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Crop load and rates of nitrogen effects on performance of 'Gala' apple

Utjecaj opterećenja rodom i gnojidbe dušikom na osobine jabuke sorte Gala

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ABSTRACT

The trial was conducted in 'Gala'/M9 orchard with 5100 trees/ha. The experimental design was as split-block comprising three rates of nitrogen (N) as broadcast fertilization with 60 kg N/ha, 90 kg N/ha and 120 kg N/ha, and three crop load [(9, 6 and 3 fruits/cm^2 trunk cross sectional area (TCSA)]. The treatments with different rates of applied N lasted two years beginning in the 6th year after planting. In the 6th growing season crop load was adjusted by hand thinning whereas in the next year fruits were not thinned (control year). The major effect of excessive crop load of 'Gala' apple was reduced flowering in the following year. A positive relationship was found between the rates of N in year of applied treatments and return blooming in control year. The results showed no significant effect of N treatment on the TCSA and fruit size.

Key words: *Malus* x *domestica*, growth, return blooming, yield, yield efficiency, fruit size

SAŽETAK

Pokus je izveden sa sortom Gala, cijepljenom na podlozi M9, u gustoći sklopa od 5100 stabala po hektaru. Pokus je postavljen po metodi split-blok, a obuhvaćao je 3 razine gnojidbe sdušikom (60 kg N/ha, 90 kg N/ha i 120 kg N/ha) i 3 razine opterećenja rodom (3, 6 i 9 plodova na cm^2 površine porečnog presjeka debla na visini od 20 cm iznad cijepljenog mjesta. Pokus je proveden u dvije uzastopne godine počevši u u šestoj godini nakon sadnje. U šestoj vegetaciji opterećenje rodom određeno je ručnim prorjeđivanjem plodova, dok u sljedećoj godini nije obavljeno prorjeđivanje plodova (kontrolna godina). Glavni utjecaj većeg opterećenja rodom očitovao se kao smanjenje cvatnje u kontrolnoj godini. Pri tom su povećane doze dušićnih gnojiva imale pozitivan utjecaj na obilnost cvatnje u kontrolnoj godini. Rezultati istraživanja nisu pokazali značajni utjecaj doza dušika na prirast debla i krupnoću plodova.

INTRODUCTION

In high density orchards, it is important to establish a balance between vegetative growth and cropping. Excessively growth is undesirable because it may cause difficulties in applying appropriate management systems and may influence fruit quality and regular cropping. On the other hand, heavy fruit load during early years of orchard establishment may delay achieving full orchard productivity. This problem maybe reduced by adequate fertilization with N and fruit thinning and thus, crop adjustment. Many trials have demonstrated that increasing the N status of apple trees increases fruit set and size but results in reduced fruit colour, flesh firmness, and storage quality (Raese et al.,1997.; Drake et al.,2002.). Fruit size and firmness are usually inversely related, and both are influenced by the N status of the tree. Size generally increases with higher N levels if the crop load is not excessive and other factors are not limiting. Fruit size and return bloom was reduced by heavy crop load and return bloom the following season was also reduced by increasing of crop loads (Robinson and Watkins,2003.). Therefore, one of the goals of N management is to achieve and maintain a tree N status that balances these opposite effects.

MATERIALS AND METHODS

The orchard site was located at ‘Pohorski dvor’ Agricultural Center of the University of Maribor in Slovenia. The experiment was conducted on soil that contained 39% sand, 46% silt and 15% clay from 0- to 30- cm depth. This soil contained 3.2% organic matter, 3.5 mg P_2O_5/100 g soil, 47.2 mg K_2O/100 g soil, and pH (in KCl) was 5.3. Climatic conditions in the orchard site were favourable for apple growing. Long-term average temperature in Maribor is 9.7°C. Annual precipitation is about 1045 mm, and during growing season is about 638 mm.

The trial was conducted on heavy soil with ‘Gala’ apple on rootstock M9 grown at 2.8 x 0.7 m spacing. Trees were trained as a slender spindle. Vegetation in the tree row was controlled with herbicide. Orchard was irrigated. Other cultural practices were similar to those practiced in commercial orchards.

Nitrogen was ground-applied at three rates (60, 90 and 120 kg N/ha). The differences in the number of fruits that remained on the trees after the natural June drop provided the possibility of dividing the trees into three variants: the variant A with the lowest natural fruitlet abscission; the B variant with a medium, and the C variant with the lowest number of fruits remaining on the TCSA) and in variant C crop load of 3 fruits/cm^2 TCSA were established by tree. In the 6th growing season in the variant A three subvariants of crop load (9,

6 and 3 fruits/cm^2 TCSA), in variant B two crop loads (6 and 3 fruits/ cm^2 hand thinning. The 7th year was used as a control in which fruits were not thinned.

Trunk circumferences 20 cm above the graft union were measured annually in early spring and converted to trunk cross-sectional area (TCSA). Crop density (CD) was calculated at picking by dividing the number of fruits per tree with TCSA. Yield (kilograms per tree) was recorded annually and by dividing with fruit number per tree average fruit weight was calculated.

Analysis of variance was performed using SPSS for Windows 10.0.

RESULTS AND DISCUSSION

No relationship was found between the rates of applied N, crop load and vegetative growth (TCSA increment) in year of applied treatments (Table 1). A positive relationship was found between the rates of applied N in year of applied treatments and return bloom in subvariants of high and medium crop loads in control year (Table 2). The trees had lower flower density at crop loads 9 fruits/cm^2 of TCSA. The suppressive effect of high crop loads on next year's flowering was significantly lower at the highest rate of applied nitrogen. Our results indicated that to achieve desirable flower density in 'Gala' apple during years of full productivity would have required moderate crop loads of about 6 fruits/cm^2 of TCSA the previous year.

Results showed no significant effect of crop loads and applied N fertilizer on external fruit quality, unlike data which have been published previously (Ferguson and Watkins,1989.,1992., Robinson and Watkins,2003.).

In general, we conclude that excessive crop load can reduce flower density in the following year and this event can be reduced by N application. In addition, to avoid or reduce the intensity of biennial bearing, a regular and early thinning is required in 'Gala' apple.

CONCLUSIONS

The results showed no significant effect of different rates of nitrogen on tree vegetative performance and fruit size.

A positive relationship was found between the rates of applied N and return blooming, crop load and yield efficiency in next growing season.

Table 1. Effects of crop loads and nitrogen rates on tree performance of ‘Gala’ apple – year of applied treatments

	Nitrogen rate (kg N/ha)	High yield potential (YP) Variant A			Moderate YP Variant B		Low YP Variant C
		Adjusted crop load (fruits/cm^2 TCSA)					
		9	6	3	6	3	3
Flower cluster/cm^2 TCSA (2003)	60	4.56	5.19	4.22	2.23	1.67	1.46
	90	6.57	5.00	3.89	2.90	3.06	1.63
	120	4.12	5.02	3.44	2.79	1.89	1.40
	Significance	ns	ns	ns	ns	ns	ns
CD/cm^2 TCSA before thinning	60	10.39	11.75	12.45	6.67	6.63	4.60
	90	10.55	10.72	11.50	7.02	6.75	4.65
	120	10.96	10.97	9.80	7.73	7.37	4.48
	Significance	ns	ns	ns	ns	ns	ns
TCSA (cm^2) increment in 2003	60	1.26	0.70	0.97	1.88	1.68	2.30
	90	0.93	1.04	0.99	1.54	1.59	2.31
	120	0.73	1.12	1.26	1.33	1.80	2.76
	Significance	ns	ns	ns	ns	ns	ns
Yield (kg/tree)	60	6.94	5.04	5.30	8.20	5.51	5.46
	90	7.06	5.69	4.49	7.33	5.12	5.07
	120	7.32	5.45	5.09	5.49	5.17	4.30
	Significance	ns	ns	ns	ns	ns	ns
YE (kg/cm^2 TCSA)	60	0.627	0.571	0.537	0.574	0.383	0.311
	90	0.585	0.562	0.411	0.559	0.399	0.279
	120	0.721	0.495	0.443	0.499	0.342	0.268
	Significance	ns	ns	ns	ns	ns	ns
Average fruit weight (g)	60	140	114	104	128	147	134
	90	98	107	117	128	125	119
	120	119	135	143	149	165	165
	Significance	ns	ns	ns	ns	ns	ns

Comparisions are made within each column. Means followed by the same letters are not statistically different at P=0.05

Results indicated adverse effects of too high or too low crop load and positive effects of moderate crop load (6 fruits/cm^2 TCSA) on the tree performance (normal tree growth, abundant return blooming, high yield and yield efficiency) in the high density ‘Gala’ apple orchard.

Table 2. Effects of crop loads and nitrogen rates on tree performance of ‘Gala’ apple –control year

	Nitrogen rate (kg N/ha)	High yield potential (YP) Variant A			Moderate YP Variant B		Low YP Variant C
		Adjusted crop load (fruits/cm^2 TCSA)					
		9	6	3	6	3	3
Flower cluster/cm^2 TCSA (2003)	60	1.54 b	3.96 a	1.69 b	1.35 b	0.99	1.59 b
	90	0.49 c	1.85 b	2.93 a	1.57 b	1.42	2.34 ab
	120	3.13 a	3.58 a	2.34 ab	4.16 a	2.66	3.72 a
	Significance	*	*	*	*	ns	*
CD/cm^2 TCSA before thinning	60	1.85 b	3.98 b	2.36 b	3.23 b	3.97	2.97
	90	1.09 b	2.99 b	5.35 a	2.72 b	4.36	3.39
	120	5.37 a	7.60 a	3.06 ab	5.59 a	3.92	4.63
	Significance	*	*	*	*	ns	ns
TCSA (cm^2) increment in 2003	60	1.39	0.95	1.60	1.49 b	2.00	2.26
	90	1.45	1.44	1.91	2.17 ab	1.76	2.16
	120	1.62	1.46	1.82	3.13 a	1.84	1.66
	Significance	ns	ns	ns	*	ns	ns
Yield (kg/tree)	60	2.58 a	3.74	2.28 b	4.84	6.02	4.54
	90	0.92 b	2.58	4.61 a	3.91	5.79	5.05
	120	3.38 a	2.94	3.41 ab	4.27	6.35	4.65
	Significance	*	ns	*	ns	ns	ns
YE (kg/cm^2 TCSA)	60	0.222 a	0.384	0.213	0.308	0.363	0.239
	90	0.077 b	0.225	0.369	0.257	0.389	0.266
	120	0.319 a	0.255	0.248	0.352	0.371	0.313
	Significance	*	ns	ns	ns	ns	ns
Average fruit weight (g)	60	160	122	102	127	102	88
	90	171	159	103	109	89	76
	120	164	159	75	116	99	91
	Significance	ns	ns	ns	ns	ns	ns

Comparisions are made within each column. Means followed by the same letters are not statistically different at P=0.05

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