (1908) reported that if the soil is deficient in K, vines would be weak in growth. It was observed by Shaulis and Kimball (1956) that K-deficient vines with only 2 per cent seorch had about 20 per cent less growth than the vines with asymptomatic foliage. Agulhon *et al.* (1964) reported that the vegetative growth was greatly increased by K-application. Spraying the vines with potassium phosphate at the beginning and again at the end of July improved shoot maturity (Arzumov, 1968).

Effect on fruit-bud differentiation

Manivel (1967) and Srinivasan (1968) showed that K was effective in promoting fruitfulness in grape. They further explained that K led to late initiation of leaves but rapid differentiation of flower buds in comparison to N and P. Hiroyasu (1968) found that the lack of K from mid-April to mid-May reduced the yield of Black Queen grape grown in sand and solution culture. Christensen (1968) found yield increases of as much as 51 per cent due to K application in K-deficient Thompson Seedless vineyards. Potassium was found to increase fertility of buds particularly in the region between 8th and 10th buds. Analysis of individual buds showed that carbohydrate content was markedly increased by K and NK which was related to fruitfulness. A rapid reduction in the N, K and carbohydrate content was associated with the time of flower-bud initiation (Manivel, 1967; Malanta, 1967; Shivashankara, 1967 and Srinivasan, 1968).

Effect on bunch size and weight

Kobayashi et al. (1961) found that increasing the level of K to twice the N level increased the bunch weight. According to Cook (1968), the K deficiency in Thompson Seedless caused small and tight clusters.

Effect on berry size and weight

Akopyan and Nazaryan (1968) reported that K in combination with organic fertilizers increased the berry size. Cook (1968) reported that K-deficient Thompson Seedless vines produced small berries.

Effect on yield

Stans (1936) noticed that the yield of grape was reduced where K was omitted from fertilizer schedule. Increase in yield by K application was reported by Viner (1935) in France and by Becker and Wetzel (1941) in Germany. Moser (1953) found that K application gave higher grape yields with better quality fruits. Depardon and Biron (1959) reported that an application of 100 kg K_2O per hectare gave higher yields of grapes than untreated plots. Kobayashi *et al.* (1961) conducted a trial on grape fertilization and found that increasing the K level double to that of N along with P, the yield was increased. Christensen (1964) also found that potassium increased yield by 31.0 per cent, cluster weight by 24.0 per cent and berry weight by 10.0 per cent by applying 5 lb potassium sulphate per vine to Thompson Seedless vines. Hassan (1968) conducted an experiment with 1, 2, 3 and 4 lb of K_2O per vine to Anab-e-Shahi cultivar and obtained the highest yield with 5 lb of K_2O .

There are, however, a few reports such as Partridge (1923), Walter (1942), Williams (1946) and Shaulis (1948) where K did not give any yield response. According to Vega *et al.* (1957) the yield response was negligible to potassium application in sandy loam soil having pH 8.

Effect on fruit quality

Raman (1959) found that the vines receiving 5 lb of potassium chloride per vine had more sugar as compared to 2 lb.

Arumakov (1966) observed that 1 per cent spray of potassium phosphate at the beginning and again at the end of July increased the sugar content of grape juice. Hassan (1968) recorded highest T.S.S. with 5 lb of K_2O per vine as compared to 1, 2 and 4 lb of K_2O per vine. Improvement in the sugar content of grapes due to K application was also observed by Moser, 1955; Liverant, 1954; Bekhehi, 1961 and Aguilhon *et al.*, 1964.

Sorader (1955) reported that the higher K content in the leaves resulted in a low acid content in grape juice. Reduction in acidity in grape juice was also noted by Arutjunjan *et al.* (1964) and Abdalla and Sefick (1968). Akopjan and Nasarjan (1966) reported that the organic fertilisers in combination with K decreased the acidity in grapes. However, Kobayashi *et al.* (1961) and Cook (1968) found that high K treatments markedly increased the acidity in grape juice.

Effect on nutritional status of vines

In Ohio, Beattie and Forshey (1954) found that the average petiole-K values were 2.55, 1.95 and 1.55 per cent in vineyards of high, intermediate and low yield respectively, thus showing decrease in average petiole concentration of K in low-yield vineyards. Loran *et al.* (1956) also reported that K was the only nutrient element that increased in the petiole as yield increased. Abdalla and Sefick (1968) found an increase in petiole-K with K_2O application. Mijer (1972) reported that with increased soil

application of K, there was no significant increase in leaf content of N, P, Ca, Mg, Na, Mn and Zn. Leaf K, Fe and B, however, showed significant increases.

N, P AND K COMBINATIONS

The NPK fertilizers should be used in proper proportion to get the maximum beneficial effects in terms of vine growth, yield and quality of fruits. The adjustment is dependent upon the type of soil, the supply of bulky organic manure, age of the vine and the varietal response.

Effect on vine growth

The grape vines deficient in NPK had weak growth and were pale in colour (Munson, 1905). All the combinations of NPK gave better vine growth, but the NK treatment gave the most pronounced results in increase in vine growth (Gladwin, 1936). Fleming *et al.* (1950) reported that the annual spring application up to 20 lb per acre of N and 50 lb per acre of K_2O increased the vine growth. Isoda (1964) observed that the NPK combination was superior to NP and NK to N alone. Further, he observed that growth was poorest in unfertilized vines and was also poor in minus-N and minus-P vines. An increase in vine growth was reported by Taschenburg and Shaulis (1955) with 400 lb of 10:10:10 fertilizer mixture per acre. Opera (1965) reported that NPK improved rooting, accelerated wood maturity and increased dry matter content of both roots and tops. Greatest

increase in the number of fruiting shoots was obtained by Serpyshovlina (1968) with mineral fertiliser plus organic fertiliser at the rate of 5 tons per hectare. Cohen (1968) also reported that 80 kg per hectare of each of N, P and K considerably increased the growth of 8-year-old vines. The improvement in general vigour and the growth of the vines with the application of N 10 : P 12 : K 10 fertiliser was observed by Danilov (1967).

Some workers did not, however, get such encouraging results. Williams (1945), for example, observed that shoot growth was not significantly increased by either N or NPK fertilisers.

Effect on fruit-bud differentiation

Naraya (1966) observed at Coimbatore that P was helpful in promoting fruitfulness in Anab-e-Ghazi. Further work done by Manivel (1967) and Srinivasan (1968) showed that K was also effective in this regard. N promoted earlier initiation of leaf primordia while differentiation of flower buds was favoured by P and K. Potassium led to late initiation of leaves but rapid differentiation of flower buds in comparison to N and P. It was also shown that the combined treatment of NPK also induced earlier initiation and differentiation of cluster primordia. Potassium was found to increase fertility of buds, particularly in the region between 8th and 10th buds. Analysis of individual buds showed that carbohydrate content was markedly increased by K and NK which was related to fruitfulness. A rapid reduction in the N, K and carbohydrate content was associated with the time of flower-bud initiation (Manivel, 1967;

Malanta, 1967; Shivashankara, 1967 and Srinivasan, 1968). Hanaya *et al.* (1970) observed that all the post-pruning treatments viz. NPK, P or digging around the vines resulted in considerably increased fruitfulness as compared with NPK dressing only at the pruning time. The P dressing had a particularly marked effect, resulting in 100 per cent fruitfulness in eight of ten buds along the cane as compared with NPK or digging around the vines.

Studies conducted with Pusa Seedless under Delhi conditions (Madhava Rao and Mukherjee, 1970) showed that among eight treatments with two levels of N, P and K, three combinations $N_1P_0K_1$, $N_1P_1K_0$ and $N_1P_1K_1$ showed significantly higher fruitfulness than the control treatment.

Effect on bunch size and weight

There was little evidence that the application of N and K without the aid of P increased the size of clusters (Randolph, 1944). Ragab and Haseeb (1961) observed that the vines receiving 100 g of inorganic NPK fertilisers produced heavier bunches than those receiving 90 g N. Serpukhovilina (1965) obtained the greatest increase in the number of bunches with mineral fertilizer plus organic material at the rate of 5 tons per hectare.

Effect on berry size and weight

Huang-Hanchin (1960) observed that the cumulative weight of 100 grape berries was increased by approximately three to 28 per cent by top dressing with ammonium nitrate, super phosphate or muriate

of potash or with their combination. Increase in berry size was also reported by Moejjan and Nasarjan (1955) with organic fertiliser plus P and K. The berry size seemed to remain the same or possibly was increased very slightly by NPK treatments (Williams, 1945, 1946).

Effect on yield

Application of 500 lb per acre of a 4:10:6 NPK mixture gave better yield as compared with the vines which received only two of these elements (Stone, 1955). Gladin (1956), in a summary of 25-year-fertiliser trial with Concord grapes, reported that all the five treatments of various NPK combinations had beneficial effect but the gain in fruit production was most pronounced with NK combination. Uphall *et al.* (1949) conducted an experiment on Concord grapes in Canada. They compared various combinations of N, P and K, green manure, hay mulch, straw plus N, lime plus wood ashes and lime plus fish meal. The highest increase in yield (15.5 per cent) was obtained from the NPK treatment, but this was considered too small to cover the cost of the treatment. Liserant (1955) obtained highest yields with NPK balance of 84.1 : 11.6 : 24.5, but the yields from the superphosphate series were somewhat higher than those of the slug series.

McVicker (1959) obtained best results with palletised 14:14:14 fertiliser mixture. He reported that NPK was superior to NP and KP to N alone. Similarly, Malvic and Koroseva (1964) recorded maximum yield from a combination of NPK at 100 + 300 + 120 kg per

hectare. Significant increase in yield was obtained with N and K combination as compared to N or K alone (Aguilhon *et al.*, 1965).

Dulas (1965) conducted a 15-year trial and noted that the yield was greatly increased from NPK and NPK plus manure treatments. A 28.4 per cent increase in yield over the control was obtained with the use of N 10 : P 12 : K 10 fertilizer combination (Danellov, 1967). Gill (1969) showed that 1 kg of N, 1.5 kg of P_2O_5 and 1 kg of K_2O applied per vine gave best response in respect of yield and fruit quality. Hijjar and Chand (1969) and Hijjar and Ram (1969) reported that high yield in Anab-e-Shahi was obtained by the application of 1 kg of N per vine combined with 1 or 1.5 kg of P_2O_5 . Yield increases with application of NPK fertilizers were also obtained by many workers (Williams, 1945; Randolph, 1944; Hsuan-Nanchin, 1959; Levinaki, 1960 and Cheban, 1966).

Effect on fruit quality

The work of Liverant (1955) showed that the highest sugar content was obtained in vines receiving complete fertilizers. It was noted by Hsuan-Nanchin (1960) that total sugar was increased by 2.54 to 5.55 per cent in 1957 and 7.8 to 27.84 per cent in 1958 with N, P and K treatments separately and NPK combination treatment but the highest sugars were recorded with NPK combination. Akopjan and Nasarjan (1965) found that organic fertilizer plus P or K increased the sugar content and reduced the acidity of grape juice. Cheban (1966) showed that sugar content^{ent} increased and acidity decreased with spring application of 60 kg of each of N, P and K per hectare. The work of

Isoda (1964), Barocelo and Palieri (1968) and Martin and Stefan (1967) also showed that higher sugar content was obtained in vines receiving complete fertilizers.

On the other hand, no consistent differences in percentage of total solids were observed with fertilizer treatment when comparisons were made between vines of approximately equal productivity (Partridge, 1951). Williams (1945, 1946) reported that quality of grape as measured by odour, acidity and T.S.S. generally deteriorated with NPK treatment of 15.5 lb per vine of a salt mixture of approximately 4.6 : 12.6 : 21.7 analysis. Levinskij (1960) observed that NPK did not affect the sugar content and the acidity of the juice.

Effect on nutritional status of vines

Bentley and Forshey (1954) noted that the N and K content in petioles were directly correlated with the yield but the concentration of P was not consistently associated with the yield. The concentration of N, P and K in the cell sap increased by the application of these nutrients to the soil.

Hijjar and Ram (1960) reported that good yield in Anab-e-Shahi grape was associated with petiole contents of 1.2 per cent N and 0.4 per cent P. Further, they observed that N content of leaf petiole increased in vines receiving 1 and 2 lb of N per vine but decreased when N was applied at a rate of 3 lb per vine, whereas different rate of P application did not decrease N uptake.

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Chapter III

MATERIAL AND METHODS

The present investigation on the effect of different doses of nitrogen, phosphorus and potassium on the fruit bud differentiation, yield and the quality in grapes and nutritional status of vines was carried out at the vineyard of the Horticulture Department, Punjab Agricultural University, Ludhiana, during the years 1972-73 and 1973-74.

The climatic conditions prevailing at Ludhiana are representative of those of the central Punjab plains. The average maximum and minimum temperature at Ludhiana is 35.6°C and 4.4°C, respectively. The average annual rainfall is 50-75 cm; the bulk of which is received during July, August and September. The source of irrigation for the vineyard is a tubewell. The soil is sandy-loam with a pH value of 8.2 and available N, P and K content of 115.4, 12.5 and 118.7 kg/ha, respectively.

Plant material

Four-year-old vines of Hybrid cultivar of grape having uniform vigour were selected for the present investigation. The

vines were planted at a distance of 5 metres both ways and were trained on six-arm Kniffin system.

Fertiliser treatments

There were 12 fertiliser treatments comprising factorial combinations of three levels of N and two levels each of P and K.

N, P and K were applied in the form of calcium ammonium nitrate, single superphosphate and muriate of potash respectively. The details are given below.

<u>Nutrients</u>		<u>Dose per vine</u>	<u>Source</u>	<u>Quantity applied per vine (kg)</u>
Nitrogen	N ₁	0.4 kg N	CAN (25% N)	1.600
	N ₂	0.8 kg N	"	3.200
	N ₃	1.2 kg N	"	4.800
Phosphorus	P ₁	0.8 kg P ₂ O ₅	Superphosphate (16% P ₂ O ₅)	5.000
	P ₂	1.2 kg P ₂ O ₅	"	7.500
Potassium	K ₁	0.8 kg K ₂ O	Muriate of potash (60% K ₂ O)	1.333
	K ₂	1.2 kg K ₂ O	"	2.000

Time of fertiliser application

The full doses of P and K and half dose of N were applied in the first week of February just after the pruning of vines. The remaining half dose of N was applied in the second week of April.

The irrigation and other cultural practices were the same for all the experimental vines.

LAYOUT OF THE EXPERIMENT

The experiment was laid out in randomised block design. The experimental unit consisted of three vines and there were four replications.

The following observations were recorded.

I. VIGOUR OF THE VINES

(1) Trunk circumference

A mark was painted on the vine trunk 15 cm from the ground level. The girth of the trunk was measured twice during the course of the study, once before the start of the experiment and another at the end of the experiment at the marked point and the increase in girth of vines was calculated. ^{with angular transformation.}

(2) Weight of prunings

To have an idea of the effect of different doses of fertilizers on the growth of the vine, the weight of prunings was recorded.

II. Bunch characteristics

Ten bunches per treatment were collected at random at harvest time to record their length, width, weight and the number of berries per bunch.



III. Berry characteristics

(1) Weight of berry

One hundred berries randomly selected, were taken from the ten representative bunches and weighed on a triple-beam balance up to 0.1 gram accuracy. The mean weight of a berry was thus worked out.

(2) Berry length

Twenty-five berries were randomly selected from the above sample and their lengths were measured with the help of a Vernier's calliper. The mean length of a berry was calculated from these data.

(3) Berry diameter

The diameter of berry at its maximum was measured in centimetres using Vernier's calliper.

(4) Juice percentage

The juice was extracted by hand from previously mentioned, randomly selected berries which were used for recording the weight of berries. The juice was strained through muslin cloth. It was weighed on a triple-beam balance and expressed in percentage on the basis of the original weight of the berries.

IV. Chemical characters

For assessing the effect of various fertiliser treatments on the fruit quality, the following observations were recorded.

T-1009

Two fully ripe bunches from each treatment were taken. The juice of all the berries of these randomly selected bunches was extracted and strained through muslin cloth.

(1) Total soluble solids

The strained juice of each sample was thoroughly stirred before taking the reading. The T.S.S. content of the juice was determined with an Optex-331 refractometer. To avoid the chances of error, two readings of each sample were taken and average was worked out. The refractometer was thoroughly cleaned with distilled water and wiped clean before taking the next reading.

(2) Acidity

Ten ml fresh juice was titrated against a 0.1 N NaOH solution using phenolphthalein as an indicator. The percentage of acidity of the juice was calculated and expressed in terms of tartaric acid (A.O.A.C., 1960).

V. Yield

The grapes in the experimental area were harvested when they were ripe (the stage when berries become soft and almost all the berries in the bunch developed uniform colour characteristic to the variety was considered to be the proper harvest stage) and total yield per vine was recorded.



VI. Petiole analysis

For analysing leaf petioles for N, P and K, the petiole samples were collected according to the procedure given by Chapman (1964). For N and P, leaf petioles were collected from the leaves which were adjacent to the clusters at the end of the bloom period. For K, the petioles were collected 60 days after full bloom from youngest mature leaves.

Twenty-five leaf petioles were taken from each treated vine and were kept in polythene bags. The samples were first washed with soap, then with 0.1 N HCl, tap water and finally rinsed with distilled water. They were dried in an oven at 65°C for 48 hours.

(1) Nitrogen

The N was analysed according to Kjeldahl method described by A.O.A.C. (1960).

(2) Phosphorus

The P was determined by ammonium molybdate-vanadate method described by Chapman and Pratt (1961).

(3) Potassium

The K was determined by wet digestion method described by Piper (1950).

VII. Collection of soil samples

The soil samples from each 50 cm zone to a depth of 150 cm, from each treatment were taken before the start of the

experiment. The soil samples were again taken, treatment-wise in the same manner at the end of the experiment. These samples were dried and prepared for analysis as described by Piper (1950).

Methods of soil analysis

(1) Nitrogen

The available N in the soil was determined by Alkaline potassium permanganate method (Subbiah and Arifa, 1956).

(2) Phosphorus

The available P was determined by Olsen's method as described by Jackson (1962).

(3) Potassium

The available K was extracted with 1 N ammonium acetate solution and estimated on Beckman flame photometer (Marrin and Peach, 1961).

VIII. Studies on fruit bud differentiation

(1) Collection of bud samples

The bud samples were collected from 2nd, 3rd and 4th bud-position of a shoot on 27th March, 1st April, 10th April and then from 20th April to 20th September, 1975, at 15-day intervals. Two buds were collected at random, with the help of sharp knife from each replication from 2nd, 3rd and 4th bud positions under each treatment. Thus eight buds were collected every time from each

treatment at a particular bud position. Out of these 8 buds, four buds were used for the purpose of microscopy. To know the percentage of dead buds, the data of all the above mentioned eight buds were utilised. In addition to this, on 20th April, the buds from bearing and non-bearing shoots were collected separately.

(2) Killing and preservation

The buds were directly collected in specimen tubes containing Formalin-Acetic-^{Alcohol}~~alcohol~~ (F.A.A.) solution.

(3) Dissection

The buds were dissected under the dissecting microscope giving a magnification of 20. The bud scales, hairs along with accessory buds were removed. The woody base was also trimmed with the help of sharp scalpel.

The cleaned buds were then placed treatment-wise in passing tubes for the purpose of dehydration.

(4) Dehydration

The buds were dehydrated in an up-graded series of tertiary butyl alcohol. The percentage of alcohol and tertiary butyl alcohol with the time required is given below.

Percentage of absolute alcohol	20	25	0	0
Percentage of tertiary butyl alcohol	80	75	100	100
Time required	3 hours	12 hours	3 hours	3 hours

The buds were then passed through three changes of pure xylene each change lasting for about six hours.

(5) Infiltration

The treated buds were kept in paraffin wax having 60° C congealing point and kept in oven at 70° C. The paraffin wax melted slowly resulting in the settling down of the buds. Then buds were changed twice to another vials containing melted paraffin wax and then allowed to remain in oven for 12 hours.

(6) Embedding

The melted paraffin wax was poured in covers of coupling jars. The buds were removed from specimen tubes with the help of a hot arrow point and put on covers of coupling jars. The orientation of the buds was done under 20 x bi-ocular microscope, when the wax was semi solid by arranging them wide apart with their apex pointing upward with the help of hot arrow point and needles. The melted paraffin wax was then poured on them. Care was taken for the complete fusion of upper and lower layers of paraffin wax. This fusion was brought with the help of hot arrow and needles. When the paraffin wax was completely cooled, its blocks were removed. Suitable size rectangular blocks were cut in such a fashion that each block contained only one bud and the edges of the blocks were parallel.

(7) Microtomy

12 μ thick sections were cut with the help of rotary microtome. Ribbons were taken on slides smeared with very thin

layer of Meyer's adhesive (Johansen, 1940). The ribbons were floated in water and slides were slightly warmed.

(8) Staining

The slides were passed through three coupling jars, containing Xylene. Each dip lasted for 3-4 minutes. Then they were passed through an up-grading series of alcohol, then in pure alcohol, then in up-grading series of distilled water and then two changes of distilled water were given. Each change lasted for 3-5 minutes. Then slides were stained in 1 per cent safranin (prepared in water medium) for 3-4 minutes. The slides were given tap water bath and examined under bi-nocular microscope. The slides having complete sections were selected for further process.

The selected slides were then transferred to distilled water. After keeping in distilled water for about 2 minutes, they were transferred to equal parts of distilled water - alcohol mixture. Then 3 changes of alcohol were given. Later on, they were transferred to Xylene. Two changes of Xylene were given, each dip lasted for about 5 minutes. Immediately after removing from Xylene, the sections were mounted in Canada balsam, taking care that no air bubbles entered under the cover slips.

The slides were allowed to dry at room temperature.

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Chapter IV

EXPERIMENTAL RESULTS

The data on the effect of factorial combinations of N, P and K on vigour of the vine, fruit bud differentiation, bunch and berry weight and size, quality and the yield of Elzard cultivar of grape are presented below.

I. Effect of N, P, K combinations on the vigour of the vines

The data in respect of the increase in trunk circumference and weight of prunings used as the indices of vine vigour are presented in Table 1.

(1) Effect on the trunk circumference

The medium dose of N significantly increased the trunk circumference (55.85 per cent) as compared with low dose of N (25.55 per cent) as well as the high dose of N (51.85 per cent). The high dose of N increased the trunk circumference as compared with the low dose of N.

The high dose of P significantly increased the trunk circumference (52.45 per cent) as compared with the low dose of P

Table 1

Effect of factorial combinations of nitrogen, phosphorus and potassium on the increase in trunk circumference and the pruning weight in Himrod Cv. of grape

Treatments	Percentage increase in trunk circumference in 1973 over that of 1972	Percentage increase in pruning weight in 1973 over that of 1972
$N_1P_1K_1$	27.42	25.01
$N_1P_1K_2$	28.65	25.45
$N_1P_2K_1$	29.87	24.41
$N_1P_2K_2$	31.29	24.65
$N_2P_1K_1$	33.05	26.28
$N_2P_1K_2$	33.84	26.93
$N_2P_2K_1$	33.70	27.33
$N_2P_2K_2$	33.09	29.25
$N_3P_1K_1$	31.30	25.33
$N_3P_1K_2$	31.43	25.43
$N_3P_2K_1$	32.19	25.73
$N_3P_2K_2$	32.33	25.94
C.D. at 5% level	1.033	1.535
C.D. at 1% level	1.431	2.144

(30.92 per cent). Similarly, the high dose of K highly significantly increased the trunk circumference (52.08 per cent) as compared with low dose of K (51.28 per cent).

The high dose of P when combined either with low or medium dose of N significantly increased the trunk circumference as compared with the low level of P combined with these levels of N. The medium level of N when combined with either level of P significantly increased the trunk circumference as compared with the low or high level of N combined with either level of P. The high level of P when combined with high level of N significantly increased the trunk circumference as compared with low level of N combined with same level of P. Also, low level of P when combined with high level of N significantly increased the trunk circumference as compared with low level of N combined with same level of P.

The NK, PK and NPK interactions were not significant.

The treatment $N_2P_2K_2$ gave the highest increase in trunk circumference (55.09 per cent). It was followed by the treatments $N_2P_2K_1$, $N_2P_1K_2$ and $N_2P_1K_1$. The treatment $N_1P_1K_1$ was least effective in increasing the trunk circumference (27.42 per cent). It differed significantly from the rest of the treatments.

(2) Effect on the pruning weight

The pruning weight of the vines was significantly increased by the medium dose of N (27.60 per cent) as compared with the low dose of N (25.88 per cent) and high dose of N (25.62

34a

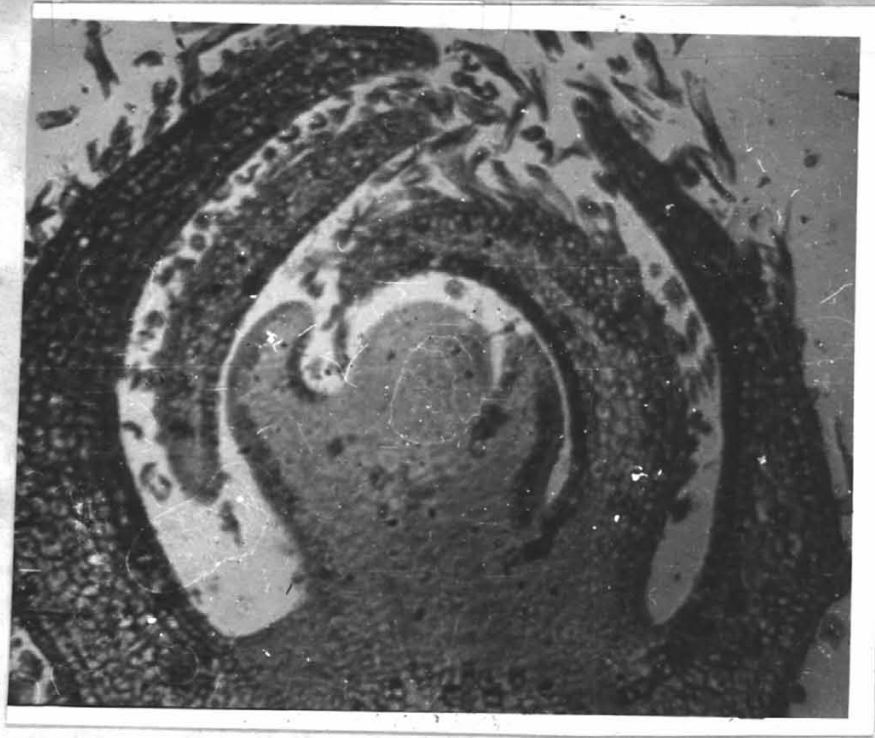


PLATE 1

(150 x)

27-3-73

H.P.K.₂ (2nd nodal bud)

Maximal vegetative phase. Shoot apex showing dome-shaped topography

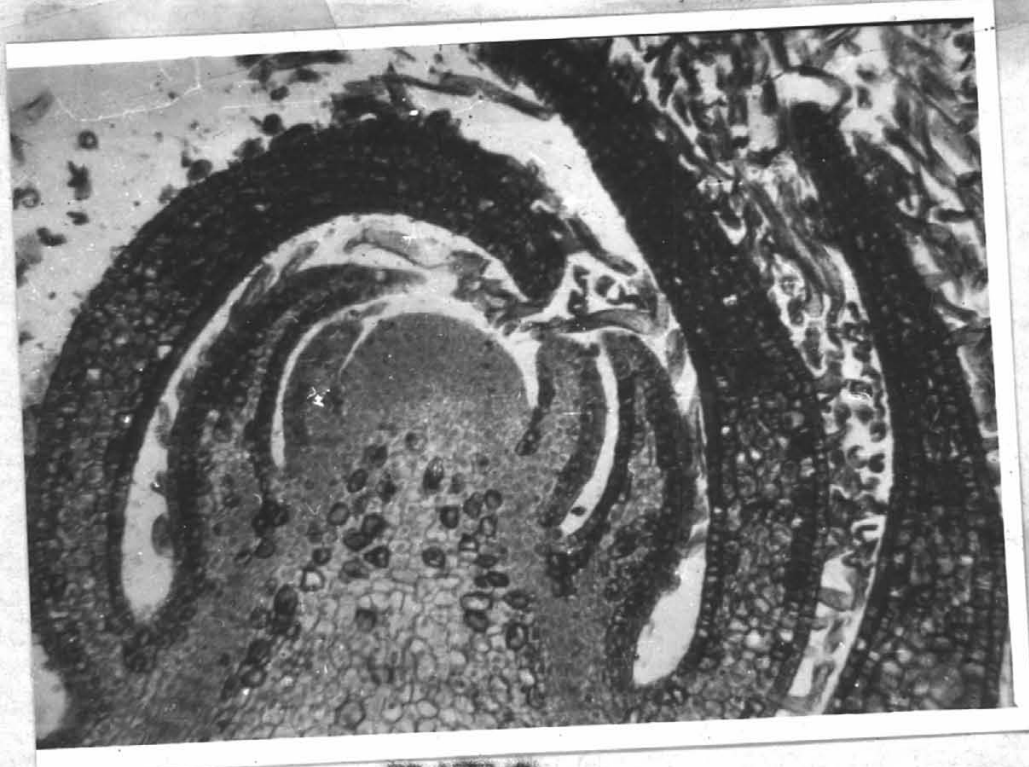


PLATE 2

(150 x)

1-4-73

H.P.K.₂ (3rd nodal bud)

Maximal vegetative phase. Shoot apex showing dome-shaped topography

per cent). The high dose of N significantly increased the pruning weight of vines as compared with the low dose of N.

The high dose of P significantly increased the pruning weight of vines (25.22 per cent) as compared with the low dose of P (25.17 per cent). Similarly, high dose of K significantly increased the pruning weight of the vines (25.94 per cent) as compared with the low dose of K (25.50 per cent).

All the first and second order interactions of N, P and K were not significant.

The $N_2P_2K_2$ treatment gave the greatest increase in pruning weight of the vines (29.25 per cent). The difference between this and the other treatments was significant. It was followed by the treatments $N_2P_1K_1$, $N_2P_1K_2$ and $N_1P_1K_1$. The $N_1P_1K_1$ treatment had the least effect on the pruning weight of the treated vines (25.01 per cent). There was a significant difference between this and the remaining treatments except $N_1P_1K_2$.

Taking into consideration both the trunk circumference and the weight of pruning data, it may be stated that 0.8 kg N combined with 1.2 kg of P_2O_5 and 1.2 kg of K_2O increased the vegetative growth of the grapevines more than any other treatment used in this experiment.

II. Effect of N, P, K combinations on the differentiation of floral buds

In order to study the effect of NPK fertilisation on the differentiation of floral buds, the bud samples were collected

35a



PLATE 3
(150 x)
27-3-73

$N_2P_1K_2$ (2nd nodal bud)

Minimal vegetative phase. Shoot apex showing hemi-
spherical topography

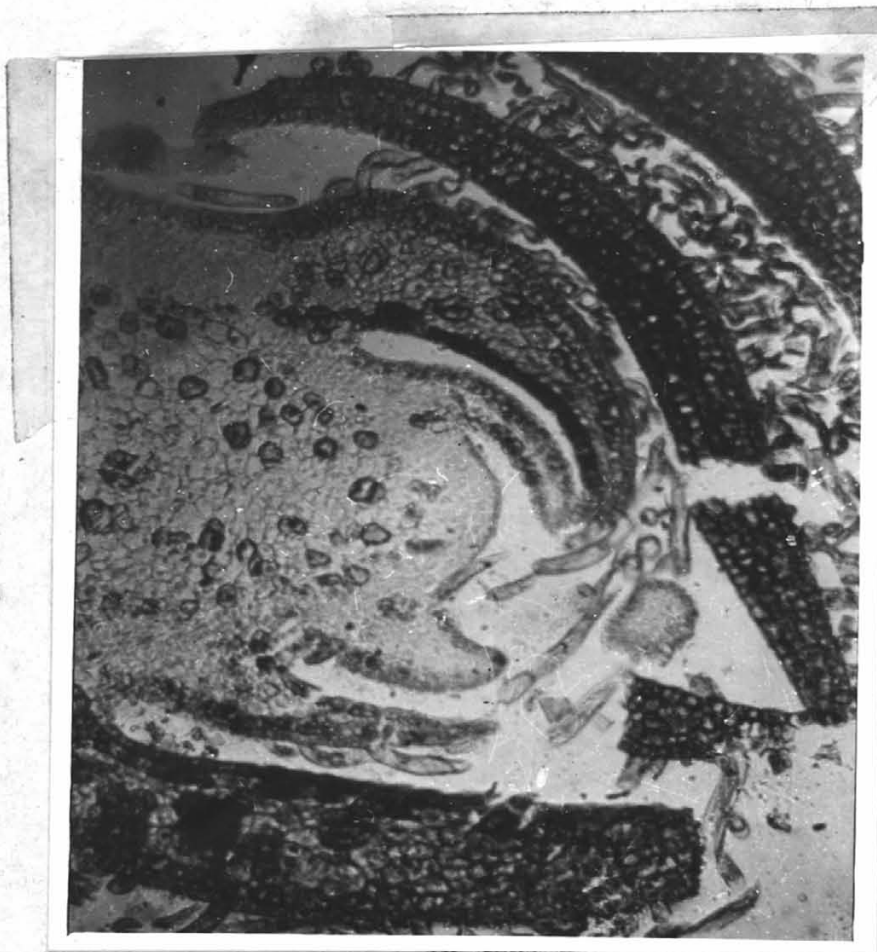


PLATE 4
(100 x)
20-4-73

$N_1P_2K_2$ (3rd nodal bud)

Cluster primordia in the axil of the leaf

on different dates, starting from 27th March to September 20. The buds were preserved in F.A.A. solution until dissection.

During the initial phase of development, topography of the spines of the inflorescence axis was carefully studied. It varied from flat to dome shaped. As pointed out by Schmidt (1924), dome and hemispherical shapes of the apex are indicative of maximal and minimal vegetative growth phases respectively (Plate 1, 2 and 3), whereas flat shape indicates that the initiation of floral primordia has just started.

The floral bud initiation had already started in certain cases when first observation was made on 27th of March. Another feature observed at this stage was that the shoots were very young and in active stage of growth. However, the peak period of floral bud initiation extended from 5th to 10th of April. At this stage, the bearing shoots were in full bloom. It may be pointed out here that full bloom stage lasted from 8th to 14th April. In other words, the development of current season's crop and initiation and development of floral primordia for the next year progressed simultaneously. It was also observed that all the fertiliser treatments used in this experiment had similar effect on the initiation of the floral buds.

In the collection of 20th April, all the inflorescence axes were having floral primordia irrespective of the treatment employed (Plate 4). In the collection of this date, when comparison was made between bearing and non-bearing shoots, it was observed that floral bud differentiation was identical and there were 100

36a

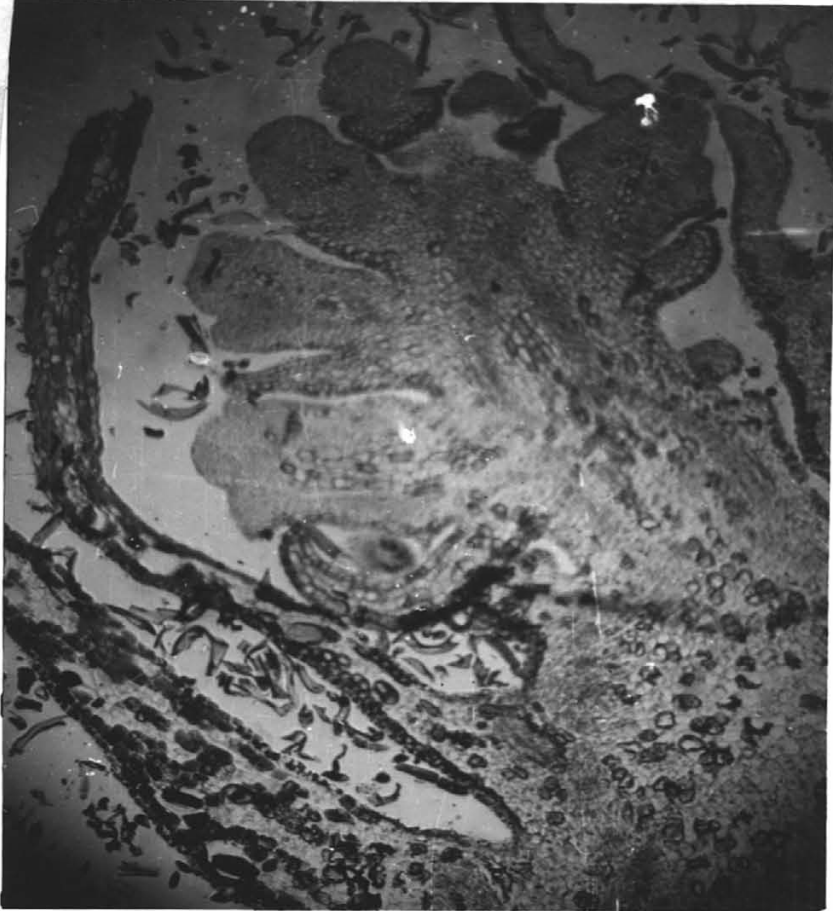


PLATE 5
(100 x)
20-6-73
N₃P₂K₁ (3rd nodal bud)
Bract formation evident



PLATE 6
(100 x)
5-7-73
N₁P₁K₁ (4th nodal bud)

per cent fruitful buds on both types of shoots (at 2nd, 3rd and 4th bud position). Here also various fertiliser treatments had similar effect. On this date, inflorescence primordia could be easily observed under the low power microscope.

It was evident from the examination of the buds collected on different dates that inflorescence primordia continued to develop and organogenic differentiation in floral buds was in progress on 20th September when the observations were discontinued (Plate 5-10).

Dead and disintegrating buds were, however, first observed on 20th July, generally in the treatments with high level of N. With the passage of time, the percentage of dead buds enhanced gradually. At the time when observations were discontinued (i.e. on 20th September), the percentage of dead buds under high dose of N was 53.12 per cent as compared with 27.08 per cent in medium dose and 17.70 per cent in low dose of N (Plate 11). The P and K did not show such killing effect of buds.

III. Effect of N, P, K combinations on bunch characteristics

The data in respect of the length, width, weight and number of berries per bunch are presented in Table 2.

(1) Effect on length of the bunch

The data on N, P, K combinations on the length of the bunch show that the main effects of N, P, K and all the first and

37a

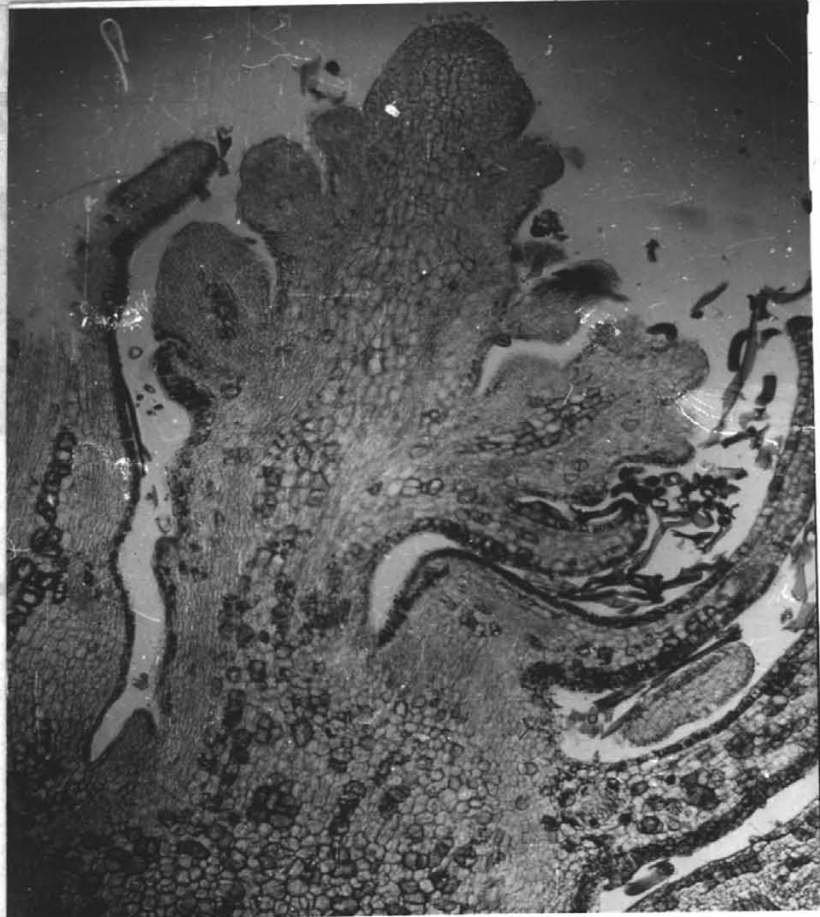


PLATE 7
(100 x)
5-8-73

$N_1P_1K_2$ (3rd nodal bud)

The cluster primordia extends beyond
the organic apex of the bud

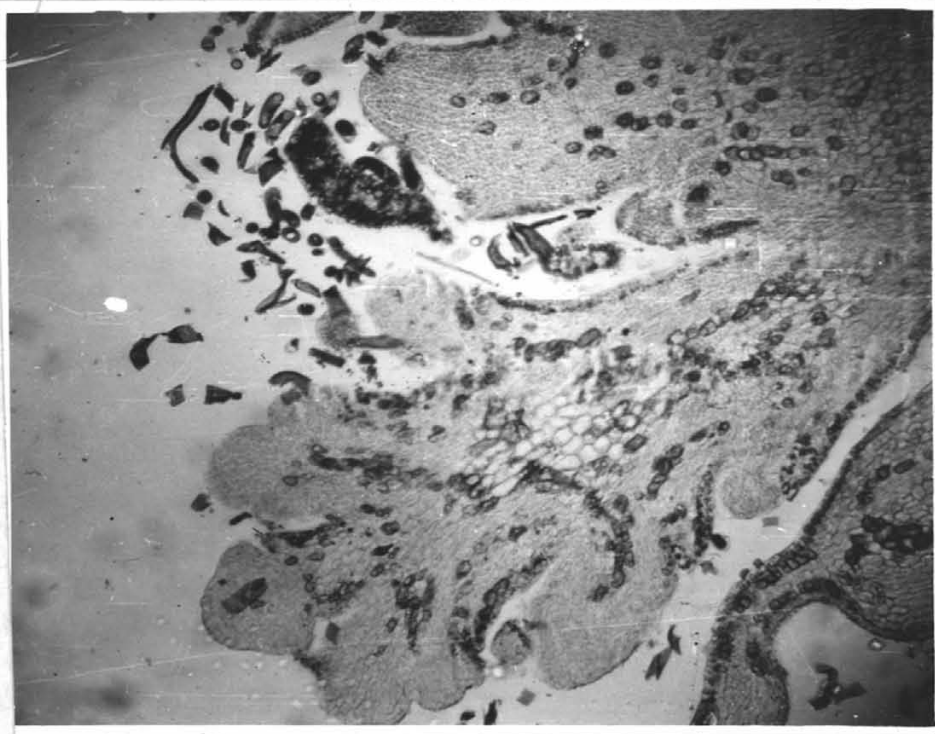


PLATE 8
(100 x)
20-8-73

$N_2P_2K_1$ (4th nodal bud)

380

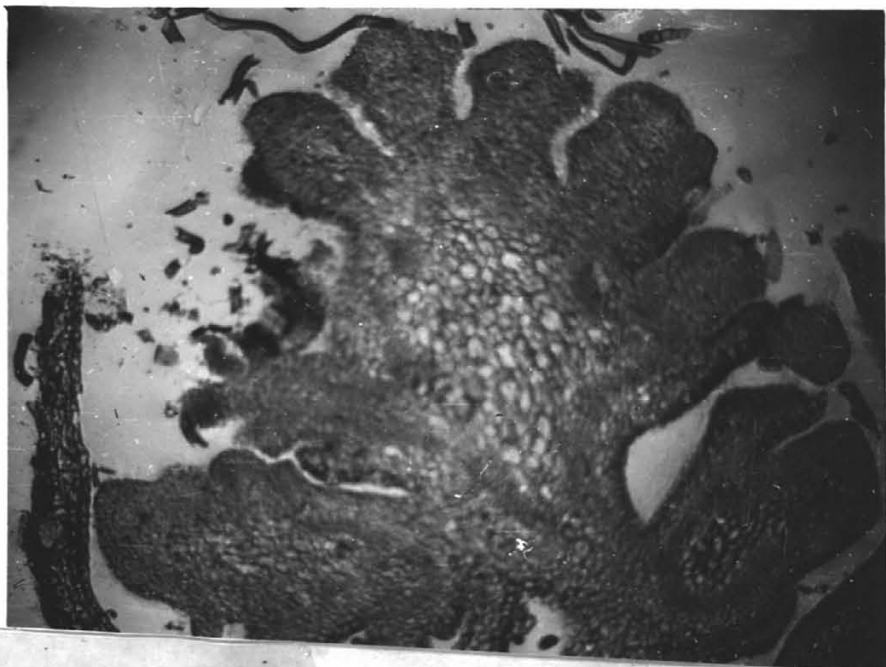


PLATE 9
(100 x)
5-9-73

$N_1 P_2 K_1$ (3rd nodal bud)

Several floral primordia in the cluster are seen

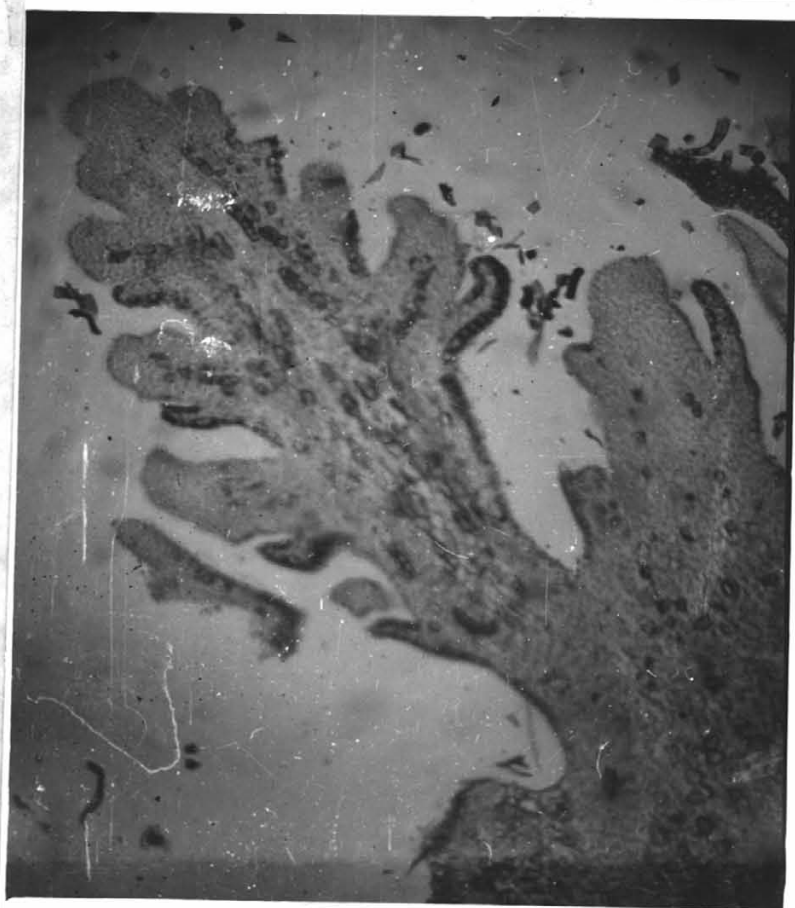


PLATE 10
(100 x)
20-9-73

$N_2 P_2 K_1$ (3rd nodal bud)

An advance stage. Floral primordia in the cluster showing initiation of the differentiation of various parts

second order interactions of N, P and K were not significant in both the years of study.

The bunches with the greatest length were, however, produced by the treatment $N_1P_2K_1$ (19.88 and 17.82 cm in 1972 and 1973 respectively), followed by the treatment $N_1P_2K_2$. The shortest bunches were produced by the vines receiving $N_1P_1K_1$ treatment (17.89 and 15.83 cm in 1972 and 1973 respectively).

(2) Effect on the bunch width

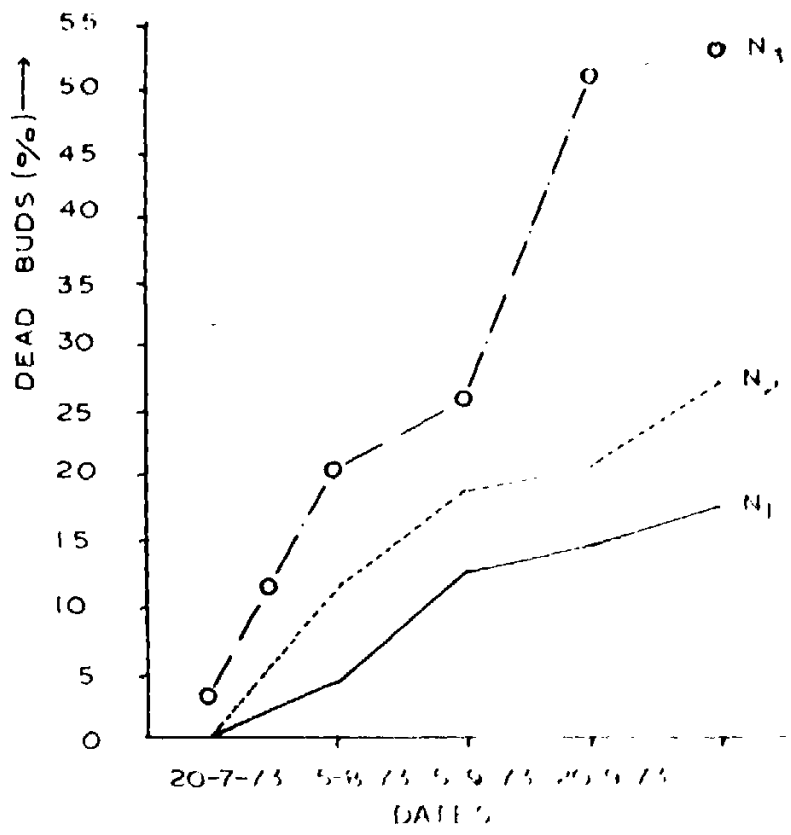
In 1972, the high dose of P increased the bunch width significantly (10.64 cm) over the low dose of P (10.61 cm). In 1973, the high dose of P did increase the bunch width, but the difference between the low and high doses was not significant.

The main effects of N, K and all the first and second order interactions of N, P and K were not significant during both the years of study.

The grape bunches with the highest width were observed under the treatment $N_1P_2K_1$ (11.12 and 9.86 cm in 1972 and 1973 respectively), followed by the treatment $N_1P_2K_2$. The $N_1P_1K_1$ treatment had the least effect on the bunch width (9.69 and 8.50 cm in 1972 and 1973 respectively). The treatment differences, however, were not significant.

(3) Effect on the bunch weight

In 1972, the high dose of P significantly increased the bunch weight (226.50 gm) as compared with that of low dose of P



Effect of different doses of nitrogen on bud killing

(204.56 gm). In 1973, the high dose of P did increase the bunch weight, but the difference between the bunch weight produced by the vines under the low and high dose of P was not significant.

The main effects of N, K and all the first and second order interactions of N, P and K were not significant.

The $N_1P_2K_1$ treatment produced the heaviest bunch (255.77 and 124.22 gm in 1972 and 1973 respectively) followed by the treatment $N_1P_2K_2$ during both the years of experiment. The $N_1P_1K_1$ treatment had the least effect as far as weight of the bunch was concerned (185.75 and 110.80 gm in 1972 and 1973 respectively). The treatment differences were, however, not significant.

(4) Effect on the number of berries per bunch

The high dose of P significantly increased the number of berries per bunch (62.01 and 64.54 in 1972 and 1973 respectively) as compared with the low dose of P (52.53 and 59.51 in 1972 and 1973 respectively) during both the years of experiment.

The main effects of N, K and all the first and second order interactions of N, P and K were not significant.

On an average, the treatment $N_1P_2K_1$ had more number of berries as compared with other treatments (94.62 and 71.07 in 1972 and 1973 respectively). It was followed by the treatment $N_1P_2K_2$. The least number of berries were recorded under the treatment $N_1P_1K_1$ (79.60 and 54.24 in 1972 and 1973 respectively).

IV. Effect of N, P, K combinations on berry characteristics

The data in respect of various berry characters such as length, diameter, weight and juice percentage are presented in Table 5.

(1) Effect on the berry length

The data show that the main effects of N, P, K and all the first and second order interactions of N, P and K were not significant.

In 1972, the vines receiving $N_1P_2K_2$ treatment produced the longest berries (1.89 cm), followed by the treatment $N_1P_2K_1$ (1.88 cm). The vines receiving $N_1P_1K_1$ treatment produced the shortest berries (1.83 cm). The treatment differences were, however, not significant.

The trend of result obtained during 1973 was similar to that of 1972 except that the $N_1P_1K_1$ treatment was significantly inferior to all the treatments.

(2) Effect on the berry diameter

There was no significant effect of N, P, K and all the first and second order interactions on the berry diameter during both the years of study.

The $N_1P_2K_2$ treatment, however, increased the berry diameter (1.67 and 1.44 cm in 1972 and 1973 respectively) as compared with other treatments. It was followed by the treatment $N_1P_2K_1$. The

Table 3

Effect of factorial combinations of nitrogen, phosphorus and potassium on the average length, diameter and weight of the berries and on the juice percentages in Marzemino Gr. of grape

Treatments	Mean length of the berries (cm)		Mean diameter of the berries (cm)		Mean weight of the berries (gm)		Juice percentages	
	1972	1973	1972	1973	1972	1973	1972	1973
$N_2P_1K_1$	1.85	1.82	1.81	1.58	2.52	1.91	60.90	60.45
$N_2P_1K_2$	1.84	1.85	1.85	1.40	2.72	1.89	66.50	67.00
$N_2P_2K_1$	1.88	1.71	1.88	1.45	2.55	2.21	70.00	69.50
$N_2P_2K_2$	1.89	1.72	1.87	1.44	2.87	2.22	69.50	68.00
$N_2P_3K_1$	1.84	1.85	1.82	1.40	2.80	2.00	61.00	67.82
$N_2P_3K_2$	1.85	1.85	1.84	1.41	2.82	2.10	62.40	68.20
$N_2P_4K_1$	1.86	1.85	1.84	1.41	2.70	2.15	65.80	65.50
$N_2P_4K_2$	1.83	1.70	1.85	1.42	2.79	2.20	61.40	64.50
$N_2P_5K_1$	1.86	1.85	1.82	1.40	2.35	1.96	62.70	67.05
$N_2P_5K_2$	1.87	1.88	1.82	1.40	2.85	2.10	62.25	64.50
$N_2P_6K_1$	1.87	1.70	1.84	1.41	2.85	2.15	65.75	65.51
$N_2P_6K_2$	1.87	1.70	1.85	1.41	2.75	2.20	61.00	65.40
C.D. at 5% level	N.S.	0.102	N.S.	N.S.	N.S.	N.S.	5.05	4.17
C.D. at 1% level	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	4.10	5.59

treatment $N_2P_1K_1$ had the least effect in increasing berry diameter in both the years of study (1.61 and 1.58 cm in 1972 and 1973 respectively).

(3) Effect on berry weight

The high dose of P had a significant effect in increasing berry weight (2.77 and 2.19 gm respectively in 1972 and 1973) as compared with low dose of P (2.41 and 2.41 gm in 1972 and 1973 respectively) during both the years of study.

The main effects of N, K and all the first and second order interactions of N, P and K were not significant during both the years.

The treatment $N_2P_2K_2$ recorded the highest weight of berry (2.87 and 2.82 gm in 1972 and 1973 respectively). It was followed by the treatment $N_2P_1K_1$. The least berry weight was obtained under the treatment $N_1P_1K_1$ (2.32 and 1.81 gm in 1972 and 1973 respectively).

(4) Effect on the juice percentage

In 1972, the juice percentage was significantly increased in the grapes borne by the vines under the low dose of N (22.45 per cent) as compared with the medium (22.10 per cent) or high (22.02 per cent) dose of N.

The high dose of P significantly increased the juice percentage (22.24 per cent) as compared with the low dose of P (22.07 per cent).

The high dose of P (1.2 kg P_2O_5 per vine) when combined with low dose of N (0.4 kg N per vine) produced the grapes which were significantly higher in juice content as compared with other treatments. Similarly, high dose of K (1.2 kg K_2O per vine) when combined with low dose of N (0.4 kg per vine) significantly increased the juice percentage in the grapes. The high doses of P and K when combined together also significantly increased the juice percentage. The second order interaction was, however, not significant.

The $N_1P_2K_1$ treatment gave highest juice percentage (70 per cent) and there was a significant difference between this and other treatments except the treatments $N_1P_2K_2$ and $N_1P_1K_2$. The $N_1P_1K_1$ yielded least percentage of juice (60.90 per cent) and there was a significant difference between this and $N_1P_2K_1$, $N_1P_2K_2$ and $N_1P_1K_2$ treatments.

In 1975, the main effects of N, P and K were not significant.

The high dose of P when combined with low dose of N significantly increased the grape juice percentage as compared with low dose of P at the same level of N. The low dose of P when combined with medium dose of N significantly increased the juice percentage as compared with high dose of P at the same level of N.

The NK and PK interactions were not significant.

It was, however, observed that second order interaction viz. NPK was significant. The $N_1P_2K_1$ treatment yielded highest

percentage of juice (89.50 per cent) and there was significant difference between this and $N_3P_2K_1$, $N_2P_2K_1$ and $N_1P_1K_1$ treatments. The $N_1P_1K_1$ yielded the least percentage of juice (80.45 per cent).

V. Effect of N, P, K combinations on the chemical quality of crop

The data in respect of total soluble solids, acidity, T.S.S./acid ratio as affected by different NPK combinations are presented in Table 4.

(1) Effect on the total soluble solids (T.S.S.)

In 1972, the high dose of P significantly increased the T.S.S. content of the juice (18.28 per cent) as compared with the low dose of P (15.54 per cent). In 1973, the high dose of P did increase the T.S.S. content of the juice but difference between the low and the high doses of this nutrient was not significant.

The main effects of N and K and all the first and second order interactions of N, P and K were not significant during both the years of study.

The total soluble solids were the highest under the $N_1P_1K_1$ treatment (18.70 and 18.00 per cent in 1972 and 1973 respectively). The $N_1P_2K_1$ treatment had the least effect on T.S.S. (15.10 and 16.70 per cent in 1972 and 1973 respectively).

(2) Effect on the acidity of the juice

The main effects of N, P, K and all the first and second order interactions of N, P and K were not significant during both the years of study.

The acidity was, however, found highest in case of juice obtained from the fruits of grape vines treated with $N_1P_2K_1$ treatment (0.630 and 0.671 per cent in 1972 and 1973 respectively). It was followed by the $N_1P_2K_2$ treatment (0.615 and 0.670 per cent in 1972 and 1973 respectively). The acidity was lowest in case of the juice obtained from the fruits of grapevines treated with $N_1P_1K_1$ treatment of fertilizer (0.588 and 0.629 per cent in 1972 and 1973 respectively).

(8) Effect on T.S.S./acid ratio

In 1972 as well as in 1973, the high dose of P significantly increased T.S.S./acid ratio of the juice (28.53 and 27.54 per cent respectively) as compared with the low dose of P (25.97 and 25.92 in 1972 and 1973 respectively).

The main effects of N and K and all the first and second order interactions of N, P and K were not significant during both the years of study.

The highest T.S.S./acid ratio was noted under the $N_1P_1K_1$ treatment (30.082 and 28.252 in 1972 and 1973 respectively). The lowest T.S.S./acid ratio was recorded under $N_1P_2K_2$ treatment (24.090 and 24.945 in 1972 and 1973 respectively).

VI. Effect of N, P, K combinations on the yield

The yield data as affected by different N, P, K combinations are presented in Table 5.

Table 5

Effect of factorial combinations of nitrogen, phosphorus and potassium on the average number of bunches and yield (by weight) per vine in Hisrod Cv. of grape

Treatments	Average number of bunches per vine		Average yield per vine (kg)	
	1972	1973	1972	1973
$N_1P_1K_1$	39.82	37.95	5.450	5.091
$N_1P_1K_2$	41.00	46.95	6.821	5.724
$N_1P_2K_1$	49.97	50.45	9.894	5.017
$N_1P_2K_2$	46.15	45.82	7.904	4.682
$N_2P_1K_1$	45.75	41.77	6.891	5.719
$N_2P_1K_2$	39.85	48.75	6.513	4.541
$N_2P_2K_1$	39.43	40.37	6.400	5.797
$N_2P_2K_2$	45.02	45.75	7.671	4.823
$N_3P_1K_1$	44.25	43.05	6.757	4.075
$N_3P_1K_2$	45.00	45.30	6.980	4.499
$N_3P_2K_1$	42.60	39.82	6.854	5.322
$N_3P_2K_2$	40.97	45.22	6.991	4.101
C.D. at 5% level	N.S.	N.S.	N.S.	N.S.

(1) Effect on the number of bunches per vine

The main effects of N, P, K and all the first and second order interactions of N, P and K were not significant in both the years of study.

The vines receiving the $N_1P_2K_1$ treatment, however, produced the greatest number of bunches (49.87 and 50.45 in 1972 and 1973 respectively), followed by the treatment $N_1P_2K_2$. The vines receiving $N_1P_1K_1$ treatment produced the least number of bunches (39.82 and 37.95 in 1972 and 1973 respectively).

(2) Effect on the yield (in weight) per vine

The main effects of N, P, K and all the first and second order interactions were not significant in both the years of study.

The vines receiving $N_1P_2K_1$ treatment, however, produced the highest yield (9.824 and 5.017 kg in 1972 and 1973 respectively). It was closely followed by the $N_1P_2K_2$ treatment which gave the yield 7.084 and 4.682 kg in 1972 and 1973 respectively. The lowest yield was obtained from the vines fertilised with $N_1P_1K_1$ treatment (5.450 and 5.031 kg in 1972 and 1973 respectively).

VII. Effect of N, P, K combinations on the nutrients content of the vine

The data in respect of the effect of soil application of N, P and K on the N, P and K content of grape petioles are presented in Table 6.

Table 6

Effect of factorial combinations of nitrogen, phosphorus and potassium on the petiole content of N, P and K in Marud Cv. of grape

Treatments	Nitrogen %		Phosphorus %		Potassium %	
	1972	1973	1972	1973	1972	1973
$N_1P_1K_1$	1.04	1.08	0.268	0.270	1.79	1.81
$N_1P_1K_2$	1.05	1.08	0.259	0.252	1.81	1.82
$N_1P_2K_1$	1.05	1.08	0.275	0.277	1.75	1.74
$N_1P_2K_2$	1.04	1.08	0.262	0.262	1.80	1.80
$N_2P_1K_1$	1.10	1.12	0.239	0.255	1.82	1.85
$N_2P_1K_2$	1.09	1.11	0.210	0.215	1.83	1.85
$N_2P_2K_1$	1.10	1.11	0.274	0.260	1.74	1.79
$N_2P_2K_2$	1.07	1.11	0.245	0.250	1.81	1.80
$N_3P_1K_1$	1.14	1.17	0.244	0.206	1.70	1.75
$N_3P_1K_2$	1.15	1.16	0.182	0.200	1.70	1.78
$N_3P_2K_1$	1.16	1.18	0.202	0.208	1.86	1.85
$N_3P_2K_2$	1.15	1.16	0.200	0.205	1.89	1.87
G.D. at 5% level	0.088	0.082	0.061	0.065	0.168	N.S.
G.D. at 1% level	0.088	0.045	0.055	0.045	-	-

(1) Effect on the nitrogen content of the grape petioles

There was significant increase in the petiole-N with the increasing level of N application to the soil during both the years of investigation.

The high dose of P increased the N level in grape petioles as compared with low level of P, but there were no significant differences in petiole-N levels as affected by high and low doses of P during both the years of investigation.

The high dose of K significantly depressed the N content in grape petioles as compared with the low dose of K in 1972. In 1973, the high dose of K did depress the uptake of N, but the depression was not significant.

All the first and second order interactions of N, P and K were not significant during both the years of study.

In 1972, the N content in petioles of the vines receiving $N_3P_2K_1$ treatment was highest (1.18 per cent). The differences in N-content of vines under this treatment and the rest of the treatments (except $N_3P_2K_2$, $N_3P_1K_1$ and $N_3P_1K_2$) were highly significant. The least N content was observed in the petioles of the vines receiving $N_1P_1K_2$ treatment (1.08 per cent). There was highly significant difference between this treatment and the other treatments (except $N_1P_1K_2$ and $N_1P_2K_1$).

In 1973, the N content was highest in the petioles of the vines receiving $N_3P_2K_1$ treatment (1.18 per cent) and this

treatment significantly differed from the other treatments (except $N_3P_1K_1$, $N_3P_2K_2$ and $N_3P_1K_2$). The least N (1.05 per cent) content was in the petioles of the vines receiving $N_1P_1K_2$ treatment. There was highly significant difference between this treatment and rest of the treatments (except $N_1P_1K_1$, $N_1P_2K_2$ and $N_1P_2K_1$).

(2) Effect on the phosphorus content of the leaf petioles

The high dose of P increased the P content in petioles as compared with the low dose of P during both the years of study, but the differences were not significant.

The high dose of N had significant depressing effect on the P content of petioles as compared with the low or medium dose of N. The medium dose of N also exerted a significant depressing effect on P content of petioles as compared with the low dose of N, but the differences were not significant.

As the K application to the soil increased from 0.8 kg K_2O per vine to 1.2 kg K_2O , the P content of grape petioles was significantly decreased.

All the first and second order interactions of N, P and K were not significant during both the years of study.

In 1972, the P percentage was the highest (0.275 per cent) in grape-petioles of the vines receiving $N_1P_2K_1$ treatment. There was a significant difference between this and $N_3P_1K_2$, $N_3P_1K_1$, $N_3P_2K_1$ and $N_3P_2K_2$ treatments. It was followed by the $N_2P_2K_1$, $N_1P_1K_1$ and $N_1P_2K_2$ treatments. The P content was the least (0.152 per cent)

in the petioles of the vines receiving the $N_2P_1K_2$ treatment. There was a significant difference between this treatment and the other treatments, except $N_2P_2K_2$, $N_2P_2K_1$ and $N_2P_1K_2$ treatments.

In 1975, the P content of the grape petioles of vines receiving $N_2P_2K_1$ fertiliser treatment was the highest (0.277 per cent). There was significant difference between this treatment and the $N_2P_1K_2$, $N_2P_2K_2$, $N_2P_1K_1$, $N_2P_2K_1$ and $N_2P_1K_2$ treatments. It was followed by $N_2P_1K_1$, $N_2P_2K_2$, $N_2P_2K_1$ treatments. The P content was the least in petioles of the vines receiving $N_2P_1K_2$ fertiliser treatment (0.200 per cent). There was a significant difference between this and the other treatments (except $N_2P_2K_2$, $N_2P_1K_1$, $N_2P_2K_1$ and $N_2P_1K_2$ treatments).

(5) Effect on the potassium content of the petioles

The high dose of K increased the K content in petioles as compared with the low dose of K during both the years of study, but the differences were not significant.

In 1972, the high dose of N exerted a significant depressing effect on the K content of petioles as compared with the low or medium dose of N. In 1973, the high dose of N did exert the depressing effect on the K content, but the depression was not significant.

The main effects of P and all the first and second order interactions of N, P and K were not significant during both the years of study.

In 1972, the K content was the highest in the petioles of the vines receiving $N_2P_1K_2$ treatment (1.85 per cent). It was followed by $N_2P_1K_1$, $N_1P_1K_2$, $N_2P_2K_2$, $N_1P_2K_2$, $N_1P_1K_1$ treatments. The K content was the least (1.55 per cent) in the petioles of the vines receiving $N_2P_2K_1$ treatment. There was significant difference between this treatment and other treatments except the $N_2P_2K_2$, $N_2P_1K_1$ and $N_2P_1K_2$ treatments.

In 1973, although the treatment differences were not significant, the K content was the highest (1.85 per cent) in leaf petioles of the vines under the $N_2P_1K_2$ treatment. It was followed by the $N_2P_1K_2$, $N_1P_1K_2$, $N_1P_1K_1$ and $N_1P_2K_2$ treatments. The K content was the lowest (1.65 per cent) in the leaf petioles of the vines under the $N_2P_2K_1$ fertilizer treatment.

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Chapter V

DISCUSSION

The salient features of the results of the present study presented in Chapter IV are discussed below:

I. Fruit bud differentiation

All the NPK treatments had similar effect on the bud initiation. Studies conducted on Pusa Seedless Or. under Delhi conditions (Madhava Rao and Mukherjee, 1970) showed that among 8 treatments with two levels of N, P and K, only in $N_2P_1K_1$ treatment some indication of earlier fruitfulness was noted. In South India, under the tropical conditions, Manivel (1967) and Srinivasan (1968) found that the combined treatment of NPK induced earlier initiation and differentiation of cluster primordia in Anab-e-Shehd.

Regarding the pace of the development of floral buds, it was interesting to observe that irrespective of treatment, all the sces had the floral buds by 20th of April. On the basis of present study, it is rather difficult to delineate the differential effect of N, P and K doses on the fruitfulness of the buds as in

all the cases 100 per cent fruitfulness was observed. However, Kanyo *et al.* (1970) observed that all the post pruning treatments like the application of NPK, P or digging around the vines resulted in considerable increase in fruitfulness. Mazival (1987) and Srinivasa (1989) also reported almost similar results in Anab-e-Shahi. The role of phosphorus and to certain extent that of nitrogen in the differentiation of floral buds can easily be explained on the basis of well-established findings that these are the two basic elements required in the synthesis of RNA and DNA. At the time of floral induction the concentration of RNA tends to increase (Gifford and Syper, 1962; Lance, 1967). Confining our discussion to grapes in particular, Mathura Rao and Srinivasa (1971) have made similar observations in Anab-e-Shahi. They observed high rate of RNA synthesis at the time of flower bud formation and higher RNA/DNA ratio at the 6th bud which is the most fruitful region in this cultivar.

The data collected during the present study showed that the bearing and non-bearing shoots behaved similarly as all the ones studied carried the fruitful buds. As far as the nutrient status of such shoots was concerned, studies of Gallo and De Oliveira (1961) have shown that fruiting and non-fruiting shoots differed very little in their composition of N, P and K. This suggests that the causes of differences may have to be sought in endogenous growth regulators.

As the level of nitrogen application to the soil was increased, the percentage of dead and disintegrating buds was also increased. It might be due to the fact that vines absorb the ions

of nitrates and ammonia excessively under the high doses of nitrogenous fertilizer. When the accumulation of these go beyond the particular level, they might be causing toxic effects on delicate tissues like buds. Ismail *et al.* (1954) also observed that the higher nitrogen rates increased the nitrate level in the cluster axis tissues.

II. Vine vigor and yield

The yield was not significantly affected by the various treatments employed. However, the high dose of phosphorus (1.2 kg per vine) and low dose of nitrogen (0.4 kg per vine) were beneficial in increasing the yield. The high dose of phosphorus, in general, increased the berry size and weight, number of berries per bunch, size and weight of the bunch and the number of bunches per vine and hence increased the yield also. The beneficial responses of phosphorus seem to be due to high pH of sandy soil (8.2) in which the present experiment was conducted. Under such conditions, most of the phosphorus applied to the soil gets reprecipitated and hence application of high dose of phosphorus is required for better yield. Under the low dose of nitrogen, the less percentage of the buds were killed and there were more number of bunches which resulted in increased yield.

The vines receiving 0.4 kg N plus 1.2 kg P_2O_5 and 0.8 kg K_2O produced the highest yield. The same treatment combination was responsible for recording highest number of berries per bunch, the

biggest and the heaviest bunches and it was the second best treatment in improving the berry size and weight. Also, it produced the highest number of bunches per vine. The treatment combination comprising of 0.4 kg N, 0.8 kg P_2O_5 and 0.8 kg K_2O produced the least number of berries per bunch, the smallest and lightest berries, the smallest, lightest and the least number of bunches per vine and hence lowest yield was recorded.

The vines which were poor in vigour were poor in yield. Also, the vines having luxuriant vigour might have wasted the energy in vegetative growth and did not record the highest yield. The treatment combination of 0.4 kg N, 1.2 kg P_2O_5 and 0.8 kg K_2O responsible for medium vigour of the vines recorded the highest yield.

The berries of the vines receiving 0.4 kg N were more juicy than the berries of the vines receiving either 0.8 kg N or 1.2 kg N. It was also observed that high doses of phosphorus and the potassium were beneficial in improving the juice percentage of the berries.

The treatment combination of 0.4 kg N, 1.2 kg P_2O_5 and 1.2 kg K_2O gave the highest juice percentage.

It may be pointed out here that the low level of nitrogen and high levels of phosphorus and potassium might have increased the dry matter content of the juice and hence increase

in juice percentage as the data of juice percentage were worked out on weight basis and not on the volume basis.

III. Quality of the grapes

The treatment combination comprising of 0.4 kg N, 0.8 kg P_2O_5 and 0.8 kg K_2O , responsible for recording the lowest yield recorded the highest T.S.S./acid ratio (better quality fruits). Contrary to this, the treatment combination of 0.4 kg N, 1.2 kg P_2O_5 and 0.8 kg K_2O , giving the highest yield has given the lowest T.S.S./acid ratio. It indicates that there was an inverse relation between the yield and the quality of the grapes. The inverse relation between the yield and the quality of the grapes was also observed by Williams (1945), Vega *et al.* (1957) and Verghese (1959).

The 1.2 kg of P_2O_5 per vine improved the T.S.S./acid ratio as compared with the 0.8 kg of P_2O_5 per vine. This response might be due to the high pH of sandy soil in which the present investigation was conducted. Under the same agro-climatic conditions where the present experiment was conducted, Mijar and Chauri (1969) observed that the 1.5 kg level of P_2O_5 was highly effective in improving the quality of the grapes as compared with the 0.5 kg and 1.0 kg levels of this element.

IV. Nitrogen, phosphorus and potassium content of the petals

Increasing level of soil application of nitrogen, phosphorus and potassium had a corresponding increase in the petals

content of N, P and K. It is natural to expect that when the level of application of a particular element to the soil increase, then there is a corresponding increase in the uptake of that element upto some extent. Singh (1968a) and Gill (1969) reported that the direct relationship between the dose of these nutrients and their percentage in petioles.

The high dose of potassium had depressing effect on the nitrogen content of the grape-petioles, indicating thereby antagonistic effect of potassium on nitrogen. The depressing effect of potassium on nitrogen was also observed by Singh (1968a) and Gill (1969). The high dose of phosphorus, though not significantly but had a beneficial effect on the nitrogen content of the grape-petioles. Gill (1969) reported that the application of P had a favourable effect on nitrogen content of grape petioles.

As the doses of nitrogen and potassium to the soil increased, the phosphorus content of the grape-petioles decreased. The high doses of nitrogen and potassium might have depressed the uptake of phosphorus. Ram (1966) reported that the nitrogen application to the soil beyond the medium level (2 lb N per vine) depress the uptake of phosphorus by the plants. Gill (1969) reported that increase in the dose of potash application to the soil decrease the phosphorus content of grape-petioles.

The high dose of phosphorus as well as high dose of nitrogen had depressing effect on potassium content of grape-petioles.

It might be due to the antagonistic effects of phosphorus and nitrogen on the potassium uptake.

The results of present study showed that the petiole content of N, P and K at 1.06, 0.276 and 1.73 per cent respectively obtained by application of 0.4 kg N plus 1.2 kg P_2O_5 and 0.8 kg K_2O per vine gave the highest yield.

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Chapter VI

SUMMARY AND CONCLUSIONS

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Chapter VI

SUMMARY

The present investigation on the effect of factorial combinations of N, P and K on fruit bud differentiation, vine vigour and yield and quality of the grape was conducted during the years 1972 and 1973.

The experiment was conducted on four-year old vines of Himrod cultivar of grape, which were trained on six-arm Kniffen system. Three levels of N (0.4 kg, 0.8 kg and 1.2 kg per vine) and two levels each of P and K (0.8 kg and 1.2 kg P_2O_5 and K_2O) were used in factorial combinations. The trial was laid out in a randomised block design with four replications. The experimental unit consisted of three vines.

The following results were obtained:

1. All the treatments employed had similar effect on fruit bud initiation and differentiation. All the vines studied were carrying the fruitful buds indicating thereby that there was

a 100 per cent fruitful buds irrespective of the treatment employed. The bearing and non-bearing shoots behaved alike. As the level of nitrogen application to the soil was increased, the percentage of dead and disintegrated buds was increased.

2. The treatment combination of 0.8 kg N, 1.2 kg P_2O_5 and 1.2 kg K_2O had the greatest effect in improving vine vigour.

3. Application of 0.4 kg N, 1.2 kg P_2O_5 and 0.8 kg K_2O per vine produced the greatest number of berries per bunch and the largest and the heaviest bunches.

4. Application of 0.4 kg N, 1.2 kg P_2O_5 and 1.2 kg K_2O had greatest effect in increasing the berry size and the weight.

5. The treatment combination comprising of 0.4 kg N, 1.2 kg P_2O_5 and 0.8 kg K_2O gave the highest yield.

6. The highest T.S.S., lowest acidity and consequently the highest T.S.S./acid ratio was noted in the juice of the berries of the vines receiving 0.4 kg N, 0.8 kg P_2O_5 and 0.8 kg K_2O .

7. Increasing level of soil application of N, P and K had a corresponding increase in the petiole content of N, P and K. The high dose of K had a depressing effect on the N content of grape-petioles; while the high dose of P increased the N content of grape petioles. As the doses of application of N and K increased

the P content of grape petioles decreased. High dose of N and high dose of P had depressing effect on K content of grape-petioles.

On the basis of results of present investigation, it can be concluded that the treatment combination of 0.4 kg N, 1.2 kg P_2O_5 and 0.8 kg K_2O gave the highest yield.

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