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EFFECT OF POTASSIUM, MAGNESIUM AND NITROGEN SOIL APPLICATIONS ON FUERTE AVOCADO FRUIT QUALITY

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ABSTRACT

In a three-year study, Fuerte avocado trees received soil applications of K_2SO_4, $MgSO_4$ and LAN during the period September to February. Single tree yields were recorded. After simulated sea export, i.e. four weeks of storage at 5 °C, fruits were examined for internal physiological disorders (pulp spot, grey pulp, vascular browning). The three-year average yield from heavily N fertilised trees tended to be lower than that of the other treatments. None of the treatments increased the percentage of fruit free of physiological disorders over three years when compared to the untreated control. N applications alone considerably increased the percentage of fruit with physiological disorders. However, when N was applied in combination with K and Mg, the percentage of fruit free of physiological disorders did not differ from the untreated control.

INTRODUCTION

In South Africa, the cultivar Fuerte represents 56% of the total avocado production (Toerien *et al.,* 1992). However, industry experience is that Fuerte fruit quality is often impaired by physiological disorders following cold storage.

Physiological disorders are caused by increased membrane permeability which results in leakage of phenols from the vacuole into the cytoplasm, with subsequent oxidation by polyphenoloxidases. Membrane stabilisation is dependent on calcium binding to certain membrane components. Depending on their concentrations, other cations can replace calcium from its binding sites in the membrane. Potassium and magnesium are potentially antagonistic to calcium and may markedly increase membrane permeability (Bangerth, 1979).

In a Fuerte fertilisation experiment Embleton *et al*. (1959) found that high N applications reduced tree yield and increased vegetativeness. According to Witney *et al*. (1990), Fuerte fruit from vigorous trees contained lower Ca concentrations than fruit from non-vigorous trees. Physiological disorders in avocado fruits have been linked to low fruit Ca content (Bower & Cutting, 1988). Koen *et al* (1990) found a positive relationship between the N and K concentrations in Fuerte fruit and the severity of the physiological disorder grey pulp, while an increased K concentration in the fruit resulted in a decreased occurrence of pulp spot. These findings put the quality conscious Fuerte grower

into a conflict situation, as K applications seem to reduce one physiological disorder (pulp spot) while increasing another (grey pulp).

The purpose of this study was to determine the effects of soil applications of K, Mg and N on fruit quality in cv Fuerte.

MATERIALS AND METHODS

Climate and Soil

The three-year experiment commenced in September 1989 and was carried out at Westfalia Estate, situated in the northeastern Transvaal. The climate is warm subtropical with summer rainfall averaging 1300 mm per annum. However, the years during which the experiment was carried out were exceptionally dry (1989: 743 mm, 1990: 794 mm, 1991: 855 mm, 1992: 471 mm). Supplementary dragline irrigation was applied when soil moisture tension, measured by tensiometer at a soil depth of 30 cm, exceeded -55 kPa. Due to the drought, the orchard could not be irrigated as from October 1991. The soil is deep lateritic (Hutton form) with a clay content of approximately 40%.

Treatments

Fuerte avocado trees on Duke seedling rootstocks, planted in 1978, were used in this study. All trees received an annual aerial spray of zinc and boron during full bloom at recommended rates (Könne *et al.,* 1990). The control trees received no macro-element fertilisers during the three experimental years. The following fertiliser treatments were applied: K_2SO_4 (40% K), $MgSO_4$ (10.5% Mg), limestone ammonium nitrate (LAN, 28% N), and the combination of these three fertilisers. The fertilisers were scattered on the soil under the trees in five applications per season during the period September to February. Each application consisted of 2 kg of fertiliser per tree, and in the case of the combined treatment 2 kg of each component. There were nine single tree replicates per treatment.

Yield

At harvest 1990, 1991 and 1992, single tree yields were recorded. In the first two years of the trial, fruit were picked both early (10/04/1990 and 27/03/1991) and late (30/05/1990 and 23/04/1991) in the Fuerte season. Due to the shortage of irrigation water, all fruit were harvested on one date in the third year (10/04/1992).

Fruit quality

In order to monitor fruit quality, fruit samples (mass range 266-305 g) were drawn on each picking date. In 1990 and 1991, a combined sample of 140 fruit was drawn from the nine trees in each treatment. In 1992, a sample of 14 fruit was

taken from each tree to investigate possible fruit quality differences between trees.

The fruits were stored for four weeks at 5°C to simulate shipment to Europe. There after the temperature was increased to 18°C to induce ripening. Soft-ripe fruit were cut open and inspected for the physiological disorders pulp spot, grey pulp and vascular browning (Swarts, 1984). Results on fruit quality are presented as percentage of fruit free of the above mentioned disorders.

Fruit sampling

Eight fruits (mass range 266-305 g) per tree were picked and combined into one sample per treatment in April 1990 and 1991. In 1992, eight fruits of the same mass range were picked from each tree and combined into one sample per tree. Pulp samples were drawn with a cork bore as described by Koen *et al.* (1990). The samples were analysed for their Ca, Mg and K content by Outspan Laboratories (Verwoerdburg).

TABLE 1 Yields (kg/tree) as influenced by K, Mg and N soil applications (1990-1992).

Treatment	Kg/tree			
	1990	1991	1992	Mean (1990-92)
Control	122	136b	143	133
K	86	198ab	125	137
Mg	82	273a	113	156
N	82	138b	118	113
K + Mg +N	47	164b	233	148
	n.s.	**	n.s.	n.s.

Mean separation in columns by Duncan's multiple range test, 5% level.

TABLE 2 Percentage of fruit free of physiological disorders as influenced by K, Mg and N soil applications and picking dates (1990-1992).

Year	Treatment	Fruit free of physiological disorders (%)	
		Early season	Late season
1990	Control	94	59
	K	90	55
	Mg	90	54
	N	89	36
	K + Mg + N	92	47
1991	Control	76	47
	K	79	43
	Mg	63	53
	N	59	34
	K + Mg + N	77	36
1992	Control	99	-
	K	88	-
	Mg	85	-
	N	60	-
	K + Mg + N	97	-

TABLE 3 K, Mg and Ca content in fruit as influenced by K, Mg and N soil applications (1990-1992).

Treatment	Year	% In dry matter		
		K	Mg	Ca
Control	1990	1.55	0.09	0.04
	1991	1.32	0.10	0.04
	1992	1.16	0.10	0.02
K	1990	1.67	0.09	0.04
	1991	1.81	0.09	0.04
	1992	1.74	0.08	0.03
Mg	1990	1.30	0.10	0.04
	1991	1.33	0.12	0.04
	1992	1.09	0.09	0.01
N	1990	1.28	0.09	0.03
	1991	1.20	0.10	0.04
	1992	0.86	0.10	0.02
K + Mg + N	1990	1.77	0.07	0.04
	1991	1.73	0.10	0.04
	1992	1.64	0.09	0.03

Soil sampling

Soil samples were drawn with an augerat 0-15 cm and 15-30 cm depth on the dripline of the trees. The soil was analysed in September 1989 before starting the experiment. Soil analysis was repeated in August 1990 and 1991. Aluminium acetate extractable Ca, Mg and K and pH (H_2O) values were determined in all

cases.

Leaf sampling

Leaves were sampled from each treatment according to Koen & Langenegger (1981) in March 1990, 1991 and 1992. The leaf samples were analysed for N, P, K, Ca, Mg, Zn and B contents by Outspan Laboratories.

RESULTS AND DISCUSSION

Yields

Yield varied considerably between trees within a treatment, and fertiliser applications had no significant effect on yield (Table 1). However, the three-year average yield of the heavily N fertilised trees tended to be lower than that of the other treatments. Embleton *et al.* (1959) also found a yield decrease in trees which received high rates of nitrogen.

Fruit quality

With regard to the occurrence of physiological disorders, the following observations were made irrespective of the fertiliser treatments applied. The biggest difference in fruit quality occurred between fruit picked early and that picked late in the Fuerte season. Late in the season, the proportion of fruit free of physiological disorders was 30 to 40% lower than early in the season. Furthermore, fruit quality differed by more than 20 % between years (Table 2). When examining fruit quality on an individual tree basis in 1992, the percentage of fruit free of physiological disorders differed considerably between trees, probably due to the seedling rootstocks. Trees with low yields tended to produce less fruit free of physiological disorders than trees with high yields. This observation agrees with findings of Smith & Köhne (1992).

None of the fertilizer treatments increased the percentage of fruit free of physiological disorders over three years when compared to the control. N applications alone considerably decreased the percentage of fruit free of physiological disorders (Table 2). However, when N was applied together with K and Mg, the percentage of fruit free of physiological disorders did not differ from the control.

TABLE 4 K, Ca and Mg content in the soil (averages for 0-30 cm soil depth) and soil pH as influenced by K, Mg and N soil applications.

Treatment	Year	mg/kg			pH (water)
		K	Ca	Mg	
Initial analysis	1989	22	1056	365	6.6
Control	1990	36	1222	308	6.8
	1991	28	1083	296	7.2
K	1990	186	1081	285	6.6
	1991	520	1092	288	7.0
Mg	1990	27	1168	396	6.8
	1991	39	981	350	6.9
N	1990	23	1044	277	6.7
	1991	27	1279	326	7.3
K + Mg + N	1990	147	1006	320	6.4
	1991	318	708	278	6.5

TABLE 5 N, K and Mg concentrations in leaves as influenced by K, Mg and N soil applications (1990-1992).

Treatment	Year	% In dry matter		
		N	K	Mg
Control	1990	1.66	0.83	0.70
	1991	2.28	0.77	0.77
	1992	1.64	0.50	0.78
K	1990	1.71	0.94	0.69
	1991	1.67	1.02	0.87
	1992	1.58	0.86	0.70
Mg	1990	1.63	0.78	0.70
	1991	1.90	0.64	0.89
	1992	1.67	0.63	0.74
N	1990	1.92	0.75	0.68
	1991	2.20	0.66	0.77
	1992	2.10	0.48	0.66
K + Mg + N	1990	1.60	0.82	0.73
	1991	1.97	1.11	0.71
	1992	1..77	0.70	0.68

Fruit analysis

Over the three-year-period, fruit K content was increased following soil K applications. Fruit Mg levels varied little between treatments and years. Fruit Ca

levels were constant in all treatments in 1990 and 1991, except for a decreased Ca content following N applications in 1990. In 1992, fruit Ca content was increased by K application and decreased by Mg application when compared to the control (Table 3). However, these changes in fruit Ca content did not affect fruit quality.

Soil analysis

The potassium level in the experimental orchard was particularly low when compared to the soil analysis norms for avocado (Köhne *et al.,* 1990). There was a large increase in the initially very low soil K content when K was applied alone and in combination with Mg and N (Table 4). In 1990, the soil K content for these two treatments was within the normal range of 150 to 250 mg/kg K (Köhne *et al.,* 1990). In 1991, the soil K content was increased further to the above normal and excess range respectively. Soil Mg content was slightly increased by Mg applications and soil Ca contents remained within the normal range.

Leaf analysis

Results for the leaf levels of N, K and Mg are shown in Table 5. N applications increased the percentages of N in the leaves. When N was applied alone, leaf N levels were increased above the maximum recommended level of 2% for Fuerte leaves in 1991 and 1992. Although the soil K content was low, leaf K values were within the normal range. K applications alone as well as in the combined treatment, increased K percentages in leaves. Higher soil levels of Mg following Mg applications were not reflected in higher Mg leaf levels. P, Ca, Zn and B contents (data not shown) were within the normal ranges for these elements (Köhne *et al.,* 1990).

CONCLUSIONS

Soil applications of K to Fuerte trees grown on a soil with low K content had no beneficial effect on yield or the percentage of fruit free of physiological disorders. Heavily N fertilised trees tended to produce lower yields and lower percentages of fruit free of physiological disorders when compared to the untreated control. However, when N was applied in combination with K and Mg, the percentage of fruit free of physiological disorders was the same as in the control. It was also shown that Fuerte fruit picked early in the season always had a much lower incidence of physiological disorders than that picked late in the season.

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REFERENCES

BANGERTH, F. 1979. Calcium-related physiological disorders of plants. *Annual Review of Phytopathology* 17: 97 - 122.

BOWER, J.P. & CUTTING, J.G. 1988. Avocado fruit development and ripening physiology. *Horticultural Reviews* 10: 229 - 271.

EMBLETON, T.W., JONES, W.W. & GARBER, M.J. 1959. Curvilinear relationship between leaf nitrogen and yield of Fuerte avocados. *Proceedings of the American Society for Horticultural Science* 74: 378 - 382.

KÖHNE, J.S., KOEN, T.J., PARTRIDGE, C.J., WESTCOTT, D., WOODS, D.B., ABERCROMBIE, R.A., BOTHA, J. & FARRELL,D. 1990. Fertilisation guidelines for high yields and good fruit quality in avocado. *South African Avocado Growers' Association Yearbook* 13: 8 - 10.

KOEN, T.J. & LANGENEGGER.W. 1981. Leaf analysis of the avocado. *Farming in South Africa, Avocados* E.3.

KOEN, T.J., DU PLESSIS, S.F. & TERBLANCHE, J.H. 1990. Nutritional factors involved in physiological post harvest fruit disorders of avocados (cv Fuerte). *Acta Horticulturae* 275: 543 - 550.

SMITH, D.G. & KÖHNE, J.S. 1992. Production potential of Fuerte on seedling rootstocks. *South African Avocado Growers 'Association Yearbook* 15: 83 - 85.

SWARTS, D.H. 1984. Post harvest problems of avocados let's talk the same language. *South African Avocado Growers' Association Yearbook* 7: 15 - 19.

TOERIEN, J.C., VANZYL, R.M. & LOURENS, F.J. 1992. An overview of the South African avocado industry. *World Avocado Congress II Proceedings:* 653 - 657.

WITNEY, G.W., HOFMAN, P.J. & WOLSTENHOLME, B.N. 1990. Effect of cultivar, tree vigour and fruit position on calcium accumulation in avocado fruits. *Scientia Horticulturae* 44: 269 - 278.