Potassium Nutrition of Grapes

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Introduction

India need 92 million tonnes of fruits to feed balanced nutrition to its 1000 million population. Although the country has achieved fairly good production level of fruits, however, the present production of 43 million tonnes which is 8.6 per cent of the world production, supplies only 46% of the need of the country. Nutrient removal by fruits and its use efficiency indicate mining of nutrients from soil (Patil *et al*., 2001; Hegde and Babu, 2001). The nutrient use efficiency of N ranged from 20 to 40%, P from 5 to 20% and K from 50 to 100%, depending on the variety, growth rate and production potential.

Judicious use of nutrients envisages saving on natural resources for future use and protecting soil, water and air from pollution. Modern nutrient management strategy has shifted its focus towards the concept of practical sustainability with the components of eco-friendly approach to growers and to the crops.

Perennial fruit crops are heavy feeders of plant nutrients and a number of crops remove nearly 500 to 1500 kg of N + P_2O_5 + K_2O per hectare annually. Nutrient application is necessary to obtain high yield and good quality produce. Quantum of nutrient needed for fruit crops based on manurial schedule works out to 2.26 million tonnes of N, P_2O_5 and K_2O every year in the ratio of 0.74 : 0.51 : 1.00, compared to 18.4 million tones nutrients used for all the crops at the rate of 96 kg ha^{-1} in ratio of 7.9 : 2.8 : 1.0.

Research work and nutritional survey conducted by the scientists of Indian Institute of Horticultural research, Bangalore have shown that the pollution to soil and water in the vineyards of peninsular India on account of heavy fertilization (Bhargava and Chadha, 1993) is enormous, whereas crops like mango and guava receive nutrients rarely (Bhargava, 1999).

Area and Production of Fruit Crops

Fruit crops grown on an area of 3.68 million-hectare produce 42.9 million tonnes of fruit annually occupying third place in the world. The agro-economic importance of fruit crops both for growers as well as for country's economy are much greater than its share of 3.68 % of the cultivated area. Grapes produce higher yields and fetch extra farm income per unit area than most field and fruit crops. The area, production and productivity of fruit crops in India are given in **Tables 1** and **2**.

Grapes: Grape is grown as a sub-tropical crop in Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and western part of Madhya Pradesh following double pruning technology in one year cycle, while single pruning, similar to European countries and USA is followed in western Uttar Pradesh, Punjab and Haryana. The total area under grapes is about 40,842 ha with an estimated annual production of 9,69,302 tonnes.

Good yield and better quality of table grapes is harvested in Maharashtra, Andhra Pradesh and northern Karnataka. The popular cultivars grown are Thompson seedless, and its mutants like *Tas-A-Ganesh*, *Sonaka*, *Manik Chaman*, Kismish Charni and Flame Seedless. Some new cultivars such as Clone # 2 of

Table 1. Area, production and productivity of fruit crops in India

Fruit Crop	*Area (hectare)*	*Production (tonnes)*	*Productivity (t/ha)*
Banana	4,41,692	1,41,41,394	32.02
Grapes	40,842	9,69,302	23.73
Papaya	69,204	15,82,130	22.86
Pineapple	69,050	9,46,732	13.71
Sapota	48,224	6,29,312	13.05
Guava	1,51,501	16,31,410	10.77
Citrus	4,82,720	42,58,514	8.82
Litchi	57,844	4,54,742	7.86
Mango	13,81,177	1,01,56,963	7.35
Apple	2,27,679	13,20,586	5.80
Other Fruits	7,11,771	77,76,854	10.93
Total	36,81,704	4,28,67,919	11.64

Table 2. Area and production of fruit crops in various states of India

Fruit Crop	*Area (hectare)*	*Production (tonnes)*	*Productivity (t/ha)*
Andaman & Nicobar Islands	3730	166700	44.69
Pondicherry	802	20803	25.94
Chandigarh	141	3195	22.66
Madhya Pradesh	62442	1184000	18.96
Karnataka	314640	5446370	17.31
Maharashtra	379955	6473206	17.04
Tamil Nadu	234002	3683823	15.74
Andhra Pradesh	4,14,472	58,99,112	14.23
Rajasthan	20318	277906	13.67
Uttar Pradesh (Plains)	328791	4292978	13.05
Arunachal Pradesh	28,988	87,913	3.03
Assam	103557	1220357	11.78
Bihar	299799	3755391	12.53
Dadra & Nagar Haveli	707	7100	10.04
Daman & Diu	396	3375	8.52
Delhi	26	284	10.92
Goa	12165	84768	6.97
Gujarat	137516	1820050	13.23
Haryana	23878	176044	7.37
Himachal Pradesh	230850	303169	1.31
Jammu & Kashmir	146993	1047436	7.13
Kerala	195824	1826057	9.32
Lakshadeep	250	715	2.86
Manipur	22677	110998	4.89
Meghalaya	24800	239008	9.64
Mizoram	14965	68975	4.61
Nagaland	15603	189768	12.16
Orissa	227389	1511812	6.65
Punjab	90295	813554	9.01
Sikkim	9500	13250	1.39
Tripura	32263	400894	12.42
Uttar Pradesh (Hills)	186720	515300	2.76
West Bengal	117250	1373638	11.71
TOTAL	3681704	42867919	11.64

Thompson seedless imported from USA, which is supposed to be the original clone and true to type, superior seedless from South Africa and Israel and H-5 are also commonly grown. Seventy eight per cent of the total production is utilized for table purpose in domestic market, 20% is utilized for making raisins, 1% is exported and less than 1% is converted into wines.

Available K Status of Grape-growing Soils

Available Potassium ranged from 5 to 672 ppm during the year 1991 to 2000. It depends on native K status, type of clay minerals, clay and organic matter content and texture of the soil. In Vertisols with 500 to 700 ppm native available K, K status went up very high due to periodic addition of K fertilizers. Detailed study indicted that highest mean K content was reported from Osmanabad (496 ppm) followed by Solapur (483 ppm) and Aurangabad (429 ppm) during 1999 to 2000, and from Solapur (723 ppm) followed by Nasik (455 ppm) and Osmanabad (440 ppm) during 2000 to 2001 (Bhargava, 2001).

Nutrient Management for Grapes

Nutrient management is one of the largest shares of cost with its impact on potential yield and crop quality. Optimum status of nutrients and their relationship with the components of yield according to "Bhargava's Physiological Stage Concept" hold the key of potential yield determination for next season crop. These involved the identification of yield components, recognition of phases of development at which they are initiated and differentiated and their relative contribution to the final yield and crop quality. In order to diagnose whether nutrition is a limiting factor, it is essential to develop optimum nutrient norms for the various physiological stages by tissue analysis.

There are evidences to show conclusively that N, P and K involved in bud initiation and differentiation of grape bunches in the previous year determine the potential yield component for the current year crop. Investigations have proved that desired status of three primary nutrients leads to desired or targeted potential determination, of course coupled with specific water and hormone management and some other cultural practices. Various investigations on grapes (Bhargava and Sumner, 1987; Bhargava and Chadha, 1993; Bould, 1974; Chundawat *et al.*, 1977, Cook and Wheeler, 1978; Faruqi and Satyanarayana, 1975; Manival and Muthikrishnan, 1977) have clearly demonstrated that potential yield is determined in the prior season in peninsular India and is influenced by nutrient levels at the time of fruit bud initiation and differentiation. In peninsular India, grape bud initiation and differentiation is known to be influenced by N, P and K (Bhujbal and Phadnis, 1971; Chadha and Singh, 1971; Chitkara *et al.*, 1972; Manivel and Muthukrishnan, 1977; Nijjar and Chand, 1972), but all investigators did not attempt to relate tissue nutrient content with yield. The relationship between leaf nutrient content and yield has been well established by the classified work of Lundegardh (1951) in cereal crops and that of Cook and Krishaba (1956), Cook and Wheeler (1978), Ulrich (1942), Bhargava and Sumner (1987), Bhargava and Chadha (1993) and Bhargava and Raghupathi (1999) on grapes.

Nutrition has conclusively determined the productivity of grapevines under Indian conditions. Bud fruitfulness, which determines the productivity, has been shown to increase with adequate N, high P and optimum K (Bhargava and Sumner, 1987). N + P or P + K induced early flower bud initiation in grapevines. Application of potassium in K deficient vineyards in Latur area markedly increased the fruitfulness of latent buds of Thompson Seedless grapes and its mutant (Bhargava, 2001).

It is not N, P and K concentration, which individually affect bud differentiation but a proper balance between them induces the bud either to develop into a fruitful bunch or a non-productive tendril (Shivashankara, 1967; Srinivasan, 1968; Bhargava, 2000). The evaluation of grapevine nutrition is done using index tissue (petiole) analysis at bud initiation stage.

The main physiological stages at which K is needed at optimum for March / April pruning are bud differentiation stage, bud fixing stage and cane maturity. Adequate status of K has been emphasised for formation of fruitful buds at bud initiation and differentiation stages (Bhargava and Sumner, 1987) and at bud fixation after differentiation (50 to 55 days after pruning) and at cane maturity (Winkler *et al.*, 1974). After October pruning, adequate K is needed for translocation of sugars to the berries. Optimum K at harvest provides an attractive look and a long shelf life to grapes. The dose recommended to particular vineyard depends on available K in soil, petiole K level in the previous season and the crop yield harvested in the previous season. The amount of K recommended is 25 to 30% of the seasonal need. The K supplies during growth and development keeps the cane healthy.

Nutrient Uptake by Grapes

Nutrients removed by grapevines make a basis for nutrient management for the crop. While considering the nutrient to be returned to the soil, use efficiency of various nutrients has to be considered. Wasnik and Bhargava (1989) estimated that 25 t ha^{-1} grape of Thompson seedless cultivar removes 97.9 kg N, 15.6 kg P, 55.6 kg K, 50 kg Ca, 35 kg Mg, 9 kg S, 29 kg Na, 735 g Fe, 480 g Mn, 700 g Zn and 86 g Cu ha^{-1} $year^{-1}$ (**Table 3**).

Table 3. Nutrients removed by 25 t/ha of Thompson seedless grapes

Nutrients	*Unit*	*Nutrients removed by*			
		Grape Berries	*Pruned Canes*		*Total*
			October	*April*	
Nitrogen	kg/ha	46.35	22.50	29.11	97.93
Phosphorus	kg/ha	5.01	3.63	6.95	15.59
Potassium	kg/ha	38.77	8.08	8.74	55.59
Calcium	kg/ha	2.61	8.14	34.55	44.94
Magnesium	kg/ha	2.40	4.95	27.72	35.07
Sulphur	kg/ha	3.74	1.68	4.01	9.43
Sodium	kg/ha	2.77	1.82	24.22	28.81
Iron	g/ha	275.60	75.79	384.04	735.43
Manganese	g/ha	21.23	94.71	363.10	479.04
Zinc	g/ha	45.44	162.72	498.16	706.32
Copper	g/ha	38.92	23.65	23.58	86.15

At the ripening, the mineral content of vine stabilizes at 1.0 to 1.4 g 100^{-1} g dry matter in the aerial parts. Nutrient uptake as 36.7 kg N, 3.8 kg P and 40.6 kg K ha^{-1} from bud burst to the beginning of flowering, 6.9 kg N, 1.4 kg P and 13.3 kg K ha^{-1} from the beginning to the end of flowering, 57.6 kg N, 10.5 kg P and 112.0 kg K ha^{-1} from fruit set to the beginning of ripening and 1.10 kg N, 4.62 kg P and 19.0 kg K ha^{-1} from the beginning of ripening to the harvest have been reported. Winkler *et al.* (1974) reported 7.4 tones of fruits per ha and 1.5 tones of bunch per ha removed 11.0-20.0 kg N, 1.8-3.3 kg P and 14.2-22.3 kg K ha^{-1}.

Response of Grapes to K Application

In Grapevines, nitrogen has shown its effect in terms of growth, P in fruit bud differentiation and root growth and potassium for cane maturity, crop quality and shelf-life of bunches. Pruning weight which is a measure of over all growth of the grapevines was found to be more with increasing levels of K in Thompson seedless grapes (Khandagale, 1977). Potassium increased the radial growth of the vines, shoot diameter and dry matter of the leaves (Patil, 1977) and stem girth (Khandagale, 1977) in Thompson seedless.

Potassium was found favaourable for the inflorescence formation (Manivel, 1967; Srinivasan, 1968). Its application made those buds fertile, which under normal conditions remained sterile, through increased carbohydrate accumulation (Srinivasan and Muthukrishnan, 1970). Potassium promotes fruitfulness through its enzyme activating property. It must be activating the enzymes involved in the conversion of carbohydrates to Ribose sugar, which is a component of RNA. Application of potassium was found to increase the bunch number per vine (Gopalswamy, 1969). Increase bunch size with higher rates of K application was obtained by Hassan (1968). It has an additive effect in increasing the bunch number per vine along with N (Fruit Improvement Project of ICAR, 1982). Increased yields were obtained with increasing levels of K in Anab-e-Shahi (Gopalaswamy and Rao, 1972), and Thompson seedless (Shikhamany *et al.*, 1981).

Relation of Petiole K with Grape Yield

Petiole K was correlated positively with yield in Thompson seedless grape (Bhujbal, 1977). Low yielding Anab-e-Shahi vines have significantly lower K content as compared to high yielding vines (Shikhamany and Satyanaranaya, 1973). Relative K content of the petiole with reference to other nutrients (DRIS index) was less in low yielding vines as compared to high yielding ones in Thompson seedless (Chittiraicheven *et al.*, 1984). Potassium was found to influence and determine 19.1% of the grape yield in Thompson seedless cultivar (Shikhamany *et al.*, 1982). Thus it can be concluded that K has a role to play in floral bud differentiation and flowering.

Petiole nutrient norms developed by Leaf Analysis Laboratory of Indian Institute of Horticultural Research, Bangalore have been used to calculate the nutrients to be applied for potential yield and quality (Bhargava and Chadha, 1993). The nutrient norms have been given in **Tables 4** to **7**.

Table 4. Petiole nutrient norms for grapes – Thompson seedless bud differentiation stage (5th petiole from base 45 days from pruning date.)

Nutrient	*Unit*	*Status*				
		Low	*Hidden Hunger*	*Optimum/ Sufficient*	*More Than Required*	*Very High/ Toxic*
N	%	< 0.50	0.50-0.86	1.24 0.87-1.60	1.62-1.98	> 2.00
P	%	< 0.11	0.11-0.29	0.47 0.30-0.65	0.66-0.80	> 0.85
K	%	< 1.50	1.50-1.99	2.51 2.00-3.02	3.03-3.54	> 4.00
Ca	%	< 0.79	0.79-0.97	1.18 0.98-1.36	1.37-1.56	> 1.60
Mg	%	< 0.40	0.41-0.62	0.87 0.63-1.10	1.11-1.34	> 1.34
S	%	< 0.07	0.07-0.08	0.12 0.09-0.13	0.14-0.16	> 0.20
Fe	ppm	< 40	40-53	67 54-80	81-94	> 100
Mn	ppm	< 10	10-40	125 41-209	210-293	> 300
Zn	ppm	< 10	10-25	67 30-88	89-109	> 110
Cu	ppm	< 2	2-5	7.5 5-10	100-240	> 250
Potential Yield	t/ha	< 23	23-26	30 27-34	35-40	> 40

Source: Bhargava (2001)

Potassium and Grape Quality

Potassium was reported to have an important role in the quality of grapes. Higher levels of applied K were associated with higher TSS content of grape juice (Singh, 1968). Potassium application was found to increase the TSS content in Anab-e-Shahi (Gopalswamy and Rao, 1972, Faruqi and Satyanarayana, 1975) and Thompson seedless (Khandagale, 1977). Foliar application of K prior to anthesis (Patil, 1977) or during berry growth (Singh, *et al.* 1979) was found to increase the TSS content in Thompson seedless or Perlette grape, respectively. Potassium was found to reduce the acidity of the

Table 5 Petiole nutrient norms for grapes – *Anab – e – shahi* bud differentiation stage (5th Petiole from base at 45th day from pruning date)

Nutrient	*Unit*	*Status*				
		Low	*Hidden Hunger*	*Optimum/ Sufficient*	*More Than Required*	*Very High/ Toxic*
N	%	< 0.12	0.12-0.49	0.88 0.50-1.25	1.26-1.64	> 1.65
P	%	< 0.34	0.34-0.45	0.57 0.46-0.68	0.69-0.80	> 0.80
K	%	< 0.52	0.52-1.15	1.78 1.16-2.42	2.43-3.06	> 3.10
Ca	%	< 1.06	1.06-1.39	1.74 1.40-2.07	2.08-2.41	> 2.41
Mg	%	< 0.07	0.07-0.23	0.41 0.24-0.58	0.59-0.75	> 0.75
S	%	< 0.04	0.04-0.07	0.13 0.08-0.18	0.19-0.24	> 0.25
Fe	ppm	< 8	8– 37	72 38-107	108-142	> 150
Mn	ppm	< 10	10-18	47 19-86	87-125	> 125
Zn	ppm	< 6	6-24	60 25-94	95-128	> 130
Cu	ppm	< 4	4-9	20 10-30	31-46	> 50
Yield	t/ha	< 24	24-39	56 40-72	73-88	> 88

Source: Bhargava (2001)

juice in Anab-e-Shahi (Faruqi and Satyanarayana, 1975) and Thompson seedless (Khandagale, 1977).

Nutrient Use Efficiency in Grapes

Nitrogen use efficiency varies from 20 to 40% in grapes and depends on the status of organic matter in soil and doses of nutrient applied. N use efficiency was higher at lower doses of applied N (Bhargava, 1999). The efficiency of P is very low and ranged from 5 to 15%. The use efficiency of K ranged from 50 to 100%. This is probabely due to priming effect of fertilizer K on soil K.

Table 6 Petiole nutrient norms for grapes – Thompson seedless bloom stage (5th petiole from base 45 days (Bloom time) from date of pruning)

Nutrient	*Unit*	*Status*				
		Low	*Hidden Hunger*	*Optimum/ Sufficient*	*More Than Required*	*Very High/ Toxic*
N	%	< 0.87	0.87-1.31	1.76 1.32-2.21	2.22-2.60	> 2.66
P	%	< 0.19	0.19-0.37	0.57 0.38-0.75	0.76-0.95	> 0.95
K	%	< 0.60	0.60-1.13	1.67 1.14-2.20	2.21-2.73	> 2.75
Ca	%	< 0.53	0.53-0.73	0.94 0.74-1.14	1.15-1.35	> 1.35
Mg	%	< 0.30	0.30-0.49	0.65 0.50-0.80	1.81-1.00	> 1.00
S	%	< 0.07	0.07-0.13	0.21 0.14-0.27	0.28-0.34	> 0.34
Fe	ppm	< 10	10-29	55 30-80	81-200	> 200
Mn	ppm	< 26	26-75	125 76-174	175-223	> 225
Zn	ppm	< 13	13-52	92 53-132	133-171	> 175
Cu	ppm	< 2.0	2.0-4.9	7.5 5.0-10.0	11.0-100.0	> 100.0
Yield	t/ha	21.6	21.6-25.8	30 25.9-34.2	34.3-38.5	> 40.0

Source: Bhargava (2001)

On application of fertilizer K, some of soil K get released and become available to the crop.

Nutrients Mining from Grape Soils

According to recent estimate, use of N, P_2O_5 and K_2O is 18.4 million tonnes against the uptake of 28.0 million tonnes by various crops, leaving a deficit of 6 million tonnes even after considering nutrient addition from manures etc. to the extent of 4 million tonnes. Considerable amount of nutrients are being mined from the soils of Maharashtra and Karnatka. In Maharashtra

Table 7 Petiole nutrient norms for grapes – *Anab – e – shahi* bloom stage –(5th petiole from base at full bloom stage 45th day from pruning date)

Nutrient	*Unit*	*Status*				
		Low	*Hidden Hunger*	*Optimum/ Sufficient*	*More Than Required*	*Very High/ Toxic*
N	%			1.22		
		< 0.64	0.64-0.92	0.93-1.51	1.52-1.80	> 1.80
P	%			0.46		
		< 0.16	0.16-0.30	0.31-0.60	0.61-0.75	> 0.75
K	%			2.29		
		< 0.34	0.34-1.31	1.32-3.27	3.28-4.24	> 4.24
Ca	%			0.44		
		< 0.17	0.17-0.30	0.31-0.57	0.58-0.71	> 0.71
Mg	%			0.38		
		0.10	0.10-0.24	0.25-0.50	0.51-0.70	> 0.75
S	%			0.42		
		< 0.12	0.12-0.26	0.27-0.56	0.57-0.71	> 0.71
Fe	ppm			38		
		< 8	8-13	13-45	46-83	> 85
Mn	ppm			107		
		< 18	18-73	73-142	143-290	> 300
Zn	ppm			50		
		< 29	29-41	42-58	59-93	> 100
Cu	ppm			7.5		
		< 4	4-9	5-10	11-100	> 100
NO_3-N	ppm		300	426		
		< 100	100-265	301-600	601-1000	> 1200
PO_4-P	%			0.40		
		< 0.03	0.03-0.21	0.22-0.58	0.58-0.76	> 0.76
Water Soluble K	%			2.10		
		< 0.30	0.30-1.20	1.21-2.99	3.00-3.60	> 3.60
Yield	t/ha			57		
		< 23	23-40	41-74	75-91	> 91

Source: Bhargava (2001)

State (1988 to 1999) the nutrient mining from the soil is reported to be 3.0 million tonnes, with the application of about 1.6 million tonnes and removal of 4.7 million tonnes. The computed deficit in Karnataka is 5 lakh tonnes, with the application and removal of 1.27 and 1.32 million tonnes respectively.

In Punjab, with an area of 1,48,000 ha, production of 13,79,000 tonnes and the productivity of 19,538 kg ha^{-1} from of temperate and sub-tropical fruits, the nutrient removal is 4994 tonnes of N, 2256 tonnes of P_2O_5 and 8435 tonnes of K_2O in the ratio of 0.53 : 0.24 : 1.00. Average annual nutrient consumption is estimated to be 90 kg N + P_2O_5 + K_2O, however it is approximately 50 kg ha^{-1} for horticultural crops. On comparing the yield of horticultural crops (5 to 100 tonnes ha^{-1}) and field crops (0.8 to 4.5 tonnes ha^{-1}), it is clear that soils under horticultural crops are being continuously mined rather than maintaining or building its fertility for sustainable horticulture.

Future Strategies for Efficient Fertilizer Management in Grapes

Leaf Analysis: Leaf is the principal site of plant metabolism. Therefore, changes in nutrient supply are reflected in the composition of leaf. These changes are more pronounced at certain stages of development and the concentration of nutrients in the leaf at specific growth stages are related to the performance of the crop. Leaf analysis methodology consists of leaf sampling technique, sample preparation, analysis, making diagnosis and nutrient recommendation using leaf nutrient guide. A large number of plant, environmental and procedural parameters vitiate the plant nutrient concentration. A carefully worked out sampling technique of index tissue for nutritional diagnosis and subsequently fertilizer recommendations, will make a sound foundation of leaf analysis and advisory service program.

Modern methods of interpretation of leaf analysis data such as Critical Limit Concept, Nutrient Ratio, Crop Logging, Diagnosis and Recommendation Integrated System (DRIS), Boundary Line Concept, Compositional Nutritional Diagnosis (CND) and Principal Component Analysis (PCA) can diagnose the growth / yield limiting nutrient(s) and provide guidelines for recommendation for optimum use of fertilizers. Physiological basis of leaf sampling at bud initiation and differentiation stages holds the key of meaningful relationship of plant nutrient status with yield according to “Bhargava’s Physiological Stage Concept”. Application of these interpretation systems as well as the feed back mechanism from carefully monitored orchards will help in optimizing the use of nutrients through leaf analysis.

Leaf analysis, indeed is the best diagnostic tool for nutritional diagnosis, an excellent method for monitoring the nutrient status of perennial fruits and to recommend manures and fertilizers. Recent observation made on grapes indicated stunted growth under deficient K situation and leaf rolling in sub-optimum supply of K.

Soil Analysis: The chemical analysis of soil is based on the assumption that roots extract nutrients from the soil in a manner comparable with chemical soil extractants and that there is a direct relationship between the extractable nutrient in the soil and its uptake by plants. Soil texture, cation exchange capacity, organic matter and finally the microbial activity has great bearing on fertilizer management and need to be taken into account.

Soil analysis provides the information regarding acidity, sodicity, salinity or other factors affecting growth, productivity and quality. The interaction of nutrients with soil moisture influenced the crop growth, which in turn depends on soil texture, soil depth and land slope. Soil Fertility Norms for plantation of grapes have been developed and are reported in **Table 8**.

Water Analysis: Attention has been paid on the quantum of water available for irrigation rather than on its quality. Most of the water coming from rivers and bore wells/tube wells are free from soluble salts and toxic ions. Nutritional survey conducted by IIHR, Bangalore (1977 to 1999) has revealed chloride ions in toxic concentration (> 3 me/l) for grapes, resulting in leaf scorching and leaf fall before grape maturity. Since grape is a non-climacteric fruit, the bunches remain unripe due to premature leaf fall before fruits get full maturity. Data pertaining to Maharashtra indicated highest average chloride concentration in ground water in Sangli district to be 5.98 me l^{-1} . To avoid accumulation of chlorides in ground water, the growers are advised to use SOP, although it is more expensive. To overcome the problem created by enriched ground water with high chlorides the growers were advised to use Bangalore Dogridge as a biological barrier in addition to the use of chloride free manures and fertilizers. Toxic concentration of nitrate (>10 ppm NO_3-N) was found in ground water vineyards of Nasik, which although suitable for irrigation purpose, however, unfit for drinking purpose, particularly for children. Very limited quantity of K (1 to 3 ppm) is also added through irrigation water. The quality norms of irrigation water for grapes have been reported in **Table 9**. The grape growers have been advised to take note of the chloride toxicity observed in Solapur and Sangli and salinity in Sangli district of Maharashtra. Chloride toxicity is emerging in Chickaballapur area of Karnataka. The growers were advised to use rootstocks like “Dogridge” or “Salt Creek” to keep high productivity and quality levels in adverse soil and water conditions.

Table 8. Soil fertility norms for grapes

Parameter	*Unit*	*Status*				
		Very low/ Deficient	*Low*	*Optimum/ Sufficient*	*More than Required/ High*	*Very High*
pH	–	< 4.00	4.00-6.00	6.50 6.00-7.00	7.00-8.60	> 8.60
EC	dS/m	–	0.10-0.50	0.75 0.50-1.00	1.00-2.00	> 3.80* Dogridge B is necessary
Organic Carbon	%	< 0.50	0.50-1.00	2.00 1.00-2.00	2.00-4.00	> 5.00
Available P	ppm	< 5	10-50	75 50-100	100-200	> 200
Available K	ppm	< 30	30-100	575 350-800	800-1000	> 1000
Available Ca	ppm	< 250	250-500	625 500-750	750-1000	> 1000
Available Mg	ppm	< 250	250-350	425 350-500	500-750	> 750
Available S	ppm			37		
		< 10	10-25	25-50	50-100	> 100
Available Fe	ppm	< 2.5	2.5-4.5	7.25 4.50-10.0	10.0-50.0	> 50.0
Available Mn	ppm	< 2.0	2.0-4.0	7.0 4.0-10.0	10.0-75.0	> 75.0
Available Zn	ppm	< 0.50	0.5-1.00	3.0 1.0-5.0	5.0-10.0	> 40.0
Available Cu	ppm	< 0.20	0.20-0.50	0.75 0.5-1.0	1.0-10.0	> 30.0
Available B	ppm	< 0.20	0.20-0.50	0.75 0.50-1.00	1.00-5.00	> 5.00
Yield	t/ha	< 23	23-26	30 27-33	34-37	> 38

Recommended Doses of Potassium for Various Grapes

Potassium is mainly recommended as muriate of potash, except where chloride toxicity is established. The recommendations for various States have been given in the **Table 10**.

Table 9. Quality norms for irrigation water for grapes

Parameters	*Units*	*Values*	*Interpretation*
Electrical Conductivity	dSm^{-1}	<1.00	Safe for grapes
		1.00-2.00	Increasing problems
		>2.00	Not safe for grapes, Rootstock needed
		>3.8	Tolerance limit for Rootstock- Bangalore Dogridge, 10% reduction in yield even after planting grapes on rootstock
		>8.00	Tolerance limit for Rootstock, 25% reduction in yield even after planting on rootstock-Bangalore Dogridge
Chlorides	Me l^{-1}	>3.00	Safe for grapes
		3.00-4.00	Upper limit for tolerance
		>4.00	Rootstock- Bangalore Dogridge is necessary
		>8.00	Chloride toxicity masked the harmful effect of salinity
		18.00-20.00	Tolerance limit of Bangalore Dogridge
		21.00-24.00	10% reduction in yield and quality even after planting grapes on rootstock
		25.00-28.00	25% reduction in yield and quality even after planting grapes on rootstock

Suggestions for Efficient Fertilizer Management

For efficient fertilizer management, there is a need to promote secondary and micronutrients to increase efficiency of primary fertilizer nutrients. Production, marketing and promotion of foliar spray grade in various packing sizes for spray purpose. Recommendations for various agro-ecological situations, taking into account soil nutrient status, efficient fertilizer use and orchard management. In grapes apart from soil analysis, plant analysis is an important tool. This has to be taken up in all horticultural crops and specially on fruits. Location of active root zone and placement of fertilizers for various crops has

Table 10. Recommendation of potassium for grapes

Crop	State	Spacing	Units	Age of the grapevines in years									
				1	2	3	4	5	6	7	8	9	10
Grapes	Andhra Pradesh	4.5 x 4.5 (AS) 3.0 x 3.0 (TS)	g/plant	250	500	1000	–	–	–	–	–	–	–
	Delhi	–	g/plant	–	–	200	–	–	–	–	–	–	–
	Haryana	2.5-3.5	g/plant	–	200	250	320	400	–	–	–	–	–
	Himachal Pradesh	3 x 3 m	g/plant	–	–	–	480*	–	–	–	–	–	
	Jammu & Kashmir	3 x 3 m	g/plant	25	50	75	100	–	–	–	–	–	
	Karnataka	–	g/plant	–	750	1500	1500	1500	1500	1500	1500	–	–
	Madhya Pradesh (Northern) (Southern)	 3 x 4 m 3 x 4 m	g/plant	 0 0	 150 0	 720 600	 720 600	 720 600	 720 600	 720 600	 720 600	 – –	 – –
	Maharashtra	3 x 1.5 m	g/plant	–	180	180	–	–	–	–	–	–	–
	Punjab	3 x 3 m	g/plant	150	230	330	380	480	–	–	–	–	–
	Rajasthan	2.5 x 3 m	g/plant	–	–	–	–	240	240	240	240	–	–
	Tamil Nadu	4 x 3 (TS)	g/vine	400	800	1200	–	–	–	–	–	–	–
	Uttar Pradesh	3 x 3 m	g/vine	80	80	80	80	400	400	400	–	–	–
	Punjab	6 x 6 m	g/plant	60	120	240	360	480	600	720	840	900	900
	Rajasthan	6-7 m	g/plant	–	–	–	720*	–	–	–	–	–	–
	Tamil Nadu	6 x 6 m	g/plant	–	–	–	1000*	–	–	–	–	–	–
	Uttar Pradesh	6 x 6 m	g/plant	50	100	150	200	250	300	–	–	–	–

to be worked out in the changing horticultural scenario, where irrigation practices are being switched over to drip, sprinkler and efficient water use systems. Future work has to be concentrated on the production of high quality fruits by efficient fertilizer management. Balanced and judicious use of fertilizers will result in good quality fruits. Considering the present situation of global warming, it is necessary to go for integrated nutrient management, where use of organic manures, biofertilizers and chemical fertilizers will be used simultaneously.

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