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Department of Horticulture, Punjab Agricultural University, Ludhiana , India

# Effect of plant density on vine growth, yield, fruit quality and nutrient status in Perlette grapevines

by

S. S. BRAR and A. S. BINDRA

## Der Einfluß der Standweite auf vegetatives Wachstum, Traubenertrag, Beerenqualität und Ernährungszustand der Rebsorte Perlette

Zusammenfassung: In den Jahren 1980, 1981 und 1982 wurden in Ludhiana (Punjab) Untersuchungen über den Einfluß der Standweite auf das vegetative Wachstum, den Ernährungszustand sowie auf Traubenertrag und -qualität der Rebsorte Perlette durchgeführt. Das Rebenwachstum (Trieblänge, Stammumfang, Gewicht des Schnittholzes) sowie der Gehalt der mineralischen Nährstoffe (N, P, K, Fe, Mn, Zn) und der Kohlenhydrate waren bei der maximalen Standweite (3,0 × 3,0 m) am stärksten gefördert; sie nahmen mit zunehmender Pflanzdichte der Reben ab. Die meisten Nährstoffe zeigten zu Frühjahrsbeginn oder in der Regenzeit Konzentrationsmaxima. Die höchsten Durchschnittserträge je Rebe wurden bei der Standweite 3,0 × 3,0 m, je ha bei 2,0 × 2,0 m erzielt. Die verschiedenen Qualitätsmerkmale der Beeren wurden durch die Pflanzweite nicht signifikant beeinflußt. Unter den agroklimatischen Bedingungen des nordindischen Anbaugebietes liefert die Sorte Perlette in Kopferziehung bei einer Standweite von 2,0 × 2,0 m optimale Erträge.

Key words: spacing, shoot, growth, yield, must quality, mineral, carbohydrate, climate, India.

## Introduction

The total area under grapes in India is about 10,000 ha, mainly situated in south India. In the plains of north-west India the total area is about 1,250 ha. Perlette is the most important commercial cultivar of this region occupying over 80 % of the total acreage. It is an early ripening, prolific bearer having yellowish white seedless berries, medium sized bunches, good keeping quality with a sugar content of 16—18 %.

Little attention has been given towards vine spacing which is an important variable in vine growth and production. Plant density requirements can be affected by various factors such as training system, vegetative growth and bearing habit of a cultivar under the local agro-climatic conditions. In some grape growing countries of Europe, vines are allotted as little as 1 $m^2$ each. Conversely, in some vineyards of California as much as 15 $m^2$/vine are available (WIEBE and BRADT 1973).

The physiological situation of the grapevines growing in the plains of north India is unique. It is different from that of the vines growing in south India or in a temperate climate. In the former region, minimum temperature from mid-December to mid-January can be as low as 0 °C. While from 15th May to the end of June maximum temperature often hovers around 43 °C and may even reach 47 °C. Around 1st July both the minimum and maximum temperatures fall by about 10 °C on arrival of monsoon. 80 % of the rainfall is during the next 45 d i. e. until 15th September. There are some cyclonic showers in December—January and May—June. During these latter 2 months, hot dry winds and dust storms engulf this region, similar as Harmatan in southwest Africa.

In north India, bud burst of grapevines takes place in the 4th week of February and full bloom is around 1st of April. Sometimes, fruit set, flower bud differentiation as well as profuse vegetative growth occur together in April. Under other agro-climatic conditions harvesting is followed by dormancy, but in the Punjab harvesting in June is succeeded by a peak in shoot growth activity during July and August which is more pronounced than the early summer growth. The vines enter into dormancy in October. Pruning is between 15th January to 15th February.

The objective of the present investigation was to study the effect of plant density on vine growth, yield, fruit quality and nutrient status of Perlette grapevines under the conditions mentioned above.

## Materials and methods

The experiments were conducted in the Department of Horticulture of the Punjab Agricultural University, Ludhiana, during 1980, 1981 and 1982. 7-year-old vines of Perlette held by bamboo stakes were trained to a head trunk carrying 3—5 short arms. All the healthy canes having a diameter of 0.4 cm and more were pruned back to 3—4 buds (pruning to vigour). No bunch thinning or trimming was done. The spacing distances tried were 3.0 × 3.0 m, 3.0 × 2.5 m, 3.0 × 2.0 m, 2.5 × 2.0 m, 2.0 × 2.0 m and 1.5 × 2.0 m. The experiment was laid out in a Randomized Block Design and was replicated four times.

The physico-chemical characteristics of the upper 30 cm of soil were as follows: Texture: sandy loam; colour: light brown; organic matter: 0.25 %; nitrogen (available): 104 kg/ha; phosphorus (available): 17.4 kg/ha; potassium (available): 120.0 kg/ha; soil pH 8.1.

### Experimental details

Observations were made on vine growth, seasonal variations in the nutrient status, biochemical constituents of the canes and yield and quality of grapes.

Table 1

Effect of various spacings (m) on vine vigour (cv. Perlette)

Einfluß verschiedener Standweiten (m) auf die Wüchsigkeit der Rebsorte Perlette

| | Year | 3.0 x 3.0 | 3.0 x 2.5 | 3.0 x 2.0 | 2.5 x 2.0 | 2.0 x 2.0 | 1.5 x 2.0 | LSD at 5 % | Regression coefficient |
|---|---|---|---|---|---|---|---|---|---|
| Trunk girth | 1980 | 4.8 | 4.7 | 4.2 | 4.3 | 4.2 | 4.1 | 0.26 | 0.122 ± 0.025* |
| (cm) | 1981 | 5.3 | 5.1 | 4.6 | 4.5 | 4.5 | 4.4 | 0.28 | 0.159 ± 0.026* |
| | 1982 | 5.8 | 5.6 | 4.8 | 4.7 | 4.6 | 4.5 | 0.60 | 0.237 ± 0.038* |
| | Mean | 5.3 | 5.1 | 4.5 | 4.5 | 4.4 | 4.3 | | |
| Pruning weight | 1980 | 425 | 429 | 399 | 332 | 319 | 294 | 109 | 24.764 ± 4.292* |
| (g) | 1981 | 326 | 316 | 281 | 261 | 241 | 273 | 55 | 12.643 ± 3.634* |
| | 1982 | 512 | 480 | 443 | 399 | 365 | 298 | 71 | 34.462 ± 3.631* |
| | Mean | 421 | 408 | 374 | 331 | 308 | 288 | | |

* = Significant at P = 5 %.

Pruning weight and trunk girth of all the experimental vines were recorded every year during January at the time of pruning. Data on shoot growth were recorded from March to September at 15 d intervals.

For studying the food reserves in canes, the samples collected during January were subjected to analysis for starch, reducing and non-reducing sugars (A.O.A.C. 1980). For determination of the mineral nutrient status of grapevines under various spacings, petiole samples were collected from March till September at monthly intervals. N, P and K were determined by usual analytical methods, while the micronutrients were analysed by atomic absorption spectrometry. To study the effect of various spacings on yield and quality, data on bunch weight, berry weight, total soluble solids and acidity were recorded using conventional methods.

## Results and discussion

### 1. Vine growth

Spacing had positive and significant effects on trunk girth and pruning weight, as is evident from the regression coefficients (Table 1). The vines planted at widest spacing (3.0 × 3.0 m) exhibited 4.8, 5.3 and 5.8 cm trunk girth during 1980, 1981 and 1982, respectively. Vine growth at 3.0 × 3.0 m and 3.0 × 2.5 m spacing was on par with each other and significantly higher than found for the remaining plant densities in the respective years of study. The pruning weight followed the same trend as trunk girth.

Table 2

Regression coefficients of shoot growth versus spacing at various dates

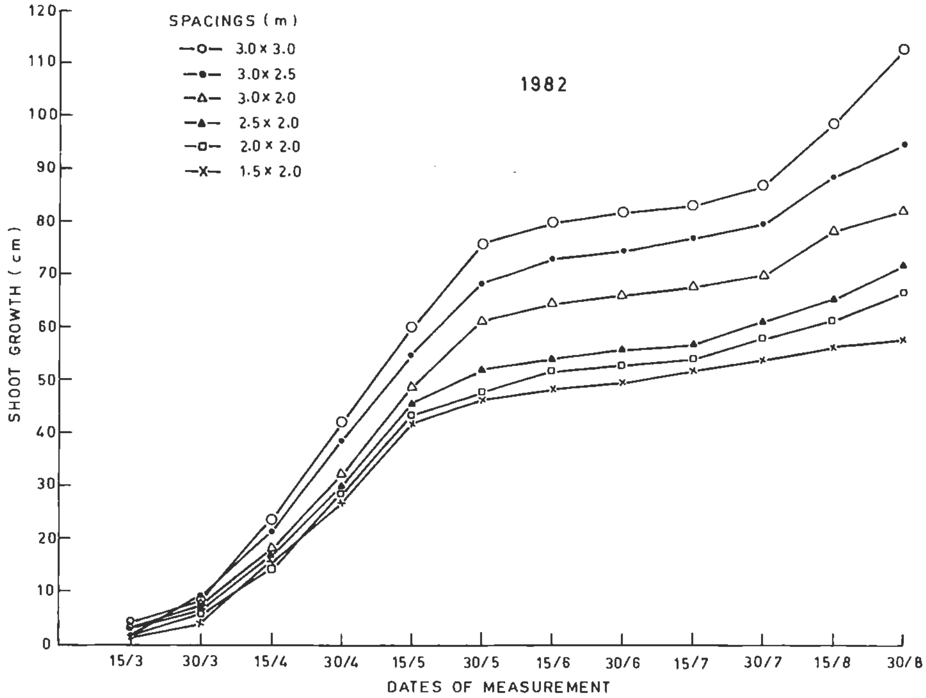
Regressionskoeffizienten „Triebwachstum/Standweite" für verschiedene Termine

| Dates | 1981 | 1982 |
|---|---|---|
| 15/3 | 0.583 ± 0.125* | 0.352 ± 0.156 NS |
| 30/3 | 1.749 ± 0.230* | 0.774 ± 0.162* |
| 15/4 | 3.598 ± 0.484* | 1.397 ± 0.223* |
| 30/4 | 4.382 ± 0.353* | 2.553 ± 0.244* |
| 15/5 | 5.829 ± 0.635* | 3.146 ± 0.217* |
| 30/5 | 5.960 ± 0.448* | 5.256 ± 0.444* |
| 15/6 | 6.302 ± 0.509* | 5.648 ± 0.453* |
| 30/6 | 6.653 ± 0.428* | 5.709 ± 0.434* |
| 15/7 | 6.915 ± 0.549* | 5.678 ± 0.538* |
| 30/7 | 8.884 ± 0.720* | 5.809 ± 0.374* |
| 15/8 | 9.317 ± 0.775* | 7.407 ± 0.492* |
| 30/8 | 8.935 ± 0.648* | 8.191 ± 0.316* |

* = Significant at P = 5%.
NS = Not significant.

Fig. 1: Shoot growth under various spacings in the grapevine cv. Perlette during 1981 and 1982.

Das Triebwachstum der Rebsorte Perlette bei verschiedener Standweite (1981 und 1982)


SPACINGS ( m )
3.0 × 3.0
3.0 × 2.5
3.0 × 2.0
2.5 × 2.0
2.0 × 2.0
1.5 × 2.0
1982
SHOOT GROWTH ( cm )
0
10
20
30
40
50
60
70
80
90
100
110
120
15/3
30/3
15/4
30/4
15/5
30/5
15/6
30/6
15/7
30/7
15/8
30/8
DATES OF MEASUREMENT

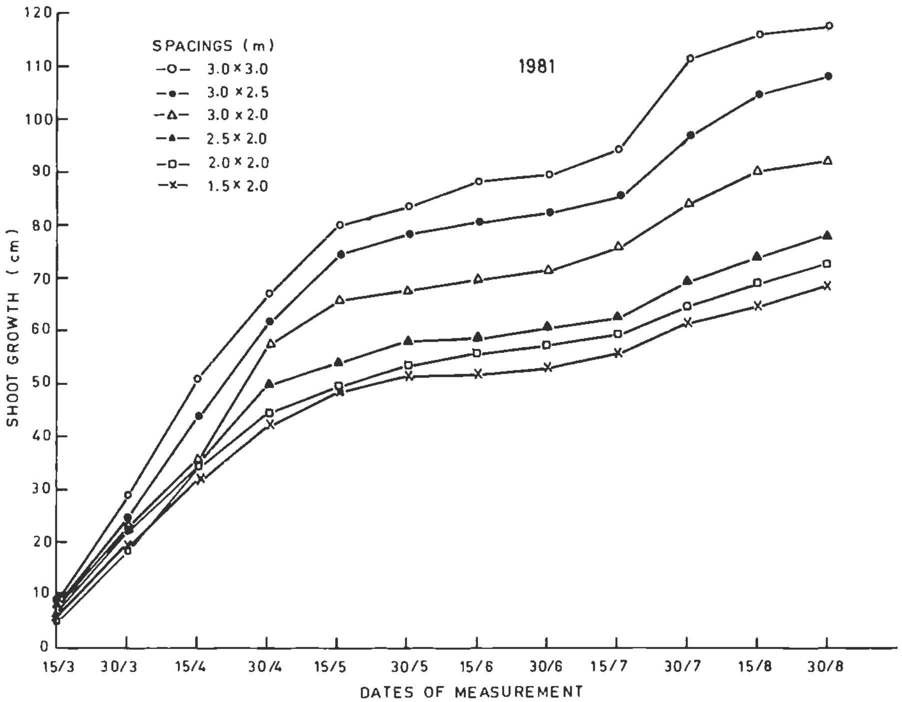

SPACINGS ( m )
3.0 × 3.0
3.0 × 2.5
3.0 × 2.0
2.5 × 2.0
2.0 × 2.0
1.5 × 2.0
1981
SHOOT GROWTH ( cm )
0
10
20
30
40
50
60
70
80
90
100
110
120
15/3
30/3
15/4
30/4
15/5
30/5
15/6
30/6
15/7
30/7
15/8
30/8
DATES OF MEASUREMENT

Table 3

Regression coefficients of nutrients versus spacing during different months

Regressionskoeffizienten „Mineralstoffe/Standweite" in verschiedenen Monaten

| Months | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 |
|---|---|---|---|---|---|---|
| | Nitrogen | | Phosphorus | | Potassium | |
| March | 0.079 ± 0.013* | 0.043 ± 0.007* | 0.016 ± 0.004* | 0.017 ± 0.003* | 0.021 ± 0.003* | 0.047 ± 0.014* |
| April | 0.076 ± 0.011* | 0.038 ± 0.009* | 0.017 ± 0.003* | 0.016 ± 0.003* | 0.018 ± 0.003* | 0.045 ± 0.012* |
| May | 0.067 ± 0.006* | 0.017 ± 0.003* | 0.016 ± 0.002* | 0.033 ± 0.004* | 0.019 ± 0.005* | 0.045 ± 0.011* |
| June | 0.050 ± 0.006* | 0.010 ± 0.006 NS | 0.014 ± 0.002* | 0.028 ± 0.004* | 0.022 ± 0.003* | 0.051 ± 0.001* |
| July | 0.055 ± 0.010* | 0.011 ± 0.007 NS | 0.018 ± 0.003* | 0.027 ± 0.006* | 0.031 ± 0.002* | 0.059 ± 0.012* |
| August | 0.056 ± 0.012* | 0.012 ± 0.007 NS | 0.014 ± 0.002* | 0.012 ± 0.003* | 0.033 ± 0.005* | 0.060 ± 0.010* |
| September | 0.061 ± 0.008* | 0.013 ± 0.005 NS | 0.016 ± 0.002* | 0.026 ± 0.003* | 0.033 ± 0.007* | 0.016 ± 0.012* |
| | Iron | | Zinc | | Manganese | |
| March | 0.271 ± 0.987 NS | 2.305 ± 1.199 NS | 1.206 ± 0.809 NS | 0.305 ± 0.785 NS | 1.688 ± 0.254* | 1.950 ± 0.324* |
| April | 2.141 ± 0.820 NS | 2.764 ± 1.111 NS | 1.266 ± 0.923 NS | –0.070 ± 0.773 NS | 1.423 ± 0.116* | 2.734 ± 0.506* |
| May | 2.010 ± 0.544* | 2.684 ± 1.106 NS | 1.638 ± 0.815 NS | 1.156 ± 0.276* | 1.337 ± 0.175* | 1.789 ± 0.313* |
| June | 2.231 ± 0.720* | 2.442 ± 0.740* | 1.769 ± 1.068 NS | 2.432 ± 0.435* | 2.502 ± 0.545* | 2.693 ± 0.452* |
| July | 1.850 ± 0.387 | 2.714 ± 0.377* | 0.884 ± 0.918 NS | 0.824 ± 0.841 NS | 2.543 ± 0.623* | 2.281 ± 0.487* |
| August | 2.332 ± 0.492* | 1.930 ± 0.768* | 0.975 ± 0.745 NS | –0.090 ± 0.944 NS | 1.136 ± 0.185* | 2.462 ± 0.375* |
| September | 2.332 ± 0.490* | 1.146 ± 0.765 NS | 2.070 ± 0.328* | 1.015 ± 1.041 NS | 1.206 ± 0.268* | 1.990 ± 0.298* |

* = Significant at P = 5%.
NS = Not significant.

The regression of shoot growth versus spacing was significant in all cases except for the first date of observation in 1982 (Table 2). The differences in shoot growth increased as growth advanced with the season (Fig. 1).

The differences of vine growth depending on spacing could be due to the availability of water and nutrients which in turn influenced the biological productivity and yield per vine (ATANASOR 1983). However, under local conditions the role of radiant energy in affecting this parameter is uncertain. Fig. 1 also shows that the vines underwent a partial check in shoot growth as the berries entered into their rapid growth stage. The cessation of shoot growth during June was probably due to the rise in air temperature (45 °C or more) and a markedly low relative humidity (25 % or less) which resulted in excessive transpiration, closure of stomata and enzymatic inactivation. About 3 weeks after the harvest, the monsoon season starts. As a consequence of temperature fall and increase of soil and atmospheric moisture, there was a revival of shoot growth which continued until the last dates of observation during both the years. In 1981, rapid shoot growth started right from 15th March, while in the next year, on

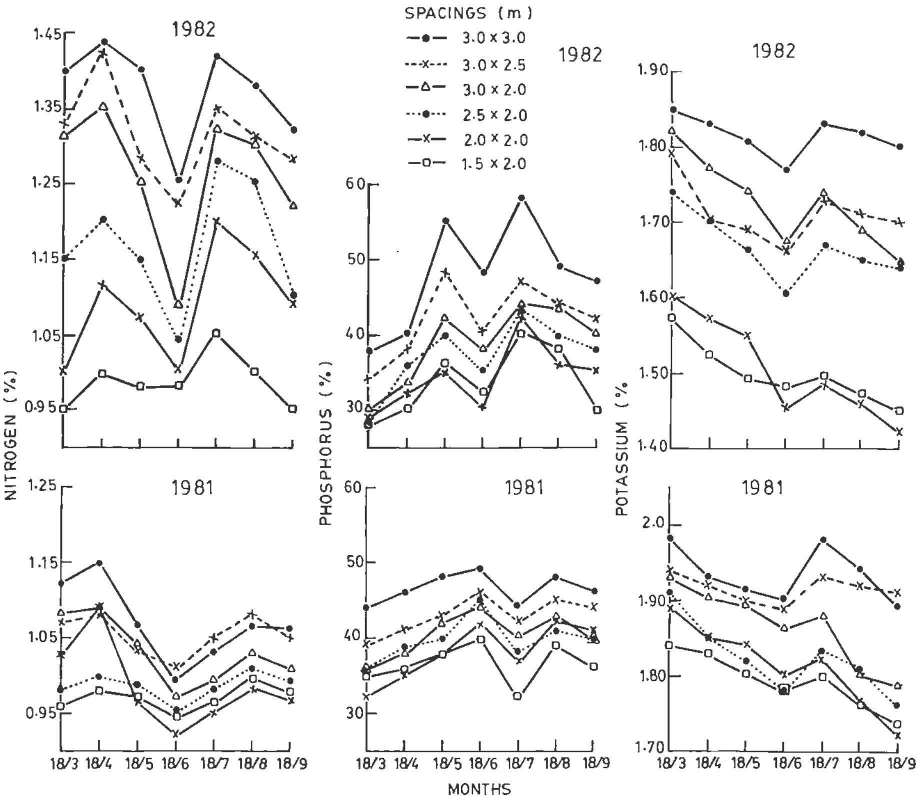



Fig. 2: Nitrogen, phosphorus and potassium contents of grapevine petioles cv. Perlette under various spacings

Stickstoff-, Phosphor- und Kaliumgehalt in den Blattstielen der Rebsorte Perlette bei verschiedener Standweite.

this date, growth activity was low, probably resulting from the relatively low temperatures prevailing in the spring of 1982.

## 2. Mineral nutrient status

The nitrogen content of the petioles increased with wider spacing on all the dates of sampling during both the years and the regression coefficients were generally significant (Table 3). Over the growing seasons, the level of nitrogen was high during March—April (Fig. 2). It showed a sharp decline till June and thereafter it continued to increase towards September. During 1982 the level of nitrogen was higher in all the spacings and sampling dates but it followed a trend similar to that of 1981. The lower level of nitrogen during May—June may be due to adverse climatic conditions, i. e. high temperature and low relative humidity. Rapid utilization of nitrogen by the young developing fruits could also be a contributing factor of grapevines (GOSEN 1963).

Like nitrogen, the levels of phosphorus and potassium were also higher in wider spacing (Fig. 2), and the regression coefficients were significant (Table 3). During 1981, the phosphorus level of the vines planted at different distances increased from March

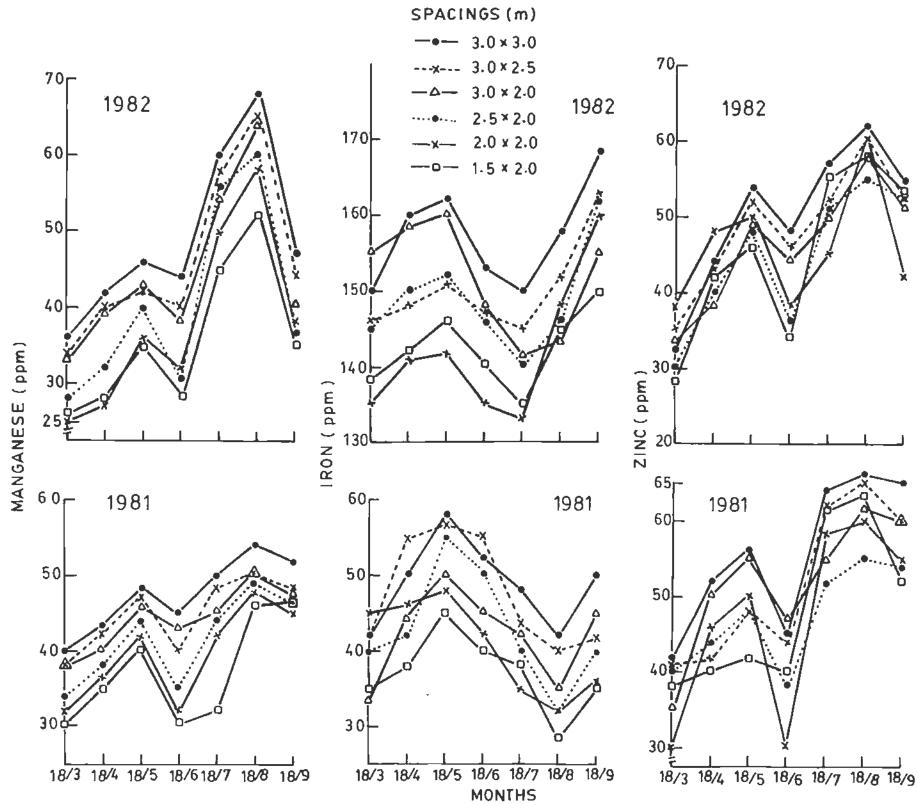



Fig. 3: Manganese, iron and zinc contents of grapevine petioles cv. Perlette under various spacings.

Mangan-, Eisen- und Zinkgehalt in den Blattstielen der Rebsorte Perlette bei verschiedener Standweite.

to June, it decreased in July and again increased in August and September. During 1982, the vines had lower levels of phosphorus as compared to 1981 with maximum values in July. Potassium was high in March and July during both the years.

The iron and manganese contents of the petioles also increased with spacing, the regression coefficients generally being significant (Fig. 3 and Table 3). The zinc content, however, did not show any significant dependence on spacing during both the years. During 1982, negative coefficients of regression were observed on two dates viz. April and July. During both the years these micro-nutrients were either high in early spring or in late summer. The results are in general correspondence with our earlier studies (BINDRA *et al.* 1979).

The level of practically all the nutrient elements tended to rise in direct proportion to the increase in space allotted per vine. Nutrient availability per vine was comparatively more or less depending upon the spacings. The increase of vine growth even with maximum spacing points out the possibility that the nutrient elements were the limiting factors. Lesser availability of nutrients led to smaller growth of roots (MORLOT *et al.* 1983), which in turn absorbed a lesser amount of nutrients.

During July and August, there was an increase in mineral absorption which coincided with the advent of the rainy season. This was probably due to high soil moisture facilitating availability of nutrients, atmospheric temperature (25—35 °C) and high relative humidity (about 80 %). Finally, the availability of photosynthates for new growth, as harvest was already over, could also be of importance. The differences in peaks in the two years of study as well as the absolute levels of the various nutrients may be due to variation of the environmental conditions.

The levels of nitrogen and other elements manifested by the grapevine petioles under north Indian conditions are considerably different from those of vines growing in temperate regions. In view of earlier work conducted under our conditions (BINDRA *et al.* 1980), they seem to be adequate for growth and productivity.

Table 4

Carbohydrate contents (%) of canes under various spacings (m)

Kohlenhydratgehalt der Tragruten (%) bei verschiedener Standweite (m)

| | Year | 3.0 x 3.0 | 3.0 x 2.5 | 3.0 x 2.0 | 2.5 x 2.0 | 2.0 x 2.0 | 1.5 x 2.0 | L.S.D. at 5% |
|---|---|---|---|---|---|---|---|---|
| Total carbohydrates | 1981 | 17.1 | 16.2 | 15.8 | 16.1 | 15.6 | 14.7 | NS |
| | 1982 | 18.1 | 18.5 | 16.8 | 16.8 | 16.1 | 16.2 | NS |
| Starch | 1981 | 14.2 | 13.3 | 12.5 | 13.2 | 12.7 | 11.9 | NS |
| | 1982 | 13.8 | 13.8 | 12.6 | 12.6 | 12.3 | 12.0 | NS |
| Reducing sugars | 1981 | 2.3 | 2.3 | 2.5 | 2.3 | 2.3 | 2.2 | NS |
| | 1982 | 3.8 | 4.3 | 3.5 | 3.5 | 3.1 | 3.6 | NS |
| Non-reducing sugars | 1981 | 0.6 | 0.6 | 0.8 | 0.6 | 0.6 | 0.6 | NS |
| | 1982 | 0.5 | 0.4 | 0.7 | 0.7 | 0.6 | 0.6 | NS |

NS = Not significant.

### 3. Carbohydrate status

Spacing had no significant effect on the contents of starch and sugars in the canes, though the vines planted at 3.0 × 3.0 m spacing had a higher level of carbohydrates and it was lowest at 1.5 × 2.0 m (Table 4). For the various other spacings it was more or less the same. During 1982, the levels of carbohydrates were higher as compared to those of 1981, but the trends were similar.

### 4. Yield and fruit quality

There were significant differences in the yield per vine under various spacings (Table 5). But the mean yield of 3 years, although higher for widely spaced vines and lower for those planted closer, indicated that 2.0 × 2.0 m spacing gave the highest yield on a per area unit basis. However, during different years the highest yield per ha was obtained with 3.0 × 2.0 m in 1980 (2.13 t) and 2.0 × 2.0 m spacing in 1981 (3.62 t) and in 1982 (4.98 t). The bunch weight was highest either at 3.0 × 3.0 m or 3.0 × 2.0 m spacing but it was lowest at 1.5 × 2.0 m. The mean berry weight was highest (1.46 g) at 3.0 × 2.0 m and 2.5 × 2.0 m and it was lowest (1.40 g) at the 1.5 × 2.0 m spacing.

There were no significant differences for the components of fruit quality, total soluble solids and acidity (Table 6). However, the total soluble solids : acid ratio was observed to have significant differences during 1980 and 1982.

Table 5

Effect of various spacings (m) on bearing of the grapevine cv. Perlette

Einfluß verschiedener Standweiten (m) auf die Ertragsdaten der Rebsorte Perlette

| | Year | 3.0 x 3.0 | 3.0 x 2.5 | 3.0 x 2.0 | 2.5 x 2.0 | 2.0 x 2.0 | 1.5 x 2.0 | L.S.D. at 5% |
|---|---|---|---|---|---|---|---|---|
| Yield/ha (t) | 1980 | 1.57 | 1.65 | 2.13 | 1.88 | 1.70 | 2.11 | 0.33 |
| | 1981 | 2.18 | 2.16 | 2.98 | 3.16 | 3.62 | 3.25 | 0.29 |
| | 1982 | 2.86 | 2.89 | 3.06 | 3.90 | 4.98 | 4.34 | 0.27 |
| | Mean | 2.20 | 2.23 | 2.72 | 2.98 | 3.43 | 3.23 | |
| Yield/vine (kg) | 1980 | 1.45 | 1.32 | 1.35 | 0.94 | 0.68 | 0.65 | 0.09 |
| | 1981 | 2.17 | 1.73 | 1.86 | 1.58 | 1.45 | 1.00 | 0.46 |
| | 1982 | 2.65 | 2.31 | 2.08 | 1.93 | 1.79 | 1.07 | 0.28 |
| | Mean | 2.09 | 1.78 | 1.76 | 1.48 | 1.31 | 0.91 | |
| Bunch weight (g) | 1980 | 190 | 191 | 207 | 162 | 169 | 150 | 14.0 |
| | 1981 | 197 | 192 | 193 | 185 | 181 | 183 | NS |
| | 1982 | 230 | 225 | 195 | 190 | 180 | 165 | 27.0 |
| | Mean | 206 | 203 | 198 | 179 | 177 | 166 | |
| Berry weight (g) | 1980 | 1.44 | 1.50 | 1.45 | 1.42 | 1.39 | 1.40 | 0.08 |
| | 1981 | 1.39 | 1.43 | 1.52 | 1.46 | 1.48 | 1.47 | 0.06 |
| | 1982 | 1.42 | 1.40 | 1.42 | 1.45 | 1.38 | 1.37 | 0.05 |
| | Mean | 1.42 | 1.44 | 1.46 | 1.44 | 1.42 | 1.41 | |

NS = Not significat.

Table 6

Effect of various spacings (m) on quality of the grapevine cv. Perlette

Der Einfluß der Standweiten (m) auf die Qualitätsmerkmale der Rebsorte Perlette

| | Year | 3.0 x 3.0 | 3.0 x 2.5 | 3.0 x 2.0 | 2.5 x 2.0 | 2.0 x 2.0 | 1.5 x 2.0 | L.S.D. at 5% |
|---|---|---|---|---|---|---|---|---|
| TSS (%) | 1980 | 14.8 | 15.2 | 13.8 | 16.0 | 15.0 | 14.8 | NS |
| | 1981 | 16.6 | 15.0 | 15.2 | 16.4 | 16.0 | 15.0 | NS |
| | 1982 | 16.2 | 16.1 | 15.8 | 15.7 | 16.0 | 14.6 | NS |
| | Mean | 15.9 | 15.4 | 14.9 | 16.0 | 15.7 | 14.8 | |
| Acidity (%) | 1980 | 0.64 | 0.58 | 0.64 | 0.55 | 0.60 | 0.57 | NS |
| | 1981 | 0.59 | 0.53 | 0.60 | 0.58 | 0.63 | 0.62 | NS |
| | 1982 | 0.59 | 0.63 | 0.64 | 0.63 | 0.66 | 0.70 | NS |
| | Mean | 0.61 | 0.59 | 0.63 | 0.59 | 0.63 | 0.63 | |
| TSS/acid ratio | 1980 | 23.1 | 26.2 | 21.6 | 29.1 | 25.1 | 25.9 | 3.2 |
| | 1981 | 28.1 | 26.8 | 25.3 | 28.3 | 25.4 | 24.2 | NS |
| | 1982 | 27.4 | 25.6 | 24.7 | 24.9 | 24.2 | 20.9 | 2.6 |
| | Mean | 26.2 | 26.2 | 23.9 | 27.4 | 24.9 | 23.7 | |

NS = Not significant.

The lower bearing of vines with most narrow spacing (1.5 × 2.0 m) may be due to population pressure affecting plant performance. As plant number per area unit increases, a point is reached at which each plant begins to compete for growth factors like nutrients and water. The effect of increasing competition is similar to decreasing the supply of growth factors. At lower spacings, although there seems to be some competition to affect the growth of individual vine, the vineyard performance improved due to decreased spacing. WIEBE and BRADT (1973) also found that where little inter-plant interference occurred closer spacing was effective in increasing the yield of a vineyard.

## Summary

Studies on the effect of plant density on vine growth, nutrient status, yield and quality of the grape cv. Perlette were carried out during 1980, 1981 and 1982. Vine growth measured in terms of shoot length, trunk girth and pruning weight as well as the level of the nutrient elements N, P, K, Fe, Mn, Zn and carbohydrates were highest at the maximum spacing i. e. 3.0 × 3.0 m and decreased with an increase in the plant density. Most of the nutrients were high either in early spring or during the rainy season. The average yields per vine and per ha were highest at 3.0 × 3.0 m and 2.0 × 2.0 m spacing, respectively. No significant differences were observed in the various quality parameters of the fruit under various plant densities. Under the prevailing agro-climatic conditions optimum yield per ha of Perlette grapes trained on head system can be obtained by planting the vines at 2.0 × 2.0 m spacing.

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Dr. A. S. BINDRA
Department of Horticulture
Punjab Agricultural University
Ludhiana — 141 004
India