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INTENSIVE APPLE ORCHARD BASED ON ADVANCED TECHNOLOGIES

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Executive Summary

During 1998 a change in the set up of 2 of the experiments proposed for Kazakhstan had to be done due to management difficulties arising in the original locations The deteriorating situation in Kazakhstan made all activities and operations of the project difficult The new locations were selected, with the participation of Prof Erez while visiting Kazakhstan in May 1998, are closer to the experimental Institute enabling an easier access and a better protection of trees and equipment It is thus expected that reliable data will be collected Because of this change and because of the delay in shipping the irrigation equipment, we asked for extension of the duration of the project by one more year and this was granted As a result the project will end by November 1999

This year was the first year of operation of the irrigation system There were still problems of operating the computer but it was solved early in 1999 In Kazakhstan climatic conditions of spring frosts, fruit drop by strong winds and atypical wet year affected part of the results

In Israel we were completing the experimental work this year From the combined data of the two years on the same trees, it is clear that the dwarfing rootstock M9, although less efficient in fruit production per unit of water, was actually the most efficient on a two-year basis as both the MM106 and the Hashabi rootstocks were biennially bearing having practically no fruits in 1998 As to the water use by the trees, the same pattern revealed in 1997 was repeated this year, namely maximal water transpiration occurs prior to mid-June Although in 1998 water use was higher than in 1997 the same pattern was maintained

Overall aim and specific objectives

The overall aim of the project is to improve production and quality of apples by both selection of appropriate rootstocks and by introducing improved and more economical orchard management

The specific research objectives are

1 To select dwarfing apple rootstocks for high yield adapted to Kazakhstan s climate

2 To improve irrigation-water use efficiency by modifying traditional irrigation management

3 To introduce advanced methods for improving orchard training and pruning in high-density apple plantations

4 Develop an irrigation control algorithm (using direct measurement of transpiration and meteorological model) targeted to maintain trees within pre scribed water stress limits

The investigations in 1998 were conducted according to the programs

A comparative evaluation of better adapted rootstocks for a super-high density orchard under the local climate conditions Evaluation of drip irrigation with simultaneous application of fertilizers in high-density apple orchard Evaluation of a more detailed pruning system in comparison to the extensive light pruning method presently adopted in the orchards Means to extend the commercial life of old' (10-12 years) super density apple orchards

Experiment 1 Testing of new dwarf rootstocks for high-density orchard

Investigator K Karychev

In 1998 the investigations were conducted in two experimental apple orchards

The variety Golden Delicious in combination with dwarf rootstocks M9 (control) B 7-35, Arm 18 62-396 SPS-7

The first orchard (A) with plant density of 1250 tree /ha was planted in 1989 in the mountain zone of Zailijskei Alatau on the territory of experimental farm Almaly 16 measured trees for each rootstock - variety combination according to the recommendation of Prof Amnon Erez

The second experimental orchard (B) was planted in 1992 with the arrangement of 2000 tree/ha in the farm Gigant 16 measured trees for each rootstock-variety combination

In 1998 fruit trees winted under unfavorable conditions severe winter spring frosts caused the damage of fruit buds what influenced negatively apple tree fruit--bearing especially in the mountain zone (orchard A) Biometrics measurements of apple trees of the variety Golden Delicious showed that they were characterize by weaker growth on dwarf rootstock SPS-7 Tree height was also lower on rootstocks B-7-35 Arm-18 than on M9 (Tab 1)

Table 1

The influence of clonal rootstocks on the size of apple trees of Golden Delicious variety 1998

Rootstocks	Above – ground part					Tree incline	
	Tree height m	% of M9	Trunk section cm²	Crown projection m	Crown volume m	The grade from the trunk axis	% of trees
A Mountain orchard Almaly 11 - year –old trees							
M9 (control)	3 0	100	11	2 0	2 8	0	0
B 7-35	2 0	67	8	1 5	1 2	0	0
Arm 18	2 1	70	7	1 1	1 0	0	0
62-396	2 2	73	11	1 5	1 3	0	0
SPS-7	1 9	63	8	1 1	08	0	0
B The orchard in farm Gigant 11 - year-old trees							
M9 (control)	1 8	100	31	1 6	1 3	20	100
B 7-35	1 6	89	20	0 8	0 6	0	0
Arm 18	1 5	83	29	1 4	1 1	0	0
62-396	1 3	72	20	0 4	0 2	5	16
SPS-7	1 3	72	12	0 5	0 2	8	20

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The first fruit-bearing of trees (orchard A) was noticed in the mountain zone (without irrigation) in the 4-th year after planting on rootstocks B 7-35 and SPS –7 (9-10 centner/ha) and under condition of irrigation (orchard B) in the 2-nd year of planting on the rootstocks B 7-35 and M9 (4-5 centner/ha)

Data on yield of apple veritv Golden Delicious for 1994-1998 are presented in the Table 2

Table 2

The yield of apple trees of variety Golden Delicious depending on dwarf rootstocks

Rootstocks	The yield centner/ha				The average
	1995	1996	1997	1998	
A Mountain orchard Almalv , 7-10 years after planting					
M9 (control)	25	40	5	0	17
B 7-35	40	38	8	4	22
Arm -18	63	48	8	0 5	30
62-396	45	63	8	1	29
SPS – 7	4	75	1	9	22
C Orchard - Gigant 4-7 years after planting					
M9 (control)	2	20	9	118	37
B 7-35	24	82	38	158	75
Arm –18	46	224	76	128	119
62-396	25	32	30	44	33
SPS-7	8	40	32	38	29

As it was established the highest yield of apple trees was on dwarf rootstock Arm 18 which exceeded 1 8-3 2 times the control rootstock on M9

Thus the rootstock Arm 18 exceeding M9 and also B 7-35 should be acknowledged as the most perspective dwarf apple rootstocks

Experiment 2 The evaluation of the new irrigation means with fertilizer application in intensive orchards

Investigators Adrianova G P
Bondartsev A I

The generalization and analysis of home and foreign experiences showed that drip irrigation is especially perspective for the regions with dry and hot climate as it is in South and South-east of Kazakhstan

The work on examination of drip irrigation and fertilizer efficiency in intensive irrigated orchards of Kazakhstan is very actual and was not conducted previously and is planned to carry out in this experiment

Proceeding from this in 1998 we selected dense intensive orchard in the peasant farm situated in the low mountain fruit zone of Almaty region

Two apple varieties Golden Delicious and Zarya Alatau grow in the orchard planting scheme is 4x1 5 m (1667/ha) on M9 rootstock Pear Talgar Beauty grows in one of the rows (Fig 1 2 3) The total area of experimental plot is 0 5 ha The experiment includes the following variants

1 Furrow irrigation + N120 P50 K 130 of active substance

The fertilizers are applicated in spring before fruit tree blooming into furrows or in pre stemmed strips along the rows

2 Drip irrigation + N120 P50 K130 a s

The fertilizers are also applicated into furrows in spring but nitrogen is applicated twice in spring and before flower bud setting in June

3 Drip irrigation + N120 P50 K130 kg/ha a s where phosphorus is applicated into furrows and nitrogen and potassium with irrigated water through drippers

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Nitrogen and potassium fertilizers are splitly applicated during two months (from the middle of June till the middle of August)

The doses of mineral fertilizers were taken from the recommendations on fertilizer dressing in intensive orchards in South-east of Kazakhstan under furrow irrigation

Further this dose will be specified by the data on nutrition element output and the level of soil fertility in the orchard Specified rates of fertilizers will be used in spring 1999 according to the experimental schedule

The scheme is used on both apple varieties and will be used beginning from spring 1999

The aim of investigations is to study the efficiency of simultaneous application of water and fertilizers with drip irrigation in intensive orchards of south-east Kazakhstan Under field conditions the experimental scheme is the following

four replications in each of both varieties where 3 variants of the experiment are arranged what makes 12 plots 8 measured trees are on each plot in the variant – 32 trees

There are two rows of trees in the variant where all 4 replications are arranged in 2 stories

Thus for two apple varieties 24 plots are selected where 192 measured trees are arranged

In inter-row spacing of the orchard natural grasses grow (cereals clover and others) In spring 1999 pre-stemmed strips of 1m wide will be treated by herbicide raundap for the creation of herbicide fallow

In summer 1998 all measured trees were numbered marked by paint and in autumn the trunks were measured

In August soil and leaf samples from all experimental plots (48 soil and 24 plant samples were selected all samples will be analyzed and will be presented in the Report for 1999 with the aim to give the characteristics of initial soil fertility in all variants of the experiment

At the beginning of September biological yield was calculated for both apple varieties and pear the average fruit mass was determined on all experimental plots

The main indexes of fruit growth (trunk diameter summary increment of shoots the mean length of one shoot the number of fruited formations) and the yield were statistically worked up by the computer

The results of these measurements are the following

The itegreited growth index and the development of fruit trees in trunk diameter

We measured trunk diameter of 192 measured trees The results of these measurements are given in Tabl 1

As it is seen from the Tab 1 the differences among apple trees according to trunk diameter are in the limits of experiment error what allows to consider the measured trees to be similar on growth and development in all variants of the experiment

Analogous result was obtained by summary shoot increment and the average length of one shoot

The obtained results testify to the fact that annual shoots have equal growth in all experimental variants and among them there were no essential differences (Tab 2 3) The summary increment of shoots on apple variety Zarya Alatau was approximately 1 5 times higher than on variety Golden Delicious (Tab 2 and 3)

However according to the average length of shoots there were no differences among the variants within each variety Higher summary shoot growth in the variety Zarya Alatau is explained by greater amount of growth points The average shoot length of apple in the limits of 20-25 cm is considered to be optimal in zone under study As it is evident from Tab 3 the length of annual shoots in these varieties responds to these parameters (18-23 cm) and it is possible to consider that the growth of fruit trees on experimental plot was quite favour able It is more complicated with the yield in the current year as in April – May there was a number of frosts and in the middle of July it was a very strong Wind and as a result of it many fruits dropped especially in last rows of apple variety Golden Delicious because fruit attachment of this variety is weaker than in variety Zarya Alatau All these facts do not allow to give objective evaluation of apple yield on experimental plots

The yield of the variety Golden Delicious was within 73-173 centner/ha (Var 1-73 Var 2-139 and Var 3 173 centner/ha accordingly)

The yield of the variety Zarya Alatau was higher within 446-809 centner/ha The highest yield was in Var 2 809 centner/ha in Var 1 it was 490 centner/ha and in Var 3-446 centner/ha

In the current years the yield of pear variety Talgar Beauty was at the level of 155-175 centner/ha Here it is possible to test only one variant – drip irrigation with the application of nitrogen-potassium fertilizers phos phorus fertilizer – in furrows

Once more it should be noticed that the yield of the current year was formed under extreme weather conditions (frosts and hurricane wind) what influences not equally the yield level of trees in variants of the experiment

For evaluation of potential apple yield in the next year (1999) we calculated the amount of such fruit organs as fruit formations in experimental variants what is presented in Tab 4

The obtained data showed that the number of fruit formations in variety Zarya Alatau was 1 5 2 times highe than in variety Golden Delicious what is the biological peculiarity of varieties This fact will accordingly influence the productivity level of these varieties next year As to the differences in fruit formation amount acco d

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ing to variants of the experiment they were insignificant in both apple varieties Consequently in 1999 it is possible to expect relatively equal initial yield the differences in which will be determined only by the influence of experimental variants

Thus the above mentioned measurements and observations in the experimental orchard showed that growth and development of apple trees of varieties Golden Delicious and Zarya Alatau respond optimal parameters and the initial state of trees and their growth processes were not essentially differed according to variants of the experiment Existing differences in the yield among experimental variants are explained by non typic weather conditions of the year Similar initial data on growth of fruit trees in the future variants will allow to lay out methodically consistent field experiment on simultaneous application of fertilizers and water under drip irrigation where this irrigation system is mounted in this current year The current 1998 year is characterized by heavy precipitation and extreme irregularity of their distribution according to vegetative period The main part of them (about 60%) fall in April and May In June and July the precipitation were 2 times more than average long-term rate (Tab 5) Thus heavy precipitation and low thermal density of meteorological conditions in the first months of vegetation delayed the beginning of irrigation to the end of July

Weather conditions also influenced the condition rate of water intake unit consisting of supplying channel setting tank and pump station and also the mounting of water-distributive unit with automatization and monitoring of irrigation process Therefore the first [illegible] irrigation in the variant under drip irrigation was conducted in the middle of August

Table 1

Initial indexes of trunk diameters of apple trees on experimental plot under drip irrigation in 1998 (mm/tree)

Variant	Golden Delicious					Zarya Alatau				
	Replications									
	I	II	III	IV	Middle	I	II	III	IV	Middle
Var 1 Furrow irrigation + NPK into furrows	108.4	100.2	98.3	93.7	100.1	27.0	113.2	108.6	121.0	117.4
Var 2 Drip irrigation + NPK in furrow	98.7	107.8	100.5	10[illegible].7	102.2	123.9	126.0	116.6	127.2	[illegible]
Var 3 Drip irrigation +NPK through drippers P into furrows	109.5	101.0	105.9	95.3	10[illegible].9	1[illegible]8.2	133.5	11[illegible]	132.0	1[illegible]4
LSD 95% m					6.3					[illegible]
P %										4[illegible]

Table 2

Initial data on summary increment of apple trees on experimental plot under drip irrigation in 1998 (m/tree)

Variant	Golden Delicious					Zarya Alatau				
	Replications									
	I	II	III	IV	Middle	I	II	III	IV	Middle
Var 1 Furrow irrigation + NPK into furrows	43	42	45	49	45	34	71	66	69	61
Var 2 Drip irrigation + NPK in furrow	50	59	47	58	48	90	45	96	68	75
Var 3 Drip irrigation +NPK through drippers P into furrows	58	[illegible]	[illegible]	[illegible]	48	74	45	10[illegible]	65	[illegible]
LSD 95% m					5					27
P %					9[illegible]					9

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Table 3

Initial data on the average length of 1 shoot of apple trees under drip irrigation in 1998 cm/tree

Variant	Golden Delicious					Zarya Alatau				
	Replications									
	I	II	III	IV	Middle	I	II	III	IV	Middle
Var 1 Furrow irrigation + NPK into furrows	18 8	23 1	16 9	21 5	20	20 7	18	18 9	20 8	19 7
Var 2 Drip irrigation – NPK in furrow	19 4	18 8	22	18 1	19 6	23 7	22 5	22	23 1	22 8
Var 3 Drip irrigation +NPK through drippers P-into furrows	14 5	22 2	19 9	18 3	18 7	18 8	19 9	22 3	26 3	21 8
LSD 95% cm					3 3					2 6
P %					8 5					5 9

Table 4

Initial data on fruit-formation number of apple trees on experimental plot under drip irrigation in 1998 (number/tree)

Variant	Golden Delicious					Zarya Alatau				
	Replications									
	I	II	III	IV	Middle	I	II	III	IV	Middle
Var 1 Furrow irrigation + NPK into furrows	495	438	849	447	557	753	966	814	911	861
Var 2 Drip irrigation + NPK through drippers P- in furrows	616	560	351	620	537	1082	1199	655	1226	1040
Var 3 Drip irrigation +NPK through drippers	806	502	457	481	561	1211	821	740	740	878
P-into furrows					204					257
P %					18					14

Table 5

Water regimes of orchard under drip and furrow irrigation

Period	Evaporation mm	Precipitation mm		Summary irrigation rates mm		Summary water consumption mm	Bioclimatic coefficient
		1988	Average long-term norm	Furrow irrigation	Drip irrigation		
April	35 1	130 1	100			21 1	0 6
May	66 2	253 2	98			52 9	08
June	120 5	80 4	61			115 6	09
July	160 2	106 3	38			160 2	1 0
August	135 1	22 0	27	110	60	148 6	1 1
September	114 9	42 0	28	70	30	91 9	0 8
October	69 4	15 6	51	70	40	41 6	0 6
Israel for vegetation	709 4	649 6	403	250	120	631 0	

Irrigation rates was established by water-reserve deficit in root layer (1m) determined by tensiometer indexes Simultaneous the observation on potential evaporation was conducted by means of water evaporators with evaporating surface of 3000 cm which are necessary for determining bioclimatic coefficient indicating ind

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vidual biological rhythm of plant development and equal to the ratio of potential evaporation to summary water consumption Irrigation rates were corrected by the coefficient of wet area equal to 0 5 and established for drip irrigation in intensive orchards Under furrow irrigation the whole area in interrow spacing is practically wetted therefore water rates here are 2 times higher than in drip irrigation Irrigation rate together with autumn water-supplying was 250 mm under furrow irrigation and 120 mm under drip irrigation

Presented in Table 5 the indexes of summary water consumption were obtained as a result of calculation taking into account coming and discharge elements of water balance in root soil layer For intensive orchard with planting scheme 4m x 1 5m summary water consumption in 1988 was 631 9 mm and was distributed according to vegetation period depending on growth rate of vegetative organs and the tention of meteorological conditions The indexes of bioclimatic coefficient are also depended on these regularities and change in the limits of 0 6 at the beginning of vegetation and to 1 1 at the end of vegetation in August Great amount of precipitation in 1998 levelled the influence of irrigation on growth processes and orchard yield and formed equal background for laying out of the experiment next year

Experiment 3 Elaboration of effective means of productive period prolongation in super density apple orchards on clonal rootstocks

Colaborators Kutsukov A S Karychev R K

In high dense orchard the productivity and trade quality of fruits considerably decrease with the age Therefore with the aim of the prolongation of productive life in such orchards different ways and means of rejuvenation of tree crown are elaborated

The objects of the investigation are the following

- to trial the different stages of rejuvenated pruning of aging orchards
- to elaborate the effective system of re-training of tree crown
- to study the peculiarities of growth and fruit-bearing of apple trees on the rootstock M9 in dense orchards
- to give the evaluation of economic efficiency of different means of tree rejuvenation

Field investigations are carried out on the experimental plot in Dzhandosov farm of Almaty region situated at the height of 850 m above sea level

The apple variety Golden Delicious graffed on the rootstock M9 planting scheme is 4 x 0 8 m (3125 trees per hectare) The year of planting is 1989 Orchard interrow spacing are under sodding by perennial grasses In previous years the orchard gave high fruit yields about 240-260 centner/ha in recent years the periodicity of fruit-bearing was observed The necessity to prolong the productive life period of fruit appeared in dense orchard

The investigation program includes the following variants

1 Contour pruning of fruit wall at a distance of 70 cm from row line with limited height of 2 2 m (control)
2 Radical crown pruning at the hight of 60 cm above the grafting level
3 Pruning of skeleton branches at a distance of 30 cm from the base to the height of 1 2-1 4 m with the leader transfer to lateral branch
4 One-sided rejuvenated pruning of branches at a distance of 30 cm from row line with the repeated operation in two years after the first pruning on the other side of the raw

The experiment was laid out with four replications of 8-10 trees in each replication

Setting of the experiment is a randomized block design

By using such means and degrees of pruning a new wave of shoot growth overgrowing and productive wood in the center of the crown fruit formations are able to prolong the productive period of plant life

During vegetative period in 1998 the following measurements and observations were conducted common tree state crown parameters the length of shoot increment freezing degree of wood the growth of trunk diameter the mass of removed wood during pruning the fixation of meteorological year conditions It should be noticed that

as a result of autumn-winter damages of apple trees by winter frost spring frosts during blooming period there was no yield in the orchard

According the results of observations the states of the plantations are characterized by the following data (Tab 1)

- Common tree state was better under strong rejuvenated pruning than in other variants

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- Tree high under one sided pruning with repeated operation in 2 years (variant 4) was greater than in other variants with crown limited the difference was 20-120 cm Fruit wall was also wider – 30-50 cm Intensive degree of vegetative shoot growth was about 35 cm and more in the variant with radical pruning it also stimulated the increasing of trunk diameter by 0 63 cm in comparison with other variants (0 2-0 5 cm) The determination of potential productivity of variants in relation of summary section area of trunks to the unit of orchard area (1 ha) according to the method of A S Devyatov (1980) showed that under radical pruning this ratio was 206 6 m²/ha in comparison with control – 194 3 m²/ha what testified to more high potential productivity by strong rate of rejuvenation

Table 1

Growth and development of apple trees of variety Golden Delicious grafted on the rootstock M9 depending on the degree of rejuvenated pruning

Variant	Common tree state 0 → 5	Height of fruit wall	Crown width cm	Trunk diameter cm	Shoot length cm top/lateral	Light of crown center % from FSL
Contour pruning (control)	3 7	283	169	6 21	27 7/5 2	52
Radical pruning	3 9	181	142	6 29	/35	81
Pruning of low part of crown	3 5	285	121	5 82	24 8/7 3	64
One sided pruning	3 9	235	156	5 7	19/6 2	57

The data are published in journal Vestnik of Agr Sci Kaz N5 1998 p 44-48

The results of light measurements of different crown parts in tested variants using the actinometric method based on photochemical reaction of decomposition of sulfate uran solution and oxaline acid (A Erez B Avidan 1986) showed that the greatest light activity (by 80% from full solar light) was observed in the crown with radical pruning 64% - pruning of the low crown part 57% - one-sided pruning and only 52% from FSL in crown centers with contour pruning were lighted (measurements were carried out in August) Thus according to indirect indexes of productivity summary area of trunk section the light of crown center shoot length the variant of radical crown rejuvenation distiguished and actually the new tree crown was formed This proposal showed be confirmed by the yield in the future years The essential shortages of radical pruning and mainly of apple varieties is weak frost resistance of rejuvenation shoots (the degree of freezing is ½ - 2/3 of increment length or 50-56%)

The investigations will be continued next year

Fig 1 Pear Talgar Beauty

Fig 2 Apple Golden Delicious on Variety 2

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Israel

Objectives

- To test the water use efficiency of apple production on various rootstocks and re-examine irrigation practices

Material and methods

The setup was a in 1997 but for selecting new trees (15 per rootstock) for the heat-pulse measurements in Golden Delicious on the three rootstocks MM106, Hashabi and M9 This time we tried to prevent excessive yield by a closer monitoring the fruit numbers per tree The Hashabi trees were smaller than a year earlier In addition the trees measured in 1997 were observed as to their return bloom and fruit load

T o prevent any water shortage the trees were irrigated in excess

Heat pulse measurements were the same as in 1997, three sets of 8 probes per unit were employed

Results

Fruit production in 1998

A more uniform yield was shown for this year on the different rootstocks MM106 was higher in yield but not significantly (Fig 1) Fruit quality with regards to size was rather very good (Fig 2) M9 had a little better fruit size in the distribution of grading especially compared to Hashabi Fruit quality was very negatively affected this year by sunburn as extremely high level of damage was noted on the M9 fruits that was much more exposed than on Hashabi and MM106 rootstocks But even on these two rather vigorous rootstocks, close to 40% of damage was noted (Table 2) The cause for the unprecedented damage was the extreme heat in summer 1998 Measures to avoid such damage are being taken by growers as of 1999

Return bloom and yield on the 1997 trees

No flower bus were formed on the MM106 trees due to the heavy yields d they bore in the previous year Few flowers were seen in the Hashabi trees while abundant bloom was noticed in the M9 trees Only the M9 trees produced a commercial crop

Evaluation of efficiency of fruit production under this system was examined again by dividing the water use of the trees for two years 1997-1998 on the cumulative yield in both years By that we could count for the biennial bearing on two of the three rootstocks The summer of 1998 was exceptionally warm and higher values of transpired water was recorded in this year compared to 1997 While values of about 6 mm/day were found in 1997 for Hashabi and MM106 and 4 mm/day for M9 in the highest transpiration period, maximal values of 6 8, 8 8 and 5 5 were recorded in 1998 for Hashabi MM106 and M9 respectively Considering the smaller Hashabi trees in 1998 than in 1997 a mean increase of about 40% in water use was noted in 1998

By combining the yields and an estimation of water use on those trees by taking data from similar fruiting trees a different picture is emerging as compared to 1997 (Table 1) While in 1997, the most efficient rootstock was MM106, the most prolific, the most efficient one seems to be M9 the only rootstock that bore fruit in 1998 too The efficiency values were less favorable even for the M9 due to higher water use in 1998, but still much better than the other two rootstocks

Details on sap flow measurements in this year are presented in fig 3

Although we did not have this year as detailed data as in last year, still very clearly the major finding that by early June apple trees reach their maximal level of transpiration has been observed this year too In spite of the very warm summer with pan A evaporation values reaching 14 mm a day (compared to less than 12 In 1997), no increased transpiration was noted after the beginning of June (160 -170 days of the year) This verifies last year observation

Discussion

An advantage to the dwarfing M9 rootstock was noted with regards to its better water use efficiency due mostly to the lack of biennial bearing in this rootstock The limited vegetative growth is probably one element in a better flower bud differentiation

Although the yields were not very high they were excellent by any commercial standard The drawback o this rootstock was very well manifested in 1998 by the sunburn damage resulting from direct insolation and heating of fruit tissues to damaging levels A need for protecting fruit from direct exposure to the sun during the summer period seems indispensable

Another very clear effect of no added water use after early June was shown again indicating that fruit development does not have an added requirement and that probably vegetative growth is the critical element in increasing water requirement by the tree Even in the warm 1998 although the level of transpiration recorded was considerably higher than in 1997, still maximal levels of sap flow were recorded already by early June This has a bearing on orchard irrigation practices With the critical shortage of water imposing heavy cut on farmer water allocation already in 1999 this finding may save considerable amount of water if no added water in the season up till fruit harvest in August-September will be applied

Table 1 Yields, water use and water use efficiency in Golden Delicious apples grafted on three rootstocks Yields are in Tons per Dunam (1/10 of hectare, Water use in mm and water use efficiency in liters of water require to produce one kg of fruit)

(Litres/kg)	Water used by trees			Yield (Tons/ Dunam)			Water use efficiency		
Rootstock	1997	1998	Combined	Yield 97	Yield 98	Combined	1997	1998	Combined
Hashabi	811	861	1672	13 0	0 0	13 00	62 4		128 6
MM106	792	1115	1907	14 6	0 0	14 60	54 2		130 6
M9	571	699	1270	7 0	6 7	13 69	81 6	104 4	92 7

Table 2 Fruit color and sunburn damage in Golden Delicious apples harvested in 1998

Rootstock	year of start	Green	Green/yellow	Yellow	Sunburn
M9	1998	1 2	25 9	4 3	68 1
M9	1997	0 6	30 9	2 8	65 6
MM106	1998	2 0	56 6	4 0	37 1
Hashabi	1998	0 7	58 7	1 3	39 2

Figure 1 Yield in the experimental trees in 1998 Out of the examined trees in 1997 only M9 was yielding in 1998 (1 Dunam = 1/10 Hectar)

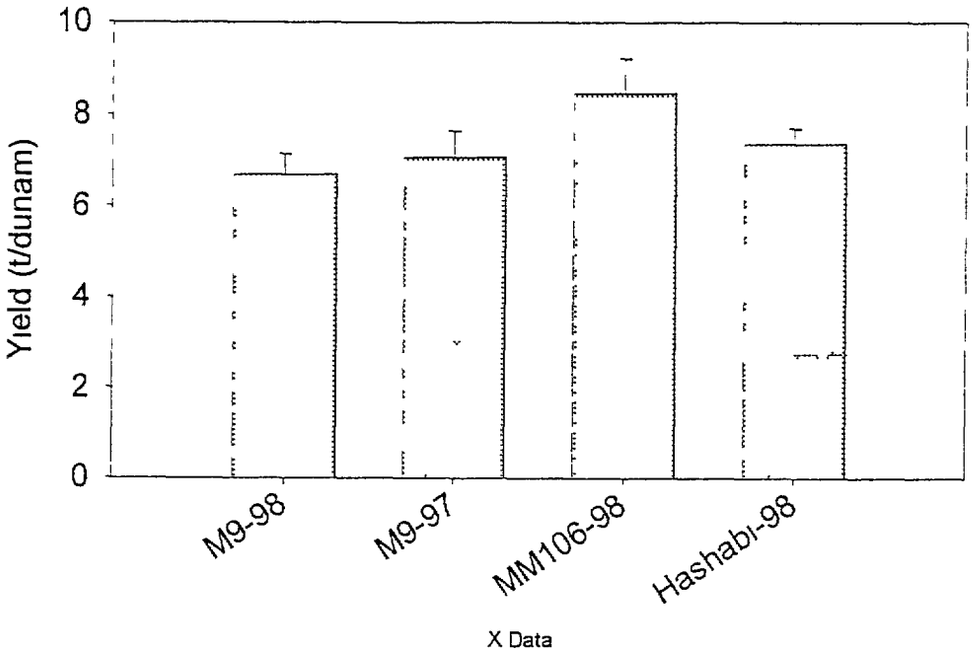


Figure 2 Fruit size distribution in yield of 1998

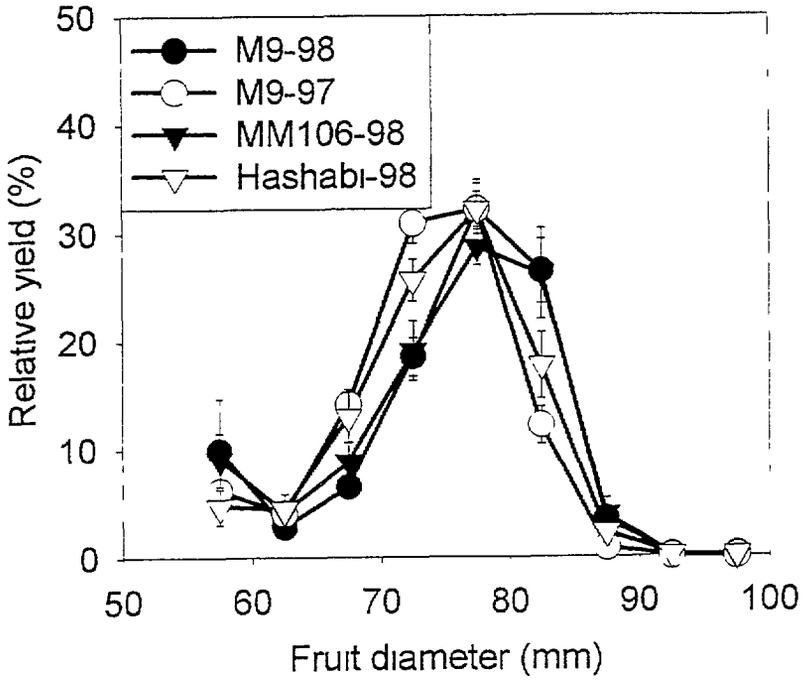
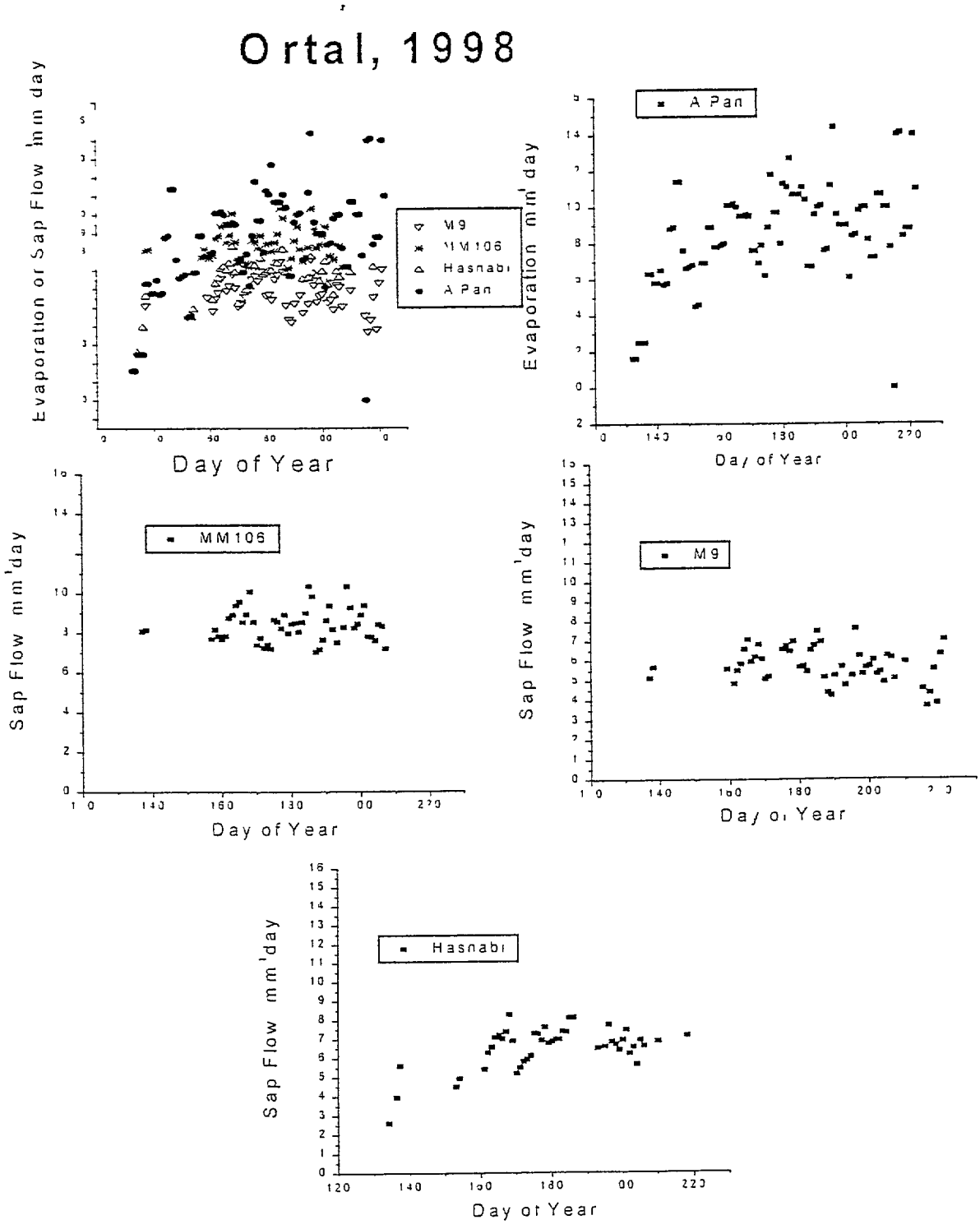


Figure 3 Orchard transpiration at Ortal in 1998 Measurements were made on 15 trees of each rootstock with sap flow meters Standard error of the means is approximately 10%



C Scientific impact of the collaboration

During the 3rd year of the project, a visit by the Israeli principle investigator to Kazakhan for a period of one week during May 1998 took place The visit was timed to explore the problem arising from sociological changes taken place by dividing the Sovhoz state farms to the individual farmers This act that caused a loss of control by the Kazakh Institute of fruit Growing and Viticulture on its farms led to a state of anarchy where all equipment could be stolen and even young trees were pulled out of ground in experimental plots On top of that, transportation means by the Institute became very limited and as the project could not help in buying a car we were looking for other better adapted plots for the planned experiments Especially important was the choice of location for the irrigation experiment as a lot of effort was put in buying and shipping the equipment as well as training Kazakh researchers in using it We have found two location one in a private farmer orchard for the irrigation experiment and another in a small mountain farm for the rootstock comparison trial Both locations much closer to Almaty where the Institute is located
In spite of the difficult times going over Kazakhstan in general and the Research Institutes in particular, we are able to conduct the proposed experiments as planned albeit with a certain delay due to mostly objective factors By approving a continuation of the project for another year, there is very good possibility that better results will be obtained in Kazakhstan The connection between the researchers was strengthened during the last year, continuous connections by fax as well as by e-mail recently help in improving the collaborative work

D Describe the project Impact

The mutual visits of researchers strengthened the connections between the Israeli and Kazakh parties involved in the project Operating the experimental irrigation trial will expand the experience of the Kazakh researchers in this important aspect of high quality fruit production where added irrigation is normally a requirement

In Israel this year, a possible implementation of the reduced water application in the 6 weeks prior to fruit harvest, as suggestion by results from this project will be implemented

Two dwarfing rootstocks imported from Kazakhstan to Israel were diagnosed virus infected and arebeen treated by heat therapy to obtain virus free material

E Strengthening of Developing Country Institution

Both the equipment bought through the project and the exchange of personnel strengthened the Kazakh Institute The opening to western approaches to fruit orchard management The visits done and scheduled for 1999 to Israel will broaden the view of

the Kazakh researchers and enable to further continue such collaboration in new proposals

Future work

The fourth year will be the final year of the project During this year a visit of 2 researchers involved in the project is scheduled further increasing the ties between the researchers involved as well exposing the Kazakh researchers to the Israeli fruit growing industry as well as research In Israel a possible implementation of the water use regime discovered by this project will be tried in face of a strict water shortage in 1999

Section 2

A Managerial issues

See above under Executive summary '

B Collaboration Travel training and publication

Travel

A Erez visited for one week during May 1998 Kazakhstan He visited the experimental plots in Dzandosov and Gigant The plot in Dzandosov was found OK although there was noted there damage to young growth by winter frost The experimental plot in Gigant had to be replaced The rootstock trial was moved to another, safer location while the irrigation experiment that was planned to be performed there was moved to another location to a private grower s orchard

A visit of 2 researchers from Kazakhstan is planned for May 1999 Dr Kutsokov and Dr Bondartsev are due to come to Israel and study training and irrigation-fertigation practices as well as see experiments in these fields in Israel