PLUM CULTIVATION IN THE HIMALAYA

ALOK TAGI

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Scientific Approach for Optimum Production of Santa Rosa Plum

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List of Abbreviations

1. N = Nitrogen
2. P = Phospohorus
3. K = Potassium
4. P_2O_5 = Phosphorus Penta Oxide
5. K_2O = Potassium Oxide
6. M^3 = Meter Cube
7. t = Tonne
8. Ca = Calcium
9. Mg = Magnesium
10. Mn = Manganese
11. Zn = Zinc
12. Fe = Iron
13. Na = Sodium
14. Cu = Copper
15. B = Boron
16. A1 = Aluminium
17. Lb = Pound
18. Fym = Farm Yard mannure
19. $Ca(No_3)_2$ = Calcium Nitrate
20. K_2SO_4 = Potassium Sulphate
21. ha = Hectare

22. CV	=	Cultivar
23. KC1	=	Potassium chloride
24. Vitamin C	=	Ascorbic Acid
25. Cm	=	Centimeter
26. C.C.	=	Cubic centimeter
27. F.C.	=	Field Capacity
28. PWP	=	Permanent wilting point
29. T.S.S.	=	Total solubic solid
30. N/10	=	Normality 0.10%
31. $CaCO_3$	=	Calcium Carbonate
32. HC1	=	Hydrochloric Acid
33. O.N.HC1	=	0.1 Normality
34. N_1	=	250 gm N/tree
35. N_2	=	500 gm N/tree
36. K_1	=	250 gm K_2/Otree
37. K_2	=	500, gm K_2O/tree
38. K_3	=	750 gm K_2O/tree
39. I_1	=	Irrigation at 75% soil moisture deflection
40. I_2	=	Irrigation at 50% soil moisture deflection
41. A.O.A.C.	=	Association of Official Analytical Chemists
42. gm	=	Gramme
43. ml	=	Mililitre
44. mg	=	*Milligram*
45. A.R.	=	Analytical Reagent

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Preface and Acknowledgement

One of the most important constituents of human being in the north east India is primary occupation in the hills of Himalayan ranges in which horticulture primitive or modern, forms the total link of man's interaction with his hilly environment. Of the Horticulture items, Plum has been accepted as one of the important stone fruits for the common people in the hills providing nutrition and occupation in the Himalayan region.

So I was first attracted to do some work in detail to provide technical know how to the workers who are engaged in the field side by side thorough knowledge to the planners and administrators to give sufficient scope for its development.

Amongst the common fruits grown in the hilly regions plum is cheaper in comparison and easily available to the common people. Its marketability also can be easily developed. Thus plum can be made the basic factor for the development of the hills. Keeping this idea in view the planners, administrators should give stress on plum as it is due.

The present work is the out-come of my Ph. D. study which was conducted during 1979-1982 in the Himachal Pradesh Krishi Vishwavidyalaya now University of Horticulture and Forestry, being sponsored by the Government of Arunachal Pradesh.

To complete this project, I have been guided, helped and encouraged by many scholars, teachers, administrators and friends. It is not humanly possible to acknowledge every one by name here and express my deep gratitude for their help. However, I would like to mention some of the names for their contribution in the work. With deepest gratitude I acknowledge the stimulating guidance and valuable suggestions by Dr. T. R. Chadda, Professor and Head of the Department of Horticulture (now retired). My thanks are due to Dr. Jagmohan Singh Chauhan, Professor in the University of Horticulture and Forestry, Solan, Himachal Pradesh for his guidance and suggestions at every stage in this work.

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My special thanks are due to Shri T. Ringu, the then Development Commissioner and now the Chief Secretary of the Government of Arunachal Pradesh, for his kind permission and encouragement for my Ph. D. work.

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I am grateful to my parents, brothers, wife and children for their kind help in my work.

Alok Tagi

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Introduction

Plum (*prunus salicina* Lindl.) is one of the most important stone fruits of temperate region of North and North-eastern parts of the country. In North India the plum cultivation has been taken up in a big way. So fat the North East is concerned, Plum has been a very popular fruit since time immemorial. A type of wild plum was avalable earlier in different parts of the state.

With the introduction of techniques and know how this fruit is produced at a large scale, in Cirnag, Nafra, Bomdila, Rupa, Kalaktang, Thrizing, Buragaon, Palizi, Tonga in West Kameng, Lumla, Zimithang in Tawang DistrictSoppa, Chayangtajo, Pakekesang in East Kameng, Ziro, Koloriang, Palin, Raga, Tamen, Daporijo, Taksing, Taliha, Nachó in Lower and Upper Subansiri Districts. Almost all the places of East and West Siang Districts Anini, Roing, Dambuk, Heyuliang area of Dibang Valley and Lohit District and Laju, Wakka and nearby area of Tirap District of Arunachal Pradesh produce this fruit.

Dirang Agriculture/Horticulture Nursery has been producing large quantity of Seedlings of the Santa Raja Plum. The total area under stone fruits in Himachal Pradesh is 21,245 hectares out of which more than 50 per cent is under plum alone (Anonymous, 1983). It has occupied a special position in the fruit industry of the state of Himachal Pradesh due to high net returns. The plum cultivar Santa Rosa is grown between the altitude of 1,000 to 1,600 meters above m.s.l. It is a mid season variety which matures in

June-July and bears a heavy crop. The Santa Rosa plum has been found to be most prolific and regular bearer. Therefore, the area under this cultivar is gradually increasing every year. The precise information on the cultural aspects of plum cultivation is lacking. As such growers are facing many production problems. It is particularly true in respect of irrigation and fertilizer requirements.

Irrigation plays a vital role in plum production where the natural precipitation is inadequate during the growth and the fruiting period. The plum trees must be irrigated to obtain optimum yield of high quality fruits. The fundamental objective in controlled irrigation is the maintenance of an adequate moisture supply in effective root zone of the tree. However, the irrigation requirements vary from area to area depending upon climatic conditions, soil texture and depth, root zone of the fruit plant and topography of the land (Victor, 1956). It is, therefore, necessary to work out the time and number of irrigations required and the amount of water to be applied in each irrigation under a particular set of agro-climatic conditions. In mid-hills of North India where the weather in summer is hot and dry, the efficient use of irrigation water for successful plum cultivation is essential. Since water resources in the State are limited it is, therefore, necessary to investigate the requirements of water to obtain optimum growth, yield and fruit quality of Santa Rosa plum.

Another major important factor in profitable fruit cultivation is the judicious fertilizer use. Three of the macro nutrients namely; N, P and K are removed from the soil in large amounts. An estimate of such removal has been given by Ferre (1961). He reported that 600 bushels of peach crop removed 95 lb N, 30 lb P_2O_5 and 120 lb K_20 per acre. This loss of nutrient from the soil has to be supplemented by the use of the manures and fertilizers in order to maintain soil fertility on long term basis.

There is disparity amongst the plum growers in various regions of India with regard to quantity and types of manurial practices based on either common experience in their localities or research works conducted elsewhere.

The fertilizer trial conducted by Chadha and Jassal (1968) obtained increase in yield and better quality of Santa Rosa plum with the application of nitrogen.

Uptill now, the attempt has been made to conduct separate experiments on fertilizer and irrigation requirements of stone fruits. Such studies have obvious limitations and do not furnish precise information on fertilizer and irrigation requirements in combination so as to exploit the maximum potential of the plum trees.

The present experiment was, therefore, undertaken to study the effects of two important production variables namely; fertilizer and irrigation in combination so as to find out the optimum N, K and water requirements of Santa Rosa plum under Solan conditions.

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Review of Literature

IRRIGATION

The main objective of irrigation studies has been to find out *how much* water should be applied each time and at what *interval* so as to produce commercial crop of fruits. The results of some of the experiments conducted on pome and stone fruits have been reviewed under following headings:

Plant Growth

Water is indispensable for the maintenance of turgor pressure in the plant cell. Water deficit interferes with the cell division and reduces the elongation of stems and enlargement of leaves. Vegetative growth is a vital function of plant life. Many research workers have reported that pome and stone fruit trees under continuous readily available soil moisture conditions during the growing season make more total growth than the trees under limited water supply (Werenfels *et al*, 1964; Carlson, 1967; Friedrich, 1967; Goode and Ingram, 1971). Umirov and Shogenov (1977) reported direct correlation between the rate of tree growth and soil water contents. Various research workers have shown that irrigation increased shoot growth of apple and peach trees (Feldstein and Childers, 1965; Rogers, 1965 and Janjic *et al*, 1972). However, Veihmeyer (1972) reported that tree growth was little affected by wide differences of soil moisture content provided that permanent wilting point was not reached and maintained at any length of time in apricot. The soil moisture content below 60 per cent of field capacity as well as the excessively high soil moisture content approaching saturation point over a prolonged period reduced the growth of peaches (Vavra, 1969). Vavra (1966) also found an increase in shoot growth of apricot trees by maintaining soil moisture at 80 to 90 per cent of field capacity at a depth of 30 cm. Kongsrud (1969) reported that the growth of the black currant and apple trees decreased with the increase in soil moisture tension from 0.5 to 2.5 bars. Dochev (1974) observed that by maintaining the soil moisture growth of young apple trees decreased as compared with no irrigation treatment.

Ninkovski *et al*, (1974) observed that irrigation improved the tree growth in peaches. Garjugin (1962) stressed the importance of early autumn irrigation in addition to irrigation during growing season of apple trees. Malcolm (1972) reported that with irrigation in peaches the rate of growth varied little. Hilkenbaumer and Engel (1963) reported that shoot growth of apple trees was strongly promoted by irrigating the plants early in the year but the irrigation after flowering was almost without effect. Goode and Hyrycz (1964) also reported that irrigation stimulated trunk and shoot growth of Laxton's Superb apple trees. Beukes and Weber (1982) reported that the irrigation at 85, 65, 45 or 25 per cent of total available water (TAW), the trunk and shoot growths were positively correlated with TAW levels in apple. Similarly, Ruger (1981) also observed that the irrigation increased the trunk and shoot growth of apple trees.

Yield

Total yield is an important factor in fruit growing. The increase in yield as a result of irrigation have been reported by many investigators (Goode and Hyrycz, 1964; Werenfels *et al*; 1964, Feldestein and Childers, 1965; Friedrich, 1967; Goode and Ingram, 1971; Janjic *et al*, 1972; Kosevska, 1972 and 1973 and Ninkovski *et al*, 1974. Agabbio (1973) observed that irrigation at the rate of 450, 500 or 600 m^3 per hectare increased the fruit yield per tree in apricot. Morris *et al*,(1961) observed that 6 irrigations to supplement the rainfall to a total of 2 inches per two weeks resulted in heavier fruit loads and increased the yield. Hilkenbaumer and Engel (1963) observed that irrigation enhanced the yield in pear and morello cherries. Goncharova (1974) in a 10-years trial on apples observed the best effect on yield by maintaining soil moisture at or above 70 per cent of field capacity during growing season. Koshevska *et al*, (1972) obtained mean annual yield of 16,160 kg/ha of peaches by wetting the soil to 80 cm depth.

Gulyamov (1972) observed that the trees of two plum and cherry cultivars irrigated once in winter and 5 times in growing period resulted in 14 to 17 per cent increase in yield than control. Garjugin (1962) obtained 70 to 100, 50 to 60, 60 to 80 and 90 to 100 per cent increase in yields of apples, plums, cherries and apricots respectively by irrigating the trees at the rate of 1500 m^3/ha in winter combined with the normal irrigation in the growing period. Prazak and Cepicka (1981) reported that application of 57 mm water amounting to total annual rate of 2477m^3/ha increased average yield of Red Haven peach cultivar by 2.19 t/ha. Albuquerque *et al*, (1981) reported that irrigation at 40 per cent available soil moisture gave good yields. Irrigation increased the yield of apple was also reported by Chapman and Crew (1978), Albori *et al*, (1982); Reday (1981) and Gergely (1973), and Ruger (1981).

However, Veihmeyer (1972) reported that the fruit yields in prune, peach, walnut and apricot were little affected by wide differences in soil moisture contents.

Fruit Quality

Fruit quality is subject to varying methods of evaluation. It is, therefore, not possible to correlate appraisal of fruit quality from diverse sources as different evaluators do not adopt common standard of evaluation. Werenfels and others (1964) reported that irrigation maintained at high levels of soil moisture produced large fruits with the highest soluble solids in peach. Rogers (1965) also observed that supplementary irrigation increased the fruit size by an average of 29 per cent in Sun High and 24 per cent in Elberta peaches. The increase in fruit size as a result of irrigation was also reported by (Feldstein and Childers, 1965; Vavra and Melichar, 1968; Ryan *et al* (1974). Veihmeyer and Hendrickson (1955) reported that moisture regimes when maintained between field capacity and wilting percentage do not greatly affect the quality of fruits. It is only when moisture was depleted beyond the wilting percentage for a considerable time that peaches become tough and leathery in texture. Vavra (1969) reported that irrigation did not affect the dry matter, sugar and acid contents of the peach fruits. A reduction in the marketable crop and increase in yield following irrigation in Elberta peaches was obtained by Morris *et al* (1961). A slight decrease in sugar content as a result of more irrigation has also been reported by Dochev *et al* (1976) and Ninkovski (1976). Albuquerque *et al* (1981) observed that irrigation had little effect on the percentage of soluble solids in peach.

On the other hand, Gadziev and Jakubov (1968) observed that when the soil moisture level was between 60 to 80 per cent of field capacity at harvest time, the sugar content of apple was more. In general, irrigation improved the quality of pome and stone fruits (Hilkenbaumer and Engel, 1963; Unrath and Sneed 1974). Unrath (1973, 1975) found an increase in soluble solid contents of apple fruits with irrigation. The acidity in apple fruit juice was slightly increased by applying irrigation (Dohono *et al*, 1964; Rom 1965 and Dochev *et al*, 1976).

Vavra (1969) reported that irrigation did not affect the dry matter, sugar and acid contents of fruits but ascorbic acid content of peach fruit was increased. Veihmeyer (1972) also found that fruit quality of peach, prune, walnut and apricot was little affected by wide differences in soil moisture regimes.

INTERVALS OF IRRIGATION

The intervals of irrigation in fruit trees vary widely depending upon the variety, environmental conditions and other basic variables. Gulyamov (1972) obtained an increase in the yield of plum and sour cherry by irrigating once in winter and 5 times during growing period. According to Goode (1975) trickle irrigation in apples applied monthly produced more fruits than annual, fortnightly or weekly application. Sulyok and Marko (1963) showed that the critical time for the application of irrigation water to Jonathan apples was after 66 per cent of the season's growth. The second irrigation may be applied at mid-August when 80 per cent of the season's growth is over. Irrigation at wrong periods in the tree's growth stages resulted in flower drop, reduced cropping, and delayed dormancy. Nasharty and Ibrahim (1961) observed that irrigation treatments of 16, 20 or 24 days intervals from March to October over two consecutive years in Japanese plum trees did not affect yields or weight of individual fruits, but fruit size was more with more frequent irrigations and the percentage of dry matter was more in dry conditions.

SOIL MOISTURE AND UPTAKE OF NUTRIENTS

Results of some of the experiments relating to soil moisture and uptake of nutrients are available. It is generally believed that a reduction in the absorption of potassium by roots of plants may occur under dry soil conditions (Weissenbarn, 1965). Dochev (1974) showed a positive correlation between N, P, K, Ca, Mg, Mn, water soluble carbohydrates, sucrose and fat concentrations in apple trees and soil moisture content. Branton and others (1961) found the highest content of K, P and Zn in apricot leaves grown under low soil moisture stress whereas N, Mg and Mn concentrations were the highest in the leaves from the trees grown under high soil moisture stress. The N, P and K content of peach leaves increased with the soil moisture levels (Dochev, 1968). Irrigation significantly increased P and K contents of Elberta peach leaves whereas the K concentration of Newday peach leaves was not affected by irrigation (Feldstein, 1963). Dimitrovski *et al* (1968, 1969) obtained higher contents of leaf N, P and K in one year old shoots of irrigated peach trees than of unirrigated ones. Dochev *et al* (1976) observed increased contents of P, Ca, Mg, Fe and Mn in the apple fruits from irrigated trees. Stojkovska *et ul* (1972) also observed increased nutrient contents in the leaves, shoots and fruits of irrigated peach trees both in fertilized or non-fertilized soils. Kumashiro and Tateishi (1967) also observed marked reduction in the leaf P content of Jonathan apples at the low soil moisture levels. Smith and Kenworthy (1979) reported that irrigation increased the leaf concentration of Na, Ca, Mg, Mn in sour cherry; P, Cu, B and Al in peach and P, Na, Fe and Cu in plum. Lehova and Dochev (1983) reported that irrigation maintained at 70 to 80 per cent field capacity increased the leaf content of P, Fe, B and N in Golden Delicious apple. Barrera and Slowik (1980) reported that irrigation increased the levels of P, K and Mg in McIntosh apple leaves.

EFFECT OF FERTILIZER

The information available in literature regarding the effect of nitrogen and potassium nutrition on growth, cropping and fruit quality and the leaf nutrient contents in pome and stone fruits is briefly reviewed below:

1. Tree Growth

(a) Effect of Nitrogen

Various fertilizers greatly influenced the tree growth of stone fruits (Overcash *et al*, 1961). Application of N has been observed to increase the girth of peach tree (Mc Munn, 1933; Howeston, 1955; Rom, 1976). In cherry also similar results were obtained by Werner, 1976; Vang, 1977 and Matzner and Maurer, 1981. Rawat (1974) reported that plum tree growth increased with the increase in the rate of nitrogen. Bordeianu and others (1964, 1965) reported that application of N fertilizer was conducive to growth, increased the trunk girth, shoot length and also the canopy of apricot and plum trees. Chohan and Sohan (1976) observed that in Titron, Ladakh, Zordalu and Alubukhara Sharbati plum, the highest tree growth was observed when the dose of N was raised from 25 to 100 gm per tree. Janjic (1979) reported that 125 or 250 kg N as Calcium Ammonium Nitrate per hectare improved the growth of Red Haven peach.

Kosher (1971) reported that N at the rate of 90 and 100 kg per hectare increased the annual growth increment of peach trees by 50 to 90 per cent as compared to control. Chadha and Jassal (1968) observed that application of nitrogen increased the linear shoot growth in plum. Chand (1969) also found that shoot growth in plum increased with the increase in doses of N. Similar reports were also given by Rogers (1971) in peach and in cherry by Kenworthy (1974), Marinov (1983) and Yamazaki *et al* (1977) in apple.

(b) Effect of Potassium

Kwong and Fisher (1962) observed marked increase in shoot length with the application of K at the rate of 4 lb and 12 lb per tree to K deficient peach orchards. Sanvad (1962) reported that the application of K at the rate of 100 kg per hectare increased the tree growth of cherry and plum. Gurgenidge (1974) reported that peach tree growth was best at 600 kg P_2O_5 plus 360 kg K_2O per hectare. However, Lenina *et al* (1977) did not record any beneficial effect of K fertilization on the growth of young peach trees. Liwerant (1955) also found that potassium fertilizer had no effect on the growth of young plum trees in soils low in potassium contents. Cline and Archibald (1965) did not observe any significant growth in cherry as a result of K or P fertilizer applications.

(c) Effect of NPK

Bajwa and Chadha (1966) reported that the application of N+P+K increased the girth of apricot trees significantly as compared to the control. The increase in trunk girth of stone fruits was also reported by Keremidarska, 1969; Degtyar and Krolik, 1972; Klossowki *et al*, 1977 and 1978; Degtyar, 1979.

Parnia (1965) obtained best shoot growth with application of 40 tonnes of FYM and 120 kg each of N and P per hectare in cherries. Nijjar *et. al*, (1972) reported that maximum growth of apricot trees was obtained when all the three nutrients, N, P and K were applied at the rate of 369.0 gm N, 198.45 gm P_2O_5 and 476.28 gm K_2O per tree, respectively. Lenina *et al*, (1977) reported that N at 0-256 kg, P_2O_5 at 0-128 kg and K_20 at 80 kg per hectare each or in combination increased the tree growth. Popovich *et al*, (1975) observed that plum tree receiving 90 : 45 : 45 kg N, P and K per hectare gave the best tree growth. Whereas Marinov (1983) found a little effect of mineral fertilization on growth of young apricot trees.

2. Fruit Set

Ludders and Bunemann (1969) reported that increased amount of N produced more prolific flowering as well as higher fruit set in apple, since higher N supply was stored by plants. Bunemann and Ludders (1969) found that development of flowers primordia, fruit set and June drop were all affected by N availability in Cox's Orange Pippin apple. Pejkic (1966) observed that NPK application gave more fruits set as compared to N or P and K treatment alone in apple. Yangaratnam and Greenham (1982) reported that in Discovery and Cox's Orange Pippin apple cultivars the increase fruit set was recorded with N application to soil.

Yield

(a) Effect of Nitrogen

Fertilizer effects on yield have been reported by various workers in stone fruits. The application of nitrogenous fertilizers increased the yield in peach (Mc Munn, 1933; Mc Hutton *et al*, 1946; Cowart and Savage, 1947; Ritter, 1961; Kidman, 1960; Stembridge *et al*, 1962; Shoemaker and Gammon, 1964; Taylor and Van 1970; Giddens *et al*, 1972; Janjic, 1979 and Cumings and Madox 1983). Similarly increase in yield of peaches with the application of nitrogenous fertilizers was also obtained by Cahoon (1971), Uchiyama (1973) and Orphanos (1974) and Baxter (1974). In most of the studies the yield increase was reported with N application in peach trees but on contrary Rogers (1971) observed that N application failed to increase the yield in Giant Elberta trees as compared with control. Sanvad (1962) obtained an increased yield of plum and cherries with the application of nitrogenous fertilizers. However, Ystaas (1966) did not obtain significant increase in the yield of plum with the application of nitrogenous fertilizers. Bajwa and Mishra (1970) observed that 450 gm N per tree was the optimum dose which gave significant increase in yield of New Castle apricot as compared with the other doses. Sadowaki and Zolcik (1978) reported that with the application of N at 40, 140 and 240 kg/ha, the yield per tree was increased with the rising of N levels. Similar report was given by Mantinger (1983) in apples.

(b) Effect of Potassium

The significant increase in the yield of plums was observed by Johanson (1962) with the application of K at Alnarp and Ugerup Research Stations in Sweden. Semenyuk (1974) observed a sharp response of K in improving the yield in peach, plum, sweet cherry and sour cherry fruit trees. Lenina *et al*, (1977) also noticed the improved yield in young peach orchards with K fertilization. Application of K fertilizer was also recommended by Humbert

(1968) for getting increased yield in peaches. Similarly, Sanvad (1962) reported that the application of K at the rate of 100 kg per hectare increased the yield of plums and cherries but higher dose of 200 kg K per hectare did not increase the yield any more. Cummings (1980) reported that K application at the rate of 66 lb per acre gave the yield of 144 lb per tree in Elberta peach. Uebel (1982) reported that K fertilization increased the yield in Idared apples. Gherghi *et al,* (1981) found that the application Ca +PK at 180 : 280 kg/ha gave the highest yield in Golden Delicious apple than other treatment combinations.

(c) Effect of NPK Combination

The highest cumulative yield in peaches was obtained by Tawfik *et al* (1974) from the trees receiving N, P and K fertilizers. Degtyar and Krolik (1972) also noted the highest yield in peaches with the application of N and K at the rate of 100 : 100 kg per hectare.

Increase in yield of peaches by the application of N, P and K has also been observed by Over Cash *et al* 1960; Ritter (1961); Esayan (1973); Kiss and Tamasi (1975); Degtyar (1979) and Sharma and Singh (1982). Bajwa and Chadha (1966) observed in their fertilizer experiment on New Castle cultivar of apricot that N+P+K treatment significantly increased the yield as compared with other treatments. Keremidarska (1969) reported that application of 9 gm per sq.m. of NPK in combination gave higher yield than when the nutrients were applied alone in apricot orchard. Parnia (1965) also observed that NPK treatment combination gave 38 per cent more yield of cherries as compared with the unfertilized trees. Bubic (1969) reported the increase in yield of plum with the application of NPK fertilizers. Ghena and Cepoiu (1966) also observed 14 per cent increase in yield of cherries with the application of N, P and K at the rate of 100 kg per hectare each as compared with the control. Popovich *et al* (1975) reported that best fertilizers combinations for plum trees were 45 : 45 : 45 kg per hectare of N, P_2O_5 and K_2O . Eismond (1976) reported that plum Cv. Vengeska Italyanskaya produced optimum yield with the application of N, P_2O_5 and K_2O at the rate of 120 : 60 : 60 kg per hectare. Similarly Mokasz *et al* (1979) also found that application of N, P_2O_5 and K_2O at the rate of 120 : 30 : 150 kg per hectare to plum Cv. Reine Claude d'Althan, Reine Claude verte gave the best yields. Werner (1977) reported that application of 150 kg N + 75 kg P_2O + 300 kg K_2O per hectare produced good yield in Morello cherry. Ljones (1982) reported that application of 50 kg $Ca(NO_3)_2$ + 20 kg K_2SO_4/ha gave best yield as compared to other treatment.

3. Effect on Fruit Size and Weight

(a) Effect of Nitrogen

The application of N increased the fruit size of peach and plum (Ystaas, 1966). Kwong (1973) also revealed that the higher rate of N application resulted in larger fruit size of Stanley prunes. Similar were the observations of Uchiyama (1973) in peaches. Bajwa and Mishra (1970) obtained the highest fruit size and weight of New Castle apricot with the application of N at the rate of 450 gm per tree. Chand (1969) reported that N at 2.32 lb per tree gave the highest fruit size, fruit weight and pulp stone ratio and stone weight in Santa Rosa plum. However, Proebsting (1945) observed little effect of N fertilizer on fruit size and weight of apricot, plum, peach and cherry. Helm and Ludders (1982) reported that increasing N resulted in increase glucose and fructose contents in Cox's Orange Pippin apple.

(b) Effect of Potassium

Kwong and Fisher (1962) obtained marked increase in fruit size with the application of K at the rate of 4 lb and 12 lb per tree to K-deficient peach orchards. Similarly, Humbert (1968) obtained increase in fruit size and weight with the application of K to peach trees. Application of K has also been shown to increase the fruit size of Victoria and Reine Claude d'Althan plums by Ystaas (1966). Sanvad (1962) reported that application of Potash at the rate of 100 kg per hectare increased the fruit size in cherries and plum. Cummings (1965) observed that application of K or Mg increased the fruit weight significantly in peach. Kwong (1965) also reported that fruit size in cherry was increased as a result of K application.

(c) Effect of NPK

Parnia (1965) obtained the maximum fruit weight in cherries with the application of 40 tonnes of FYM and 120 kg each of N, P and K per hectare. Bajwa and Chadha (1968) also reported that N + P + K fertilizer combination resulted in a significant increase in fruit size of New Castle apricot than all the other treatment combinations. Ystaas (1966) observed that with the application of potassium chloride and nitro-chalk the fruit size was increased in Victoria and Reine Claude d'Althan. Kwong (1973) reported that 793.8 gm N and 120.6 gm K per tree produced large fruit in plum. However, Yang (1977) reported that rising level of N and K diminished the fruit size in cherry Cv. Stevnsbaes.

4. Effect on fruit Quality

(a) Effect of Nitrogen

In general, increasing the rate of N increases the percentage of total soluble solids (T.S.S.) in stone fruits (Ritter, 1961; Bajwa and Chadha, 1965; Chadha and Jassal, 1968 and Chand 1969). Bajwa and Mishra (1970) obtained the highest T.S.S. contents in fruit juice of apricot with the application of 450 gm N per tree and lowest under the control. Uchiyama (1973) reported that application of 240 kg N per hectare per year enhanced the fruit quality in peach. Choureitah and Lenz (1974) observed a decrease in glucose and fructose in sour cherry fruits with the increasing level of N.

Bajwa and Mishra (1970) observed the highest acidity in the fruits of the trees receiving 600 gm N per tree and lowest in fruits of the trees under control. However, Kwong (1973) reported that N did not affect the titrable acidity or soluble solids but high K level increased the titrable acidity.

(b) Effect of Potassium

The application of K markedly increased the titrable acidity of peach fruits (Kwong and Fisher, 1962 and Kwong 1973). Cline and Archibald (1965) reported that application of K and P resulted in no significant improvement in fruit quality. Prevot *et al* (1965) observed that all treatments receiving potassium increased the sugar contents in plum fruits. Cummings (1980) reported that application of K to Elberta peach trees at 20, 66 or 132 lb per acre per year, the quality was generally increased with the increasing K level. However, Kwong (1965) reported that K application has no effect on soluble solids but titrable acidity was slightly increased in cherry. Chadha and Bajwa (1966) reported that K application alone reduced the acidity and also reduced the pulp stone ratio.

(c) Effect of NPK

Ferre (1961) obtained the best flavour, texture and colour of fruits with high N and K application to peach trees. Chadha and Bajwa (1966) reported that with the application of NPK, the effect on fruit quality was variable in apricot. Nijjar *et al* (1972) observed that NPK application at the rate of 369.90, 198.45 and 476.28 gm per tree did not affect the fruit quality of apricot. Henze (1976) reported that titrable acid and Vitamin C contents were positively correlated with NPK but soluble solids showed negative correlation in cherry. Matzner (1976) reported that application of high amount of N fertilizer with K_2SO_4 resulted in the lowest Vitamin C content but the application of KCI fertilizer alone improved the Vitamin C content in cherry.

5. Effect on Nutrient Content of the Leaf

(a) Effect of Nitrogen

An increase in leaf N content following the soil application of this element to apricot and peach trees has been reported by Margaryan (1976) and Orphanos (1974), respectively. Soil application of N has also been reported to increase the leaf N content in peaches by Monastra *et al* 1975. Vitonova (1973) observed that the application of N to soil increase the available N in the soil and leaf N concentration in plum. However, P and K application increased the leaf N content still further. Rawat (1974) reported that P content of leaves fell with increasing N fertilizer but decreased Calcium and Magnesium contents of leaves in Santa Rosa plum. Leece (1976) observed that application of nitrogenous fertilizer increased the concentration of N, Fe, Cu, Mn and Zn in the leaves but decreased the K, Ca, Mg, B and P concentration. Janjic (1979) reported that application of N fertilizer induced K deficiency but leaf P, Fe and Cu were not affected. Meland (1982) reported that leaf N content was positively correlated with fruit size and leaf K content with the titrable acidity of the fruits. Sharma and Singh (1982) reported that the high N rates increased the leaf N but decreased leaf P and K in peach. Werner (1976) observed that application of 160 kg of N per hectare increased the leaf N and K content but decreased the P and Ca contents in cherries.

Stoilov and Marinov (1983) reported a high positive correlation between N application rate and leaf N content in Hungarian apricot. Jentsch and Eaton (1982) also found a similar trend in apple leaves. Barsnes (1982) reported that increasing rate of N fertilizer lead to decreased levels of P, K and B and increased the levels of Ca and Mn in Karin Scheider apple leaves. Johnson and Johnson (1982) observed that N treatment increased that leaf N content but decreased the leaf P and K contents in apple. Ottme and Ludders (1983) reported that with the N application there was higher N and Ca content in Cox's Orange Pippin leaves.

(b) Effect of Potassium

Cummings (1973) reported that application of either K or Mg increased the concentration of K in leaves but found an antagonistic effect on Ca content. Bruchholz and Fielder (1979) found that leaf K content depended markedly on the amount and relative proportion of N or K ferlitizers' application to soil in apples. Vang (1980) reported that application of fertilizer to soil reduced the leaf Ca concentration in Cox's Orange Pippin apple.

Effect of NPK

Kenworthy and Gilligan (1948) reported that application of N, P and K gave positive correlation between N, P and K content in peach leaves. Lenina *et al* (1977) reported that NPK application to soil increased the N and K content in the peach leaves but P content did not increase. Krivoruchko (1980) reported that NPK nutrition increased the leaf N but decreased the P and K content in Melab and Renet Simirenko apples and William pears.

6. Combined Effect of Irrigation and Nutrition

Nour (1956) reported that growth of the tree was proportionate to the amount of water content in soil, P and K levels in apple leaves of peach and strawberries. Dimitrovski *et al* (1972) reported that application of fertilizer and irrigation at 40 to 60 cm improved the trunk diameter, shoot length and fruit number per tree and Vitamin C content in Cardinal peach. Till (1958) reported that highest yield was obtained from the high N plus irrigation treatment in apricot. Branton and others (1961) observed that leaf N, Mg and Mn concentrations were highest from the trees grown under high moisture stress while leaf K, P and Zn contents were highest in low moisture stress. Stojkovska *ct. al* (1975) reported that application of NPK to soil increased the leaf N, P and K and irrigation improved the uptake of these elements in Cardinal peach. Dimitrovski (1968, 1969) reported that the N, P and K contents were higher in irrigated tree than those under unirrigated trees. Dochev *et al* (1981) reported that irrigation at 80 per cent soil moisture capacity and fertilized with N at 12 or 18/m² gave higher shoot length, trunk diameter and increased the yield and fruit size. Deliver (1982) reported that irrigation plus compost gave higher shoot growth and yield as compared to unirrigated control in Jonagold apple.

3

Materials and Methods

The present investigations were carried out to study the effect of different levels of nitrogen, potassium and irrigation on growth, cropping and quality of plum Cv. Santa Rosa.

Location

The studies were conducted in the Experimental Orchards of the Department of Pomology and Fruit Technology, Himachal Pradesh Krishi Vishva Vidyalaya at Satyanand Stokes Horticultural Complex, Oachghat-Solan. The climate of this place is representative of Solan district of Himachal Pradesh with an average rainfall of 125 cm to 130 cm, the major amount of which is received during June to September. The temperature and rainfall pertaining to the study period are given in the Appendix-I.

Soil

Before the commencement of the experiment soil samples were taken from the field at 30 cm depth. The sample taken from different places were composited and analysed for some physico-chemical properties (Table-1). Mechanical analysis of soil was done by Hydrometer method (Bouyoucos, 1927). Available P and K contents were extracted with Olsen's reagent (Olsen *et al*, 1954) and neutral normal ammonium acetate (Jackson, 1967) respectively, and were determined by the stannous chloride reduced phosphomolybdate method in hydrochloric acid system and

Flame-photometerically, respectively. The available N was determined by alkaline potassium permanganate method described by Subbiah and Asija (1956).

TABLE : 1

Physico-Chemical Properties of Orchard Soil

(a) Physical Properties	Values
Sand %	37.15
Silt %	22.91
Clay %	39.94
(b) Chemical Properties	
Available N (kg/ha)	280.00
Available P_2O_5 (kg/ha)	24.00
Available K_2O (kg/ha)	320.00
pH	6.7
Bulk density (cc/gm)	1.4

Plant Material

Five year-old Santa Rosa plum trees of uniform vigour were selected for the experiment in plum orchard at Satyanand Stokes Horticultural Complex, Oachghat-Solan (H.P.). The plants were planted 6 metres apart and trained on modified central leader system. Uniform agro-cultural practices were followed for all the trees under experiment. A basal dose of 200 gm of P_2O_5, half doses of N and full doses of K were applied to all the trees under experiment. Half dose of N was top dressed after one month of first application.

Layout

Fifty four trees out of a compact block were selected for the experiment. The experiment was laid out according to Complex Randomised Block design having eighteen factorial combinations of three level each of N and K and two levels of irrigation.

Details of Experiment

Treatment combinations	=	18
Trees under each treatment (experimental unit)	=	1
Number of replications	=	3
Total number of experimental trees	=	3 x 18 = 54

Soil Moisture Characteristic Curve

In order to determine the soil moisture percentage retained by the soil at different moisture regimes as a guideline to irrigate the trees under each treatment, a composite mixture of orchard soil was taken from 0 to 150 cm depth. The samples of this composite soil mixture were saturated with water for 24 hours and then subjected to 0.3, 0.5, 1.0, 5.0, 10.0 and 15.0 atmospheric pressure in porous plate (Baver, 1956) and pressure membrane apparatus (Richard, 1949). The moisture contents of the soil were obtained by oven drying the samples at 105°C for 48 hours and were expressed in terms of percentage dry weight basis. Thus the soil moisture characteristic curve was drawn. These levels were used as guideline to irrigate the trees kept under different irrigation regimes.

TABLE : 2

Per Cent Moisture Retained at Different Atmospheric Pressure Tensions

Tension (Bar)	Moisture (%)
0.3	19.40 (F.C.)
0.5	17.07
1.0	13.37
5.0	7.40
10.0	5.79
15.0	4.66 (PWP)

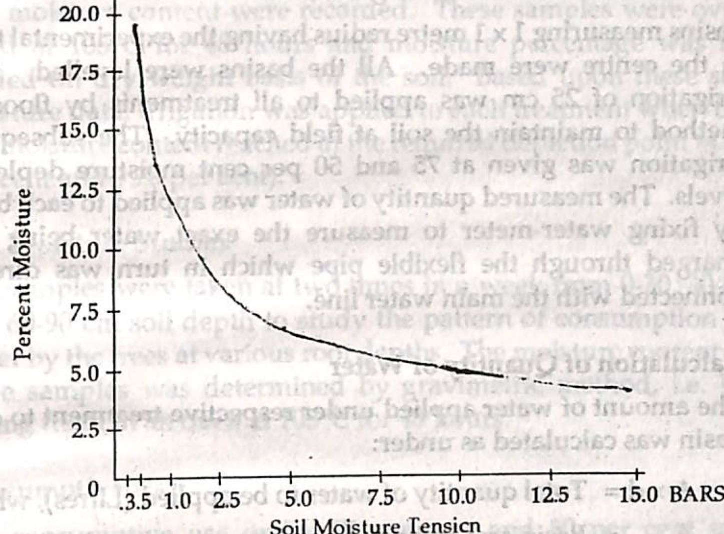


Fig. 1 : Soil Moisture Characteristic Curve (0-150 cm Depth)

Doses of Fertilizer and Irrigation Levels

Three levels each of N, K and two levels of irrigation were applied to the trees under experiment. The N and K were applied through calcium ammonium nitrate and muriate of potash, respectively. The fertilizers were applied in the last week of February each year. The first irrigation was given to the experimental trees just after the application of fertilizer doses. The P content of the orchard soil was high.

Treatment	Nutrient doses/trees
N_1	= 250 gm N
N_2	= 500 gm N
N_3	= 750 gm N
K_1	= 250 gm K_2O
K_2	= 500 gm K_2O
K_3	= 750 gm K_2O
I_1	= Irrigation at 75 per cent soil moisture depletion
I_2	= Irrigation at 50 per cent soil moisture depletion

Method and Schedule of Irrigation

Basins measuring 1 x 1 metre radius having the experimental trees in the centre were made. All the basins were levelled. First irrigation of 25 cm was applied to all treatments by flooding method to maintain the soil at field capacity. The subsequent irrigation was given at 75 and 50 per cent moisture depletion levels. The measured quantity of water was applied to each basin by fixing water-meter to measure the exact water being discharged through the flexible pipe which in turn was directly connected with the main water line.

Calculation of Quantity of Water

The amount of water applied under respective treatment to each basin was calculated as under:

A x d = Total quantity of water to be applied (Litres), where

A = Basin area in hectares

d = Depth of irrigation water (cm)

The depth of irrigation water for each application was calculated by the following formula:

$$d = \frac{Pw \times Bd \times D}{100}$$

where;

d = depth of irrigation water to be applied

Pw = moisture percentage to be raised (14.55 and 9.7)

Bd = Bulk density of the soil (1.4 gm/c.c.)

D = Depth of the root zone to be moistened (150 cm)

Time of Irrigation

In order to study the loss of soil moisture from the top 90 cm depth of soil, the samples were taken regularly from this depth and moisture content were recorded. These samples were oven dried at 105°C for 48 hours and moisture percentage was recorded on dry weight basis of the soil. Based upon these soil moisture data, irrigation was applied to each treatment when the soil moisture content reached at the required depletion point (4.85 per cent and 9.70 per cent).

Soil Moisture Studies

Soil samples were taken at two times in a week from 0-30, 30-60 and 60-90 cm soil depth to study the pattern of consumption of water by the trees at various root depths. The moisture content of these samples was determined by gravimetric method, i.e. by drying them in an oven at 105°C for 48 hours.

Consumptive Use

The consumptive use under 75 per cent and 50 per cent soil moisture depletion points was estimated from the irrigation water applied plus the precipitation occurring during the period of study.

Soil Temperature

The soil temperature at 15 cm and 30 cm depth were recorded daily at 2.30 P.M. to study the soil temperature fluctuation in different moisture regimes.

OBSERVATIONS RECORDED

Trunk Girth

To measure the tree growth, the trunk of each experimental tree was marked with permanent red circle at 15 cm above the graft point. The diameter of the tree was measured with the help of Freeman's measuring tape once before the commencement and then at the end of growing season each year.

Pruning Weight

To have an idea of the effect of different doses of fertilizers and irrigation levels on the growth of the trees, the weight of prunings in Kg was also recorded at the time of pruning operation in 1980, 1981 and 1982.

Shoot Growth

Twenty shoots in each tree were randomly selected from the current season's growth in the periphery to study the comparative linear shoot growth as affected by different treatment combinations. The annual extension growth of shoots were recorded during the dormant period.

Fruit Set

To study the percentage of fruit set, one metre branch was selected from each tree in four sides. The number of flowers present on these branches were counted which ranged from 300 to 600 in 1980, 291 to 678 in 1981 and 285 to 500 in 1982 and a month later the fruit set on those branches were counted again. The percentage of fruit set was calculated as number of fruits set multiplied by hundred; divided by the total number of flowers present on the branch.

Yield

At the time of harvest fruit yield was recorded in Kg per tree.

Physical Analysis of Fruits

The representative fruits from each experimental tree were randomly selected to determine their average weight, size and pulp/stone ratio.

Fruit Weight

The average weight of the fruit in each treatment was calculated in kg with the help of top pan balance. The weight of twenty randomly selected matured fruits was recorded and the mean weight for each treatment was worked out.

Fruit Size

The average fruit size was determined by measuring the length of the fruit from base to the apex and diameter at the broadest portion of the fruit shoulders. The fruit length and breadth were recorded with the help of Vernier's Callipers.

Pulp/Stone Ratio

This ratio was calculated by finding out the weight of fruit flesh and weight of pit separately and dividing the average weight of flesh by the average weight of the pit.

FRUIT QUALITY

Total Soluble Solids (TSS)

The juice of ten fruits was extracted and stained through muslin cloth. The T.S.S. was recorded with the help of Erma hand refractometer and the readings were corrected at 20°C.

Reducing Sugars

Boiling solution of mixture containing 5 ml each of Fehling's solution A and B was titrated against unhydrolysed but deleaded and clarified pulp solution.

Non-reducing Sugars

The amount of non-reducing sugars was calculated by subtracting reducing sugars from total sugars and by multiplying the difference by 0.95 factor.

Total Sugars

25 gm of the fruit pulp thoroughly mixed with distilled water in a Wareing blender, was made upto the volume 250 ml. To this 10 ml of saturated lead acetate was added and then filtered into flask containing potassium oxalate. The filtrate was shaken and again filtered. 100 ml of this deleaded and clarified solution was taken and hydrolysed by adding concentrated HCl and leaving it overnight. The excess HCl was neutralised by saturated sodium hydroxide solution. Total sugars were then estimated by titrating boiling mixture containing 5 ml each of Fehling's A and B solutions against the hydrolysed aliquote (A.O.A.C., 1970) using methyl blue indicator.

Titrable Acidity

25 gm of fruit pulp was thoroughly mixed with water in wareing blender. The volume made upto 250 ml in conical flask. This was filtered through Whatman filter paper. 10 ml of the sample solution was titrated against N/10 sodium hydroxide solution using phenolphthalein as indicator. The total titrable acidity was calculated in terms of malic acid on the basis of 1 ml N/10 sodium hydroxide is equivalent to 0.0067 gm anhydrous malic acid. The result expressed as percentage of titrable acidity.

Quantitative determination of Ascorbic acid/(A.O.A.C., 1970)

Extracting Solution

15 gm of metaphosphoric acid pellets were dissolved in 40 ml of glacial acetic acid and 20 ml of water and diluted to 500 ml. The solution was filtered rapidly through fluted paper in glass stop bottle and stored in refrigerator.

Ascorbic Acid Standard Solution

50 ml analytical grade ascorbic acid (Reference standard) was weighed and transferred to 50 ml volumetric flask. It was diluted to volume immediately before use with metaphosphoric acetic acid solution.

Indophenol Standard Solution

50 ml of 2, 6 dichlorophenol indophenol sodium salt that had been stored in a desiccator over $CaCO_3$ was dissolved in 50 ml water to which was added 42 mg of sodium bi-carbonate. It was shaken vigorously and when dye had dissolved then solutions diluted to 200 ml with distilled water and filtered through fluted paper into amber glass stopped bottle and stored in refrigerator.

Procedure

A known quantity of homogenous fruit extract was taken and equal volume of extracting solution was added and titrated against Indophenol Standard Solution. The end point was determined by appearance of rose pink colour which persisted for a few seconds. The titration was repeated with water for blank and with standard ascorbic acid solution. The results were expressed as mg ascorbic acid per 100 gm fresh weight of fruit pulp.

TSS and Acid Ratio

The ratio was worked out by finding out the total soluble solids and acidity of the fruit juice separately and dividing the former by latter.

Leaf Analysis

The leaves for N, P, K, Ca and Mg were collected according to the method recommended by Chapman (1964).

DIGESTION OF PLANT MATERIAL

The leaves taken from each plant were placed in polythene bags and brought to laboratory. These leaves were washed with tap water, 0.1 N HCl solution and finally with distilled water. These were then transferred to paper bags and dried in the oven at 65°C for 48 hours. Fully dried leaves were ground in willy mill and placed in an oven for 12 hours at 65°C before weighing for chemical analysis.

The digestion of samples for nitrogen estimation was carried out separately using concentrated sulphuric acid (A.R. Grade) and digestion mixture was prepared by mixing 20 : 1 : 3 parts of copper sulphate, selenium and mercuric oxide, respectively. One part of this mixture was thoroughly mixed in 20 parts of anhydrous sodium sulphate.

The digestion of samples for P, K, Ca and Mg nutrient elements were done in diacid mixture (A.R. Grade nitric acid and per-chloric acid in ratio of 4 : 1, Jackson (1967).

Leaf Analysis

Nitrogen was analysed by Technicon Auto-analyser System II. Phosphorus was determined by Ammonium molybdate van date yellow colour method described by Chapman and Pratt (1961). Potassium, Calcium and Magnesium was determined by Perkin Elmyr Atomic Absorption Spectrophotometer, Model No. 2380.

4

Experimental Results

The present studies on the effect of factorial combinations of three levels each of nitrogen, potassium and two regimes of irrigation on growth, cropping and quality of Santa Rosa plum were conducted in the plum experimental orchards of Department of Pomology and Fruit Technology at Oachghat-Solan during 1980, 1981 and 1982. Other aspects such as uptake of N, P, K, Ca and Mg were also studied. The results during these periods are given below:

Soil Moisture

Frequency and Number of Irrigations Applied

The data on the number of irrigations applied under two irrigation regimes of 75 per cent and 50 per cent soil moisture depletions are given in Tables 3A, 3B and 3C for 1980, 1981 and 1982. Starting from first irrigation in March, the schedule of irrigation shows that the interval between the subsequent irrigations went on decreasing under both the irrigation treatments. The interval between the first and second irrigation was 47 and 75 days in 1980, 46 and 74 days in 1981 and 38 days and 72 days in 1982 in the case of 50 per cent and 75 per cent moisture depletion point, respectively. The trees started consuming more moisture after middle of May, the period corresponding to the rapid fruit development stage and rise in the atmospheric temperature. The increase uptake of moisture continued till the fruit maturity stage.

The irrigation had to be applied on 14 days under 50 per cent soil moisture depletion point towards the end of May. This was the peak water use period and corresponded to the rapid fruit development stage. The shortest interval in the case of 50 per cent moisture depletion point was 6 days and in the case of 75 per cent moisture depletion point was 30 days which occurred in the month of June.

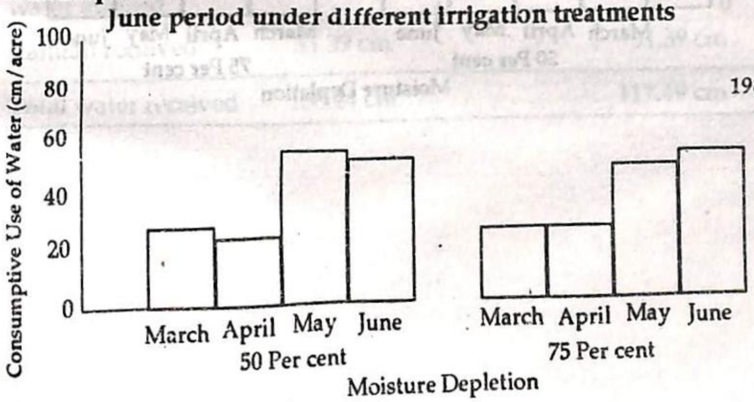
A total of six irrigations were applied to plum trees under 50 per cent moisture depletion point and three irrigations were applied to trees under 75 per cent moisture depletion point during 1980, 1981 and 1982.

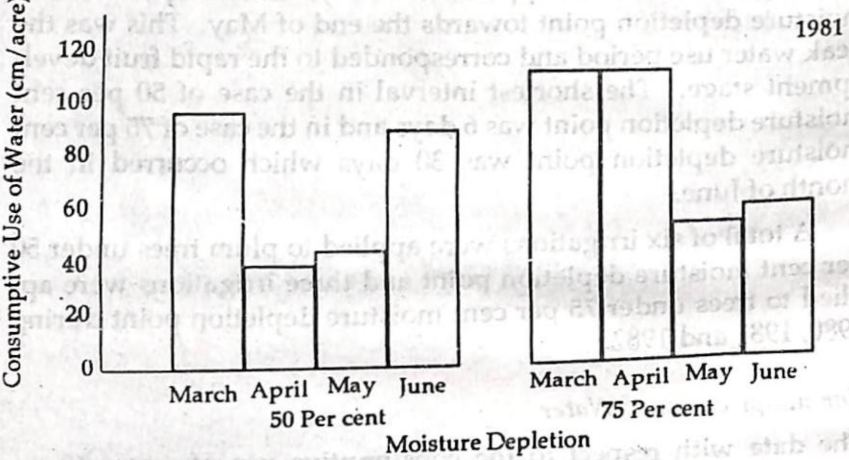
Consumptive use of Water

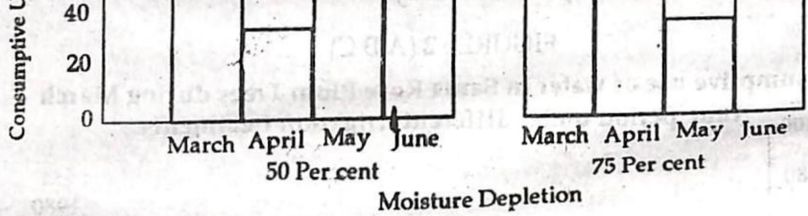
The data with respect to the consumptive use of water (from March to 2nd week of June) presented in Table 4 showed that under the 50 per cent moisture depletion point of irrigation, in moisture consumption by the trees was higher as compared to those under 75 per cent moisture depletion point. The trees consumed 158.24 and 117.49 cm in 1980, 282.15 and 241.40 cm in 1981 and 203.95 and 163.20 cm under 50 per cent and 75 per cent moisture depletion points, respectively. Under both the irrigation treatments the water used was the highest in the month of June. The consumptive use of water for the month of April under 75 per cent soil moisture depletion treatment has been included in March on all the three years of study.

FIGURE : 2 (A B C)

Consumptive use of water in Santa Rose Plum Trees during March - June period under different irrigation treatments




1981
Consumptive Use of Water (cm/acre)
120
100
80
60
40
20
0
March April May June
50 Per cent
March April May June
75 Per cent
Moisture Depletion


1982
Consumptive Use of Water (cm/acre)
100
80
60
40
20
0
March April May June
50 Per cent
March April May June
75 Per cent
Moisture Depletion

Moisture Consumption from Different Soil Depths

The data presented in Table 5 show the effect of different irrigation regimes on per cent moisture consumption from different soil depths. The highest consumption or uptake of moisture was from upper 30 cm depth of soil and the lowest from 61-90 cm layer. The consumption of moisture decreased with increased soil depth in all the years of study.

TABLE : 3A

Irrigation Schedule in Plum Trees Under Different Soil Moisture Regimes during 1980

50 per cent moisture depletion point			75 per cent moisture depletion point		
Dates of irrigation	Depth (cm)	Interval (days)	Dates of irrigation	Depth (cm)	Interval (days)
5.3.80	25.00	-	5.3.80	25.00	-
21.4.80	20.37	47			
12.5.80	20.37	21	19.5.80	30.55	75
26.5.80	20.37	14			
5.6.80	20.37	10			
14.6.80	20.37	9	19.6.80	30.55	31
	126.85	6		86.10	3
Number of irrigations		6			3
Total irrigation water applied		126.85 cm		86.10 cm	
Rainfall received		31.39 cm		31.39 cm	
Total water received		158.24 cm		117.49 cm	

TABLE : 3B

Irrigation Schedule in Plum Trees Under Different Soil Moisture Regimes during 1981

50 per cent moisture depletion point			75 per cent moisture depletion point		
Dates of irrigation	Depth (cm)	Interval (days)	Dates of irrigation	Depth (cm)	Interval (days)
5.3.81	25.00	-	5.3.81	25.00	-
20.4.81	20.37	46			
18.5.81	20.37	28	18.5.81	30.55	74
1.6.81	20.37	14			
8.6.81	20.37	7			
15.6.81	20.37	7	18.6.81	30.55	31
	126.85	6		86.10	3
Number of irrigations		6			3
Total irrigation water applied	126.85 cm			86.10 cm	
Rainfall received	155.30 cm			155.30 cm	
Total water received	282.15 cm			241.40 cm	

TABLE : 3C

Irrigation Schedule in Plum Trees Under Different Soil Moisture Regimes during 1982

50 per cent moisture depletion point			75 per cent moisture depletion point		
Dates of irrigation	Depth (cm)	Interval (days)	Dates of irrigation	Depth (cm)	Interval (days)
5.3.82	25.00	-	5.3.82	25.00	-
12.4.82	20.37	38			
16.5.82	20.37	34	15.5.82	30.55	72

(Contd.)

(Contd.)

50 per cent moisture depletion point			75 per cent moisture depletion point		
Dates of irrigation	Depth (cm)	Interval (days)	Dates of irrigation	Depth (cm)	Interval (days)
31.5.82	20.37	15			
9.6.82	20.37	9			
15.6.82	20.37	6	14.6.82	30.55	30
	126.85	6		86.10	3
Number of irrigations		6			3
Total irrigations applied		126.85 cm		86.10 cm	
Rainfall received		77.10 cm		77.10 cm	
Total water received		203.95 cm		163.20 cm	

TABLE : 4

Consumptive Use of Water (cm/acre) in Plum Trees during March to June Periods in 1980, 1981 and 1982 Under Different Irrigation Regimes

	Consumptive use of water (cm/acre)					
	1980		1981		1982	
	50 per cent	75 per cent	50 per cent	75 per cent	50 per cent	75 per cent
March	25.99	26.87*	92.70	122.90*	53.90	67.40*
April	21.25	-	40.57	-	33.87	-
May	56.76	46.57	47.77	57.95	45.44	35.25
June	54.24	44.05	91.11	60.55	70.74	60.55
Total	158.24	117.49	282.15	241.40	203.95	163.20

* = Consumptive use of water for March and April

Soil Temperature

The soil temperature as affected by different moisture regimes are presented in Tables 6, 7 and 8 for 1980, 1981 and 1982.

A perusal of the date indicates that the soil temperature was higher under 75 per cent moisture depletion point as compared with the 50 per cent moisture depletion point. This showed that higher soil moisture conditions tended to keep the soil at relatively lower temperature at both the soil depths. The data further revealed that the soil temperature tended to decrease with the soil depth as the higher soil temperatures were recorded at 15 cm depth and lower at 30 cm depth in both the irrigation regimes in all the years of study.

Tree Growth

The tree growth was measured in three ways:

(a) Trunk girth

(b) Shoot growth

(c) Pruning weight

TABLE : 5

Effect of Different Irrigation Regimes on Per Cent Moisture Consumption from Different Soil Depths in Plum Tree during 1980, 1981 and 1982

Soil depth (cm)	1980 moisture per cent		1981 depletion moisture		1982 point consumption	
	50%	75%	50%	75%	50%	75%
0-30	35.50	37.04	34.62	38.50	39.99	38.63
31-60	34.49	33.66	34.61	31.25	31.94	34.60
61-90	30.01	29.30	30.77	30.25	28.07	30.77

TABLE : 6

Effect of Irrigation Treatments on the Soil Temperature (°C) at Different Depths (1980)

Date	Weekly soil temperature variations (°C)				
	75 per cent moisture depletion point		Soil depth	50 per cent moisture depletion point	
	15 cm	30 cm		15 cm	30 cm
5.3.80	10.50	9.50		10.25	9.25
12.3.80	12.00	11.00		11.50	10.60
19.3.80	13.90	11.25		12.78	10.82
26.3.80	14.40	12.40		14.50	12.50
2.4.80	15.08	13.90		15.00	13.50
9.4.80	15.00	13.14		13.36	11.86
16.4.80	18.71	17.00		16.64	15.28
23.4.80	24.78	23.58		24.07	22.07
30.4.80	25.16	23.50		24.83	23.50
7.5.80	25.50	24.12		25.25	23.50
14.5.80	26.50	25.50		26.00	24.00
21.5.80	25.50	23.83		23.83	22.16
28.5.80	26.60	24.90		24.90	23.40
4.6.80	27.00	25.25		25.25	24.00
11.6.80	28.33	26.33		28.16	26.33
18.6.80	27.00	25.16		25.83	23.92
25.6.80	27.33	25.66		25.83	24.66

TABLE : 7

Effect of Irrigation Treatments on the Soil Temperature (°C) at Different Depths (1981)

Date	Weekly soil temperature variations (°C)				
	75 per cent moisture depletion point		Soil depth	50 per cent moisture depletion point	
	15 cm	30 cm		15 cm	30 cm
5.3.81	11.37	9.25		11.25	9.50
12.3.81	12.75	11.67		12.90	11.36
19.3.81	14.35	12.25		14.10	12.25
26.3.81	14.50	12.50		14.43	12.56

2.4.81	16.70	14.60		16.40	14.50
9.4.81	17.37	15.12		16.75	15.50
16.4.81	23.45	19.83		22.17	20.12
23.4.81	23.37	20.92		22.62	20.08
30.4.81	25.28	22.56		24.89	21.06
7.5.81	27.07	22.92		22.86	20.57
14.5.81	25.17	21.75		20.93	18.06
21.5.81	25.37	21.75		25.17	21.54
28.5.81	26.89	23.61		26.80	23.05
4.6.81	26.44	23.22		25.70	22.65
11.6.81	29.25	25.06		24.31	22.06
18.6.81	31.50	26.50		31.25	26.37
25.6.81	35.00	30.17		31.33	28.67

TABLE : 8

Effect of Irrigation Treatments on the Soil Temperature (°C) at Different Depths (1982)

Date	Weekly soil temperature variations (°C)				
	75 per cent moisture depletion point		Soil depth	50 per cent moisture depletion point	
	15 cm	30 cm		15 cm	30 cm
5.3.82	8.12	7.00		8.00	6.90
12.3.82	11.66	10.60		11.41	10.09
19.3.82	13.60	12.31		13.38	12.20
26.3.82	15.00	14.00		14.91	13.91
2.4.82	18.50	16.10		18.20	16.00
9.4.82	18.54	16.46		18.30	16.34
16.4.82	24.37	23.71		23.06	21.43
23.4.82	18.31	16.50		18.00	15.12
30.4.82	17.35	16.45		17.20	15.70
7.5.82	29.59	20.32		21.00	19.10
14.5.82	20.92	19.00		20.66	18.16
21.5.82	20.98	18.40		20.00	18.21
28.5.82	23.80	21.20		22.40	20.90

(Contd.)

(Contd.)

Date	Weekly soil temperature variations (°C)				
	75 per cent moisture depletion point		Soil depth	50 per cent moisture depletion point	
	15 cm	30 cm		15 cm	30 cm
4.6.82	26.25	24.51		24.95	22.65
11.6.82	26.70	24.70		25.85	23.30
18.6.82	24.25	22.10		22.89	20.10
25.6.82	24.20	22.75		22.50	20.15

Trunk Girth

The data with respect to the increase in trunk girth of the trees were taken in 1980, 1981 and 1982 and are presented in Table 9.

The data for three years show that there was significant effect of various levels of N on the increase in trunk girth. The trees receiving 750 gm N produced the highest increase in trunk girth than medium and low levels of N. With the increase in N level, there was an increase in trunk girth in all the years of study.

The K levels also differed significantly from each other in 1981. During 1980 and 1982 the low and medium K levels gave significantly more trunk girth than high level of K whereas the low and medium K levels did not differ significantly with each other in respect of trunk girth.

The trees under two moisture regimes differed significantly from each other in respect of increase in trunk girth. The irrigation at 50 per cent moisture depletion point produced significantly greater trunk girth than those under 75 per cent moisture depletion point in all the years of study.

The first order NK, NI and KI differed significantly in all the years of study except KI in 1980. The second order interaction NKI was significant in 1980 and non-significant in 1981 and 1982.

The differences among various fertilizers and irrigation treatments in respect of trunk girth were found to be significant in all the years of study. The treatment combinations $N_3K_1I_2$ and $N_3K_2I_2$ gave the highest increase in trunk girth and significant over the rest of the treatment combinations except $N_3K_2I_2$ and $N_3K_1I_2$ during 1981 and 1982. In 1980, $N_3K_1I_2$ gave significantly more increase in trunk girth than all other treatment combinations except $N_3K_1I_2$, $N_3K_3I_2$ and $N_1K_2I_2$. The treatment combinations $N_3K_1I_2$, $N_3K_1I_2$ and $N_3K_2I_2$ gave the greatest increase in trunk girth (5.14, 8.28 and 4.44 cm per tree in 1980, 1981 and 1982, respectively). The least increase in trunk girth 2.95, 3.81 and 2.35 cm per tree in 1980, 1981 and 1982 were recorded in trees which received $N_1K_3I_1$ treatment combination.

Shoot Growth

The data with respect to shoot growth were recorded in 1980, 1981 and 1982 and are presented in Table 10.

The data for the three years of study show that the trees receiving different N levels differed significantly from each other with respect to shoot growth. The highest level of N produced the longest shoot growth.

The various K levels also differed significantly from each other. The medium K level produced the longest shoot growth in 1980 and 1981. However, the low and medium levels of K did not differ from each other in these years. During 1982 K levels did not differ from each other with respect to shoot growth although the longest shoot growth was produced by low level of K.

The trees under different irrigation regimes differed significantly from each other with respect to shoot growth. The irrigation at 50 per cent soil moisture depletion point produced significantly more shoot growth than those under 75 per cent soil moisture depletion point in all the years of study.

The first order interactions NK and KI were not significant in 1980 while NI interaction was significant. In 1981, the first order interaction NK, NI and KI were significant while in 1982 only interaction KI was found significant and interaction NK and NI remained non-significant. The second order interaction NKI was found to be significant in 1980 and 1982. However, in 1981 the second order interaction NKI was not significant.

The differences in treatment combination of N, K and Irrigation were found to be significant in all the years of study. The treatment combination $N_3K_2I_2$ gave the longest shoot growth (96.47 cm) which was significantly greater than all other treatment combinations except $N_3K_3I_2$, $N_3K_1I_2$ $N_3K_1I_1$ and $N_3K_2I_1$ during 1980. In 1981 the treatment combination $N_3K_1I_1$ during 1980. In 1981 the treatment combination $N_3K_1I_2$ gave the longest shoot length (97.23 cm). However, this treatment did not differ from $N_3K_3I_2$ and $N_3K_2I_2$. During 1982 $N_3K_1I_2$ gave significantly the longest shoot growth (88.61 cm) than all other treatments except $N_3K_3I_2$ treatment combination. The shortest shoot growth (48.11, 54.90 and 53.19 cm) was recorded under treatment combination of $N_1K_1I_1$ in all the years of study.

TABLE : 9

Effect of Factorial Combination of Nitrogen, Potassium and Irrigation Regimes on Average Trunk Girth Increases in Santa Rosa Plum

Treatments	Average Trunk Girth Increase (cm)		
	1980	1981	1982
$N_1K_1I_1$	3.32	4.18	2.48
$N_1K_1I_2$	4.27	5.22	3.45
$N_2K_1I_1$	3.43	4.53	3.01
$N_2K_1I_2$	4.33	5.55	3.45
$N_3K_1I_1$	4.44	5.75	3.41
$N_3K_1I_2$	5.14	8.28	4.41
$N_1K_2I_1$	3.17	4.54	2.65
$N_1K_2I_2$	4.78	5.65	3.58
$N_2K_2I_1$	3.87	5.10	2.52
$N_2K_2I_2$	4.53	7.22	3.42
$N_3K_2I_1$	3.70	5.25	3.45
$N_3K_2I_2$	4.89	7.88	4.44
$N_1K_3I_1$	2.95	3.81	2.35
$N_1K_3I_2$	4.14	4.68	2.74
$N_2K_3I_1$	3.78	4.55	3.10
$N_2K_3I_2$	4.22	5.48	3.76
$N_3K_3I_1$	3.39	5.29	3.49
$N_3K_3I_2$	4.84	6.68	3.80
C.D. at 5% level	0.42	0.67	0.32

TABLE : 10

Effect of Factorial Combinations of Nitrogen, Potassium and Irrigation Regimes on the Average Shoot Growth in Santa Rosa plum

Treatments	Average Shoot Growth (cm)		
	1980	1981	1982
$N_1K_1I_1$	48.11	54.90	53.19
$N_1K_1I_2$	68.41	67.05	65.13
$N_2K_1I_1$	71.13	75.41	72.07
$N_2K_1I_2$	77.30	87.93	72.53
$N_3K_1I_1$	90.83	86.24	76.82
$N_3K_1I_2$	95.34	97.23	88.61
$N_1K_2I_1$	59.82	64.74	60.89
$N_1K_2I_2$	68.43	75.39	56.34
$N_2K_2I_1$	72.67	79.84	68.12
$N_2K_2I_2$	80.44	84.70	72.28
$N_3K_2I_1$	90.77	90.34	74.98
$N_3K_2I_2$	96.47	95.62	81.05
$N_1K_3I_1$	52.01	60.19	54.35
$N_1K_3I_2$	63.48	78.11	65.94
$N_2K_3I_1$	68.78	75.23	67.47
$N_2K_3I_2$	87.12	81.26	71.00
$N_3K_3I_1$	89.35	86.09	77.37
$N_3K_3I_2$	96.03	95.97	84.56
C.D. at 5% level	5.98	4.68	6.16

Pruning weight of the Trees

The data pertaining to this aspect was recorded in 1980, 1981 and 1982 (Table 11).

The data for 1981 and 1982 show that different N level differed significantly from each other. In 1980 the medium and high N level gave significantly more pruning weight than the trees under low N level. However, the medium and high N level did not differ significantly from each other with respect to prunings weight in 1980.

The K levels also differed significantly during 1980 and 1981. In 1980, 500 gms K_2O and 750 gms K_2O gave significantly more prunings weight as compared to the application of 250 gms K_2O

per tree. The medium and high K levels did not differ significantly from each other. During 1981, the medium K level gave significantly more prunings weight as compared to low or high K levels. However, low and high levels of K did not differ significantly from each other with respect to prunings weight. In 1982 K level did not differ significantly from each other although the medium K level gave the highest prunings weight.

The trees under 50 per cent moisture depletion point produced significantly more prunings weight than those under 75 per cent moisture depletion point in 1980, 1981 and 1982.

The first order interactions NI, KI were found to be non-significant in all the years of study. The NK was found to be significant in 1980 and 1982 but non-significant in 1981. The second order interaction NKI with respect to prunings weight was significant in 1981. In 1980 and 1982 it remained non-significant.

The treatment combinations were found to be significant in all the years of study. In 1980, $N_3K_3I_2$ gave the highest prunings weight (2.87 kg per tree) which was significantly superior to all other treatment combinations except $N_3K_2I_2$. In 1981, $N_3K_2I_3$ produced the highest prunings weight (5.89 kg per tree). During 1982 the treatment combinations $N_3K_2I_1$ produced the highest prunings weight (3.57 kg per tree) and gave significantly more prunings weight as compared to rest of the treatment combinations except $N_3K_2I_2$ and $N_3K_3I_2$. The last prunings weight 1.14, 2.52 and 1.81 kg per tree was recorded in treatment combinations of $N_1K_2I_2$, $N_1K_3I_1$ and $N_1K_2I_1$ in 1980, 1981 and 1982, respectively.

TABLE : 11

Effect of Factorial Combinations of Nitrogen, Potassium and Irrigation on Prunings Weight in Santa Rosa Plum

Treatments	Average Pruning Weight (kg/tree)		
	1980	1981	1982
$N_1K_1I_1$	1.22	3.34	2.01
$N_1K_1I_2$	1.54	3.65	2.86
$N_2K_1I_1$	1.72	3.42	2.41
$N_2K_1I_2$	1.82	5.47	2.70

$N_3K_1I_1$	1.94	4.67	2.67
$N_3K_1I_2$	2.05	5.27	2.82
$N_1K_2I_1$	1.36	4.19	1.81
$N_1K_2I_2$	1.14	4.47	1.92
$N_2K_2I_1$	2.32	4.81	2.25
$N_2K_2I_2$	2.29	5.27	2.82
$N_3K_2I_1$	2.09	5.57	3.57
$N_3K_2I_2$	2.46	5.81	3.47
$N_1K_3I_1$	1.19	2.52	2.05
$N_1K_3I_2$	1.15	4.59	2.09
$N_2K_3I_1$	2.08	4.80	2.42
$N_2K_3I_2$	2.25	4.49	2.69
$N_3K_3I_1$	2.15	5.17	2.97
$N_3K_2I_2$	2.87	5.89	3.29
C.D. at 5% level	0.45	0.75	0.58

Per cent Fruit Set

The data with respect to the fruit set are presented in Table 12.

TABLE : 12

Effect of Factorial Combinations of Nitrogen, Potassium and Irrigation Regimes on the Percentage of Fruit Set in Santa Rosa Plum

Treatments	Average Percentage of Fruit Set		
	1980	1981	1982
$N_1K_1I_1$	10.66	9.63	11.73
$N_1K_1I_2$	13.00	16.58	12.87
$N_2K_1I_1$	18.14	18.59	13.19
$N_2K_1I_2$	11.42	10.39	12.06
$N_3K_1I_1$	10.23	16.19	11.94
$N_3K_1I_2$	15.31	18.32	12.27
$N_1K_2I_1$	15.13	11.40	11.77
$N_1K_2I_2$	13.22	20.46	12.51

(Contd.)

(Contd.)

Treatments	Average Percentage of Fruit Set		
	1980	1981	1982
$N_2K_2I_1$	20.58	20.09	13.44
$N_2K_2I_2$	13.07	11.19	11.90
$N_3K_2I_1$	14.18	14.92	14.02
$N_3K_2I_2$	18.50	21.71	13.49
$N_1K_3I_1$	13.71	14.42	12.50
$N_1K_3I_2$	16.77	18.50	12.86
$N_2K_3I_1$	21.95	22.94	14.40
$N_2K_3I_2$	19.26	10.39	11.04
$N_3K_3I_1$	19.61	20.41	11.44
$N_3K_3I_2$	19.71	22.82	12.14
C.D. at 5% level	4.04	6.21	0.75

The differences in per cent fruit set in the trees receiving different N levels were significant. During 1980, medium and high N levels gave significantly more fruit set than low level of N. The medium and high N level did not differ significantly from each other. In 1981, the high N level gave significantly more per cent fruit set as compared to low and medium N levels. However, the low and medium levels did not differ significantly from each other as far as the fruit set was concerned. In 1982, the different N levels did not differ significantly from each other. However, the medium level of N produced more per cent fruit set as compared to low and high levels of N.

The K levels differed significantly among each other in respect of fruit set in all the years of study. In 1980, the high K level gave significantly more fruit set as compared to low K level. The high and medium K levels did not differ significantly from each other although both the levels gave significantly more fruit set as compared to low level of this element during 1981. In 1982, the medium K level gave significantly more fruit set as compared to low and high K levels. However, the low and high K levels did not differ significantly with each other in this respect.

The trees under 75 per cent moisture depletion point produced significantly more per cent fruit set as compared to 50 per cent moisture depletion point in 1982. The two irrigation levels were found to be non-significant during 1980 and 1981. However, 75 per cent moisture depletion point produced more per cent fruit set in these years.

The first order interactions NK, KI were not significant in 1980 and 1981. But NI was significant in these years. In 1982 NK and KI were significant but NI was not significant. The second order interaction NKI was significant in 1980 and 1982 but not significant in 1981.

The treatment combination's effects were found to be significant in all the years of study. The treatment combination $N_2K_3I_1$ gave the highest (21.95, 22.94 and 14.40 per cent) fruit set in 1980, 1981 and 1982, respectively. The lowest fruit set (10.23, 9.63 and 11.04 per cent) were recorded in $N_3K_1I_1$, $N_1K_1I_1$ and $N_2K_3I_2$ treatment combinations in 1980, 1981 and 1982, respectively.

Yield

The data on the effect of different levels of N, K and irrigation on the yield of Santa Rosa plum are presented in Table 13.

TABLE : 13

Effect of Factorial Combination of Nitrogen, Potassium and Irrigation Regimes on the Average Yield in Santa Rosa Plum

Treatments	Average Yield in Kg.		
	1980	1981	1982
$N_1K_1I_1$	42.88	10.71	11.95
$N_1K_1I_2$	44.58	10.67	13.90
$N_2K_1I_1$	45.18	10.86	12.55
$N_2K_1I_2$	43.21	11.33	13.51
$N_3K_1I_1$	44.47	10.75	12.33
$N_3K_1I_2$	47.84	10.88	12.47
$N_1K_2I_1$	43.91	10.87	12.13
$N_1K_2I_2$	44.98	11.08	12.18
$N_2K_2I_1$	47.47	11.45	14.48

(Contd.)

(Contd.)

Treatments	Average Yield in Kg.		
	1980	1981	1982
$N_2K_2I_2$	46.38	12.43	15.09
$N_3K_2I_1$	48.75	10.60	12.80
$N_3K_2I_2$	50.91	11.23	13.38
$N_1K_3I_1$	45.41	10.80	13.24
$N_1K_3I_2$	45.20	10.93	13.25
$N_2K_3I_1$	46.72	10.94	13.33
$N_2K_3I_2$	45.10	11.20	13.45
$N_3K_3I_1$	46.55	11.37	13.46
$N_3K_3I_2$	48.58	11.68	13.49
C.D. at 5% level	3.12	N.S.	1.61

The data for 1980 show that the trees under high level of N gave significantly greater yield as compared with low and medium N levels. However, there was no significant difference in yield between low and medium levels of N. With the increase in N dose there was an increase in yield of plum. In 1981 and 1982 the medium level of N (500 gm N per tree) gave significantly more yield than 250 gm N per tree. The high level of N (750 gm per tree) did not differ significantly from medium level of N in these years.

With respect to yield per tree, the different K levels differed significantly from each other in 1980. Whereas in 1981 and 1982 the K levels did not differ significantly in this respect. In 1980, the medium K level produced significantly more yield as compared to low level of this element. However, the medium and high levels of K did not differ significantly. During 1981 and 1982 also, the medium K level gave the highest yield per tree.

The trees under two levels of irrigation did not differ significantly during 1980 and 1982. However, the irrigation at 50 per cent moisture depletion point of irrigation produced more yield as compared to irrigation given at 75 per cent moisture depletion point. In 1981 high moisture level gave significantly more yield as compared to low moisture level.

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