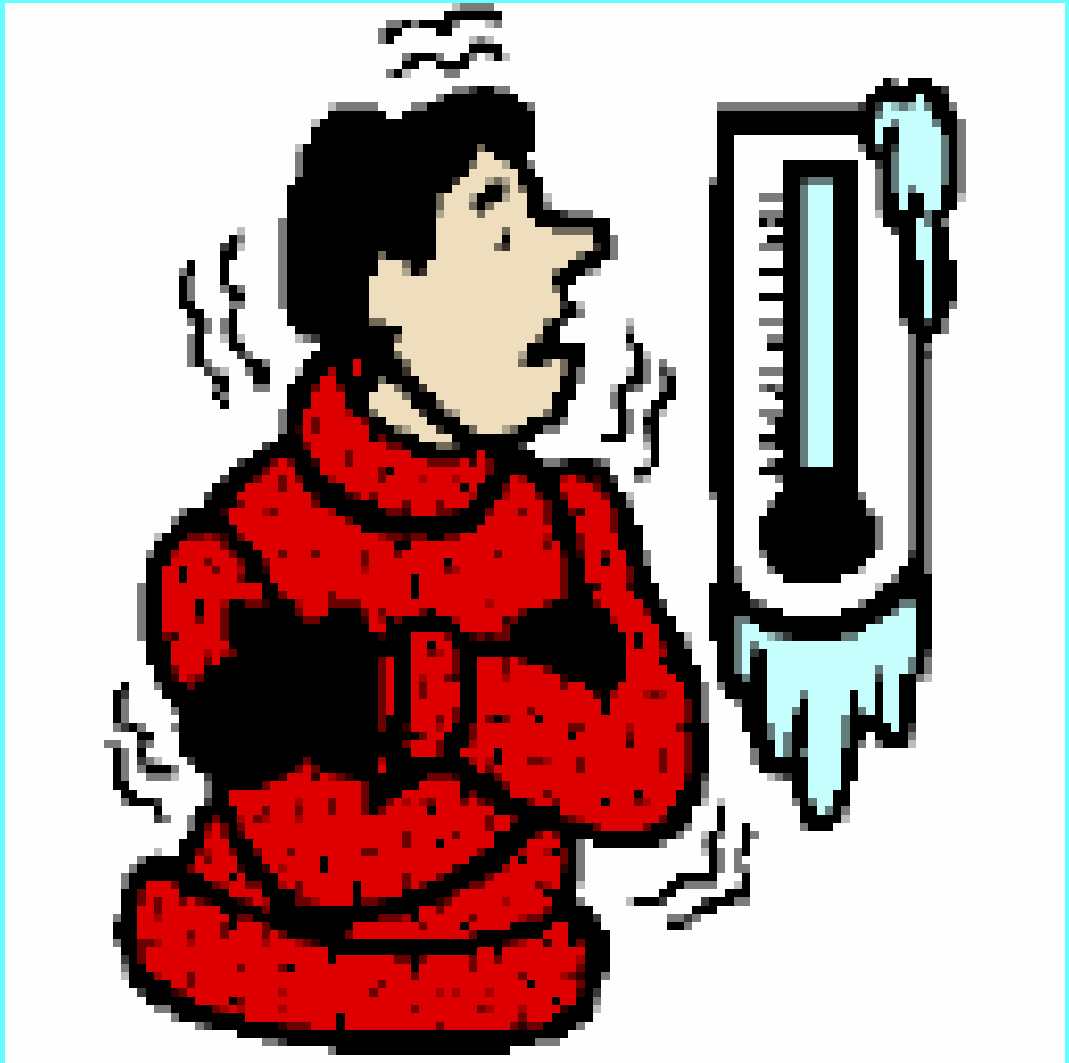
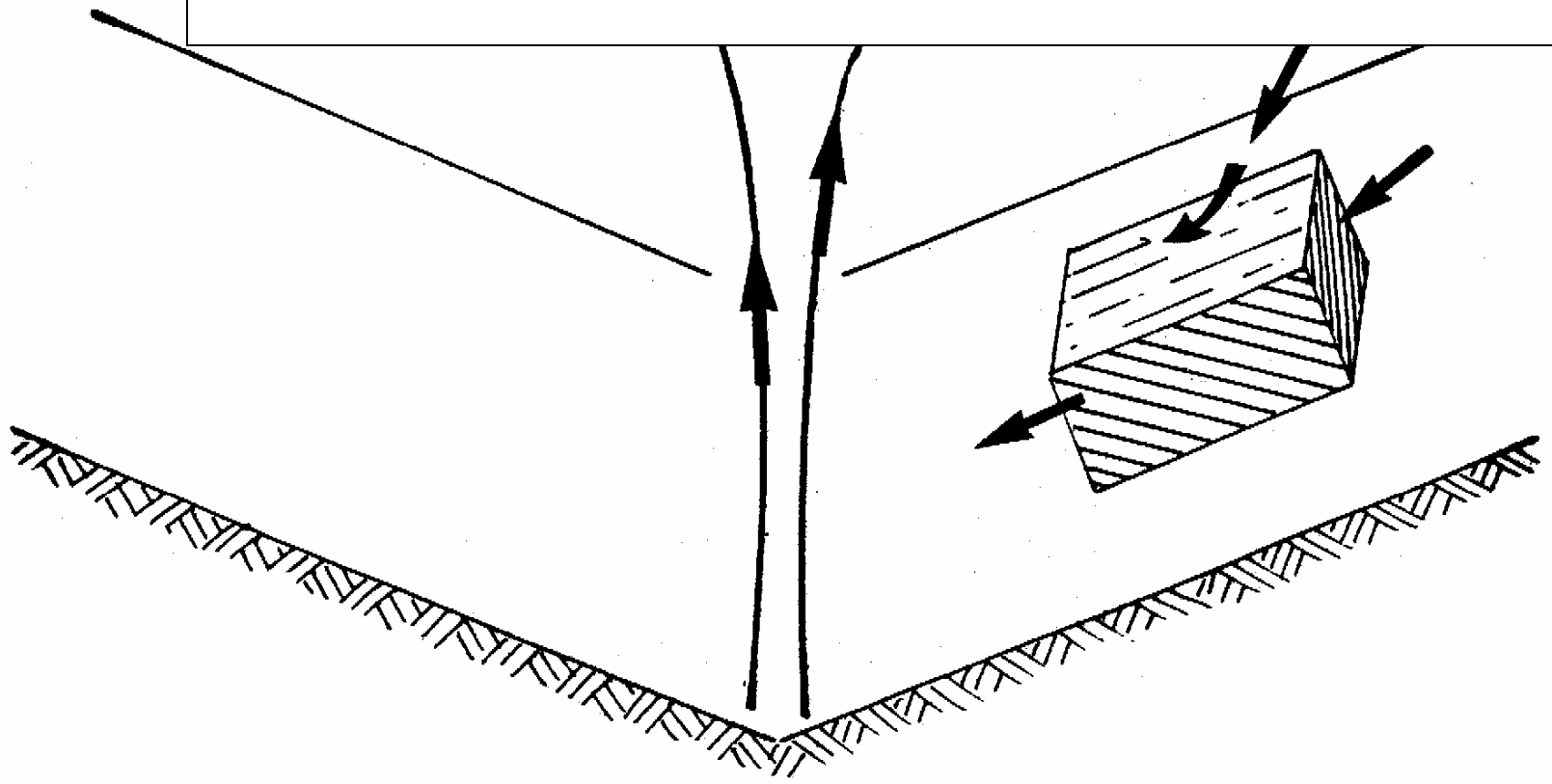

Frost
and the prevention
of frost damage



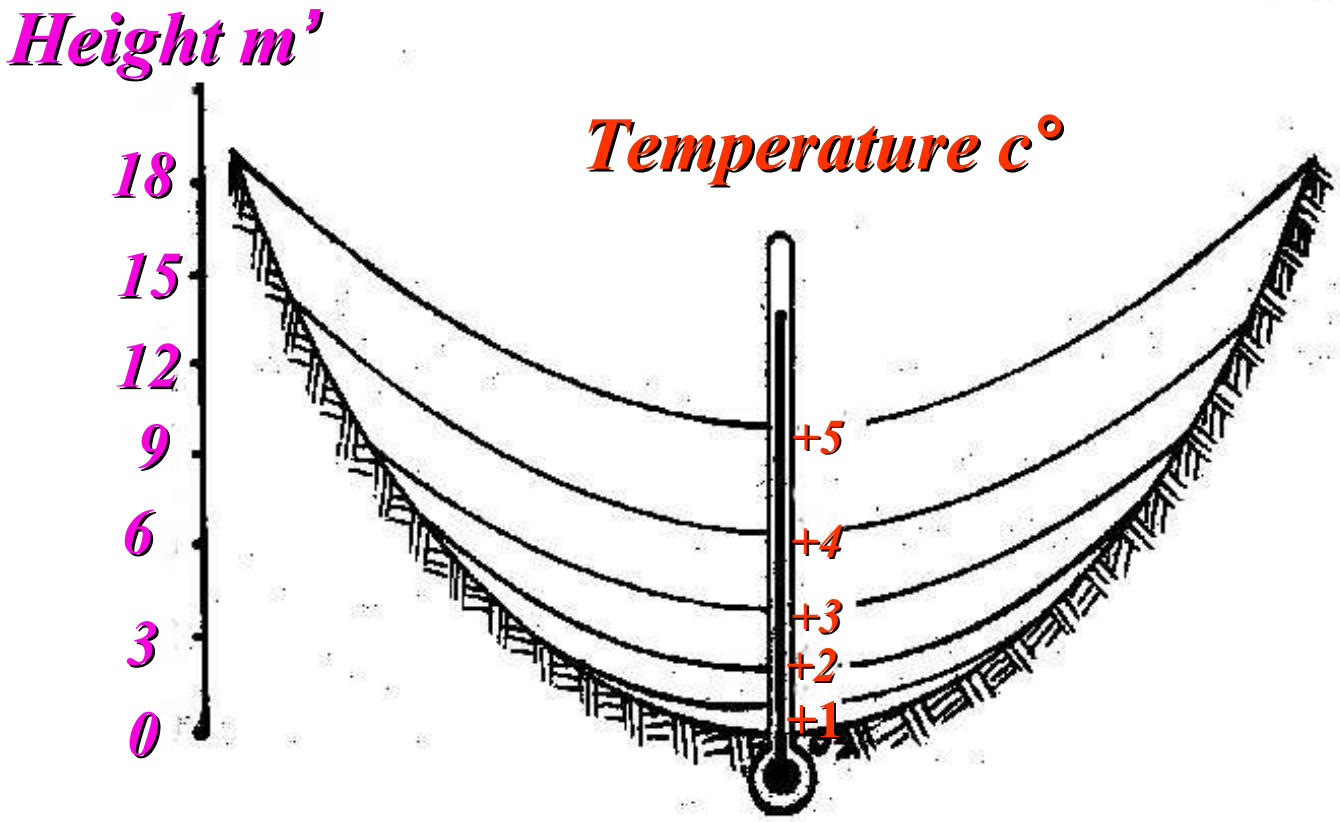
Three types of frost events

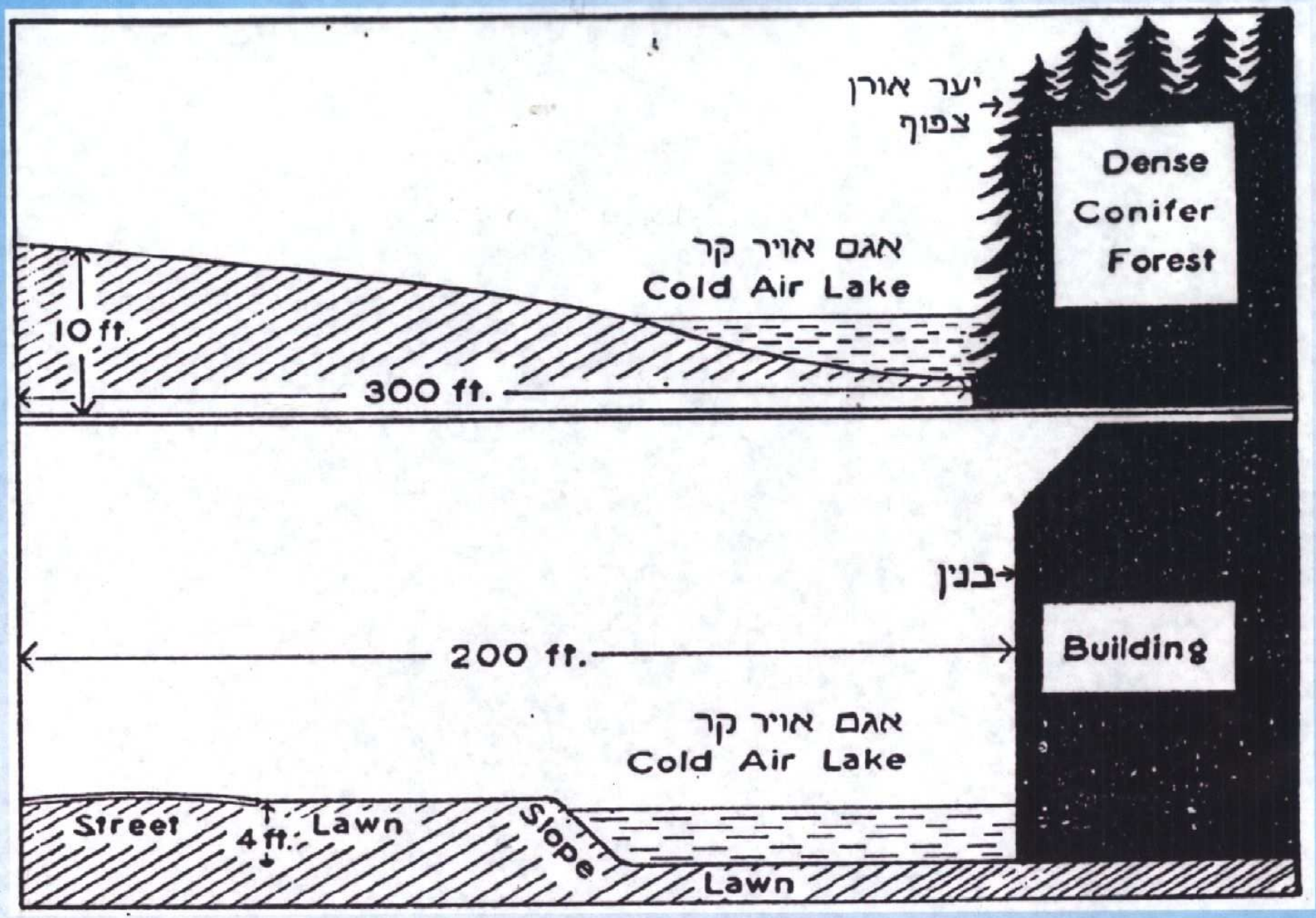
- Radiation cooling nights- The most frequent. Occurs during cold, dry (low humidity), clear (no clouds) and quiet (no wind) nights.
- Advection- Frost caused by the flow of very cold air into the area after the pass of a cold front. Effects mainly high areas (mountains & hills).
- Combination of cold air advection & radiation cooling. The most severe frost !!!

Cold & heavy air falls down to low lying places



Temperature inversion

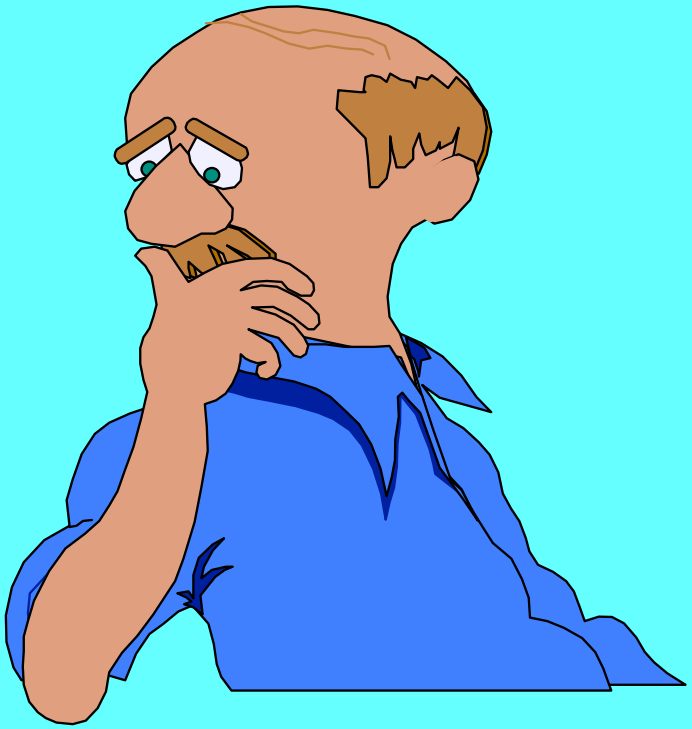


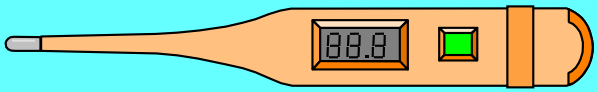


Profiles of frost pockets behind obstacles stopping flow or cold air

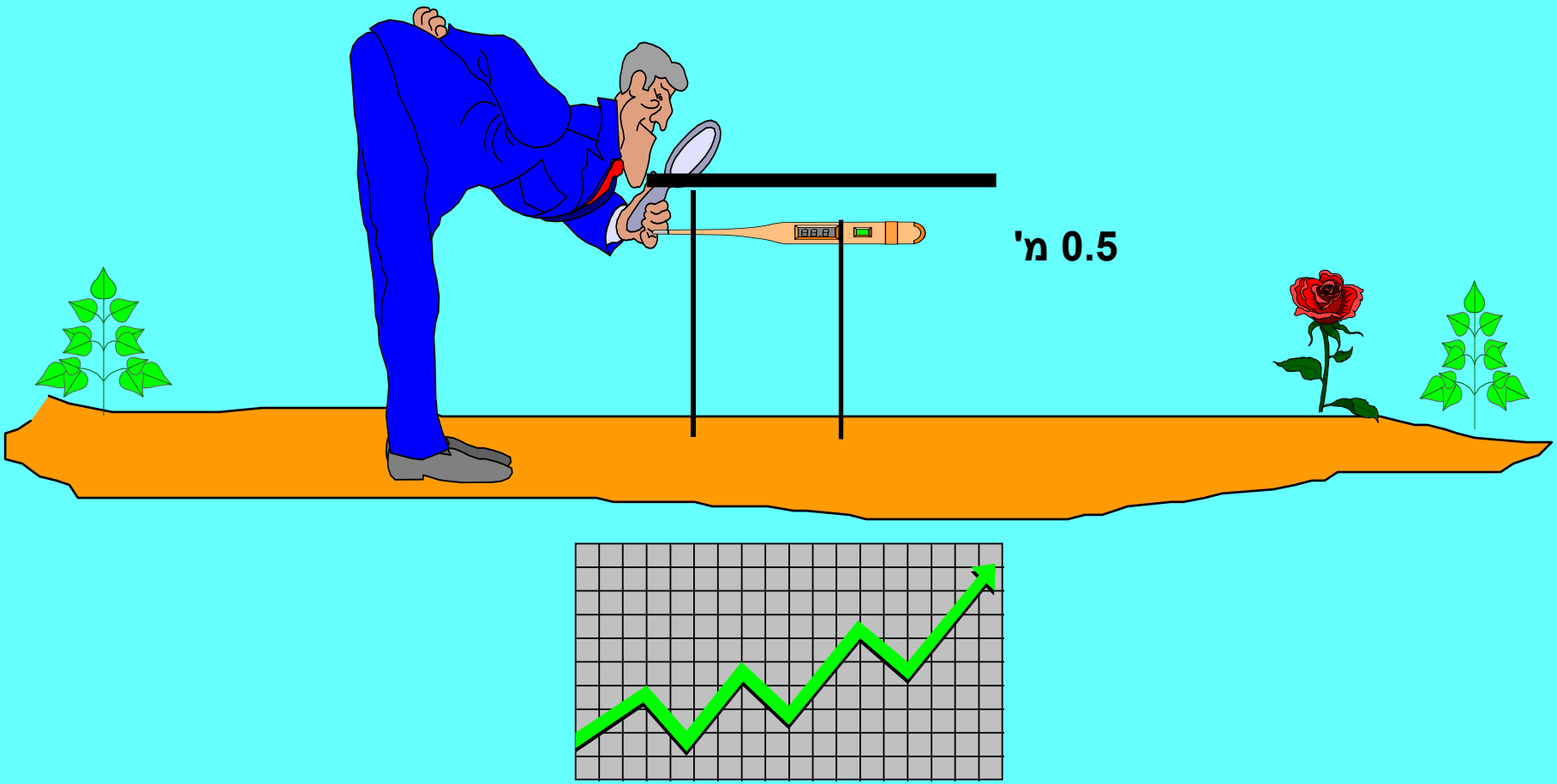
Accumulation of cold air pockets Behind natural obstacles

How to measure the temperature



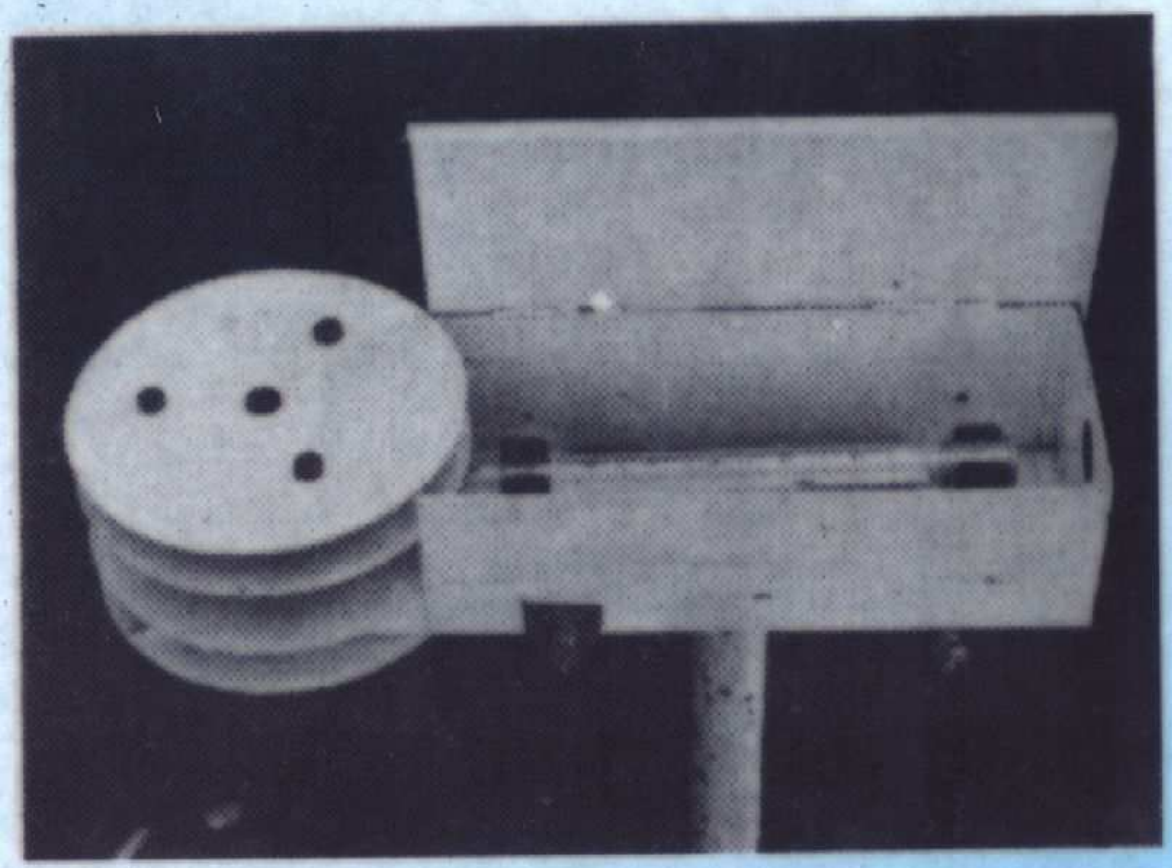


Measuring Min Temp'



Topoclimatological stations measuring min temp'

An open topoclimatological station



סוכה טופואקלימית פתוחה
(גובה - 50 ס"מ)

Automatic meteorology station

Tel mond

Frost damage

- Light frost- Damage to leaves & flowers.
- Serious frost- Damage to fruit leaves and trunk. (total crop loss).
  - Sometimes the damage at first is not visible. Later the damage occurs in quality and quantity of the crop.

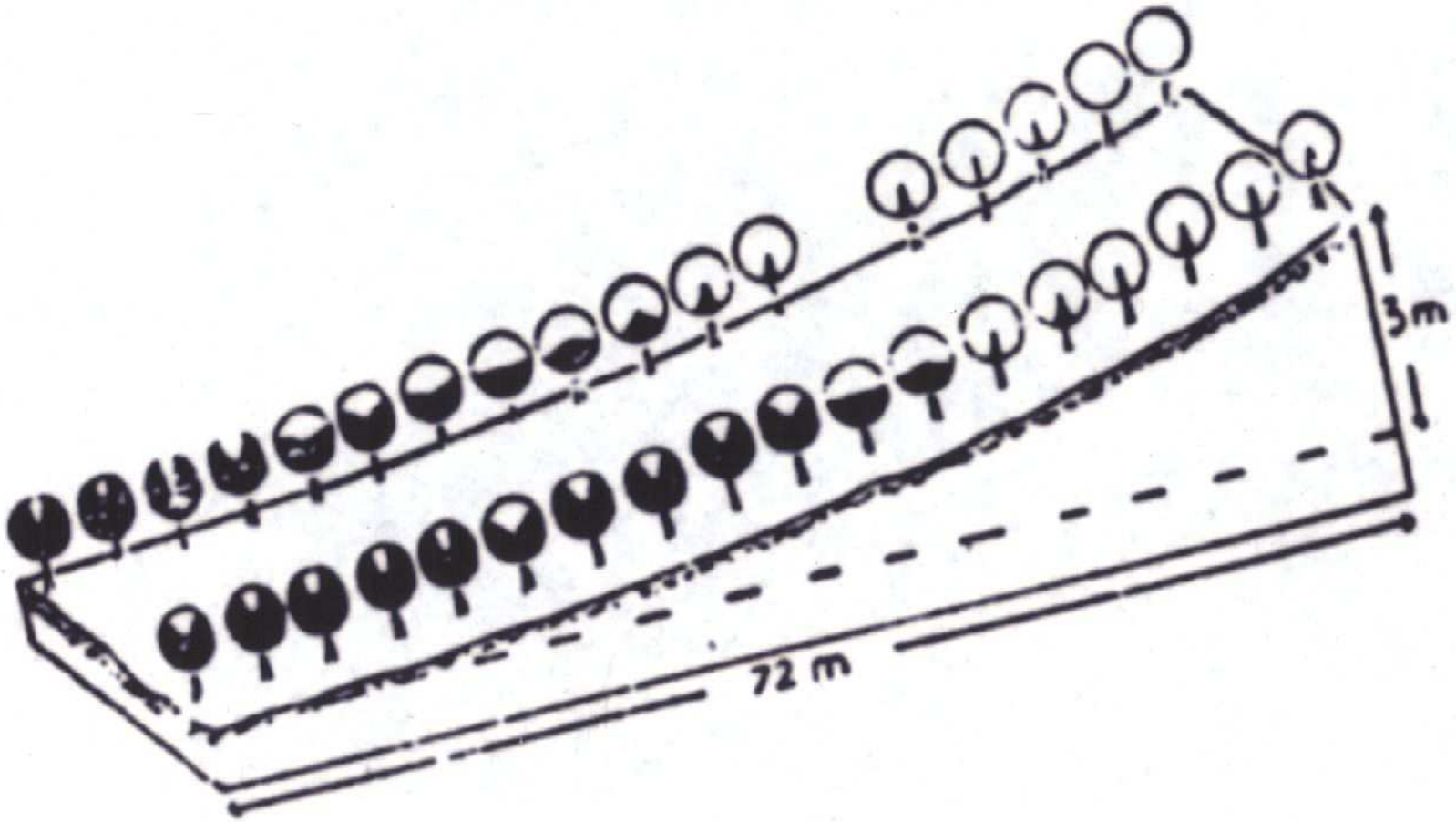
Frost intensity factors

- The temperature- The colder it gets the damage to the crops increases.
- The duration- The amount of time the crop has to suffer sub zero temperatures.
- Variety- Different resistance levels.
- Age – Young trees are very sensitive to frost.
- Phase of development- trees are more sensitive during flowering and fruiting.
- State of the tree- Healthy and well looked after trees have a better chance of survival.

Resistance of crops to frost in different development phases

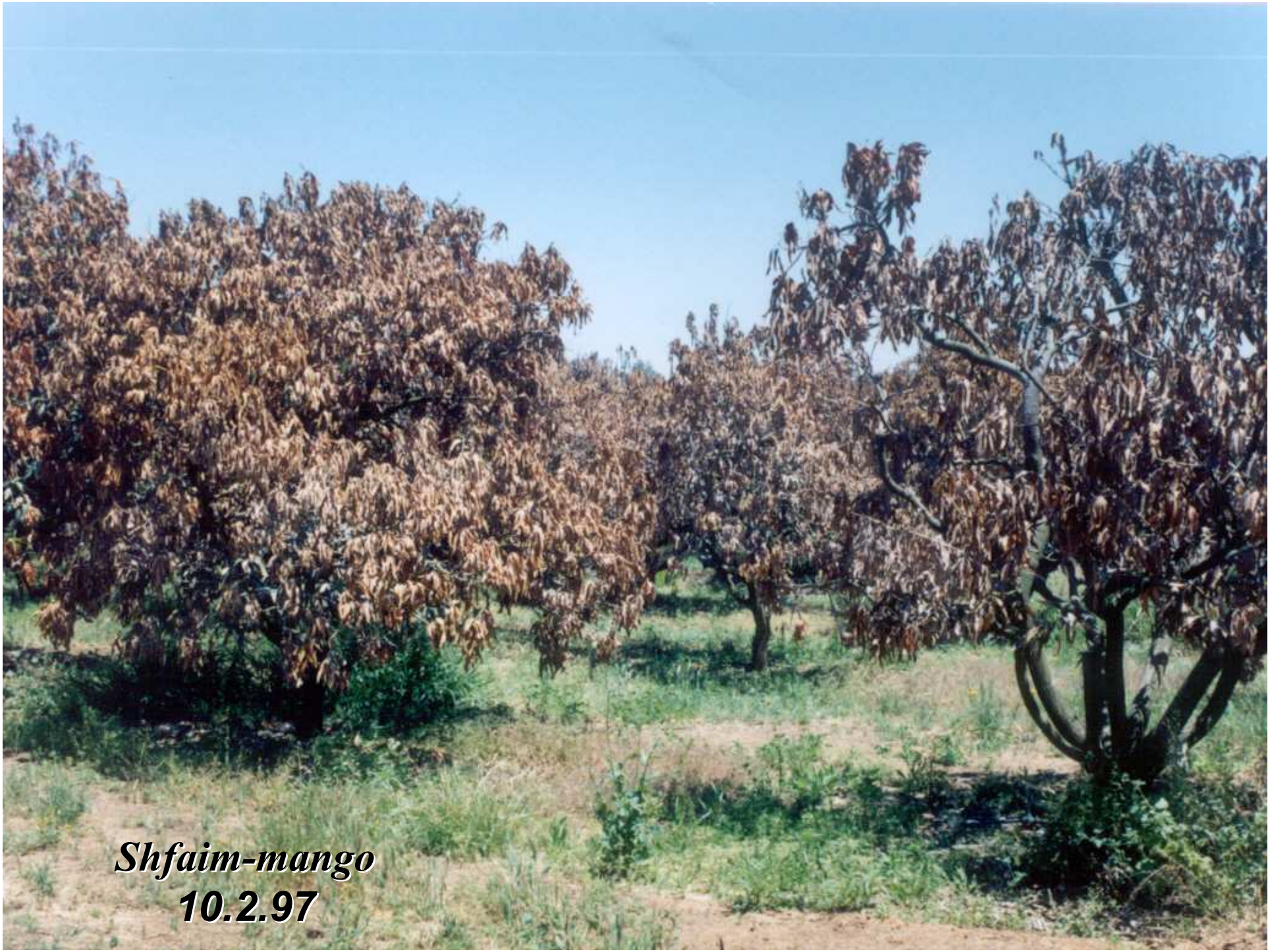
	HARMFUL TEMPERATURE (DEGREES BELOW 0°C)		
	GERMINATION	FLOWERING	FRUITING
Highest resistance			
Spring wheat	9–10	1–2	2–4
Oats	8–9	1–2	2–4
Barley	7–8	1–2	2–4
Peas	7–8	2–3	3–4
Resistant			
Vetch	6–7	3–4	2–4
Beans	5–6	2–3	3–4
Sunflower	5–6	2–3	2–3
Safflower	6–4	2–3	3–4
Flax	5–7	2–3	2–4
Sugar beet	6–7	2–3	–
Carrot	6–7	–	–
Medium resistance			
Cabbage	5–7	2–3	6–9
Soybean	3–4	2–3	2–3
Italian millet	3–4	1–2	2–3
Low resistance			
Corn	2–3	1–2	2–3
Millet	2–3	1–2	2–3
Sudan grass	2–3	1–2	2–3
Sorghum	2–3	1–2	2–3
Potato	2–3	–	1–2
No resistance			
Buckwheat	1–2	1–2	0.5–2
Castor bean	1–1.5	0.5–1	2
Cotton	1–2	1–2	2–3
Melons	0.5–1	0.5–1	1
Rice	0.5–1	0.5–1	0.5–1
Sesame	0.5–1	0.5–1	–
Peanut	0.5–1	–	–
Cucumber	0–1	–	–
Tomato	0–1	0–1	0–1
Tobacco	0–1	0–1	0–1

Proportion of young peach fruits (black) frozen on a slope in May 1957



The effect of topography

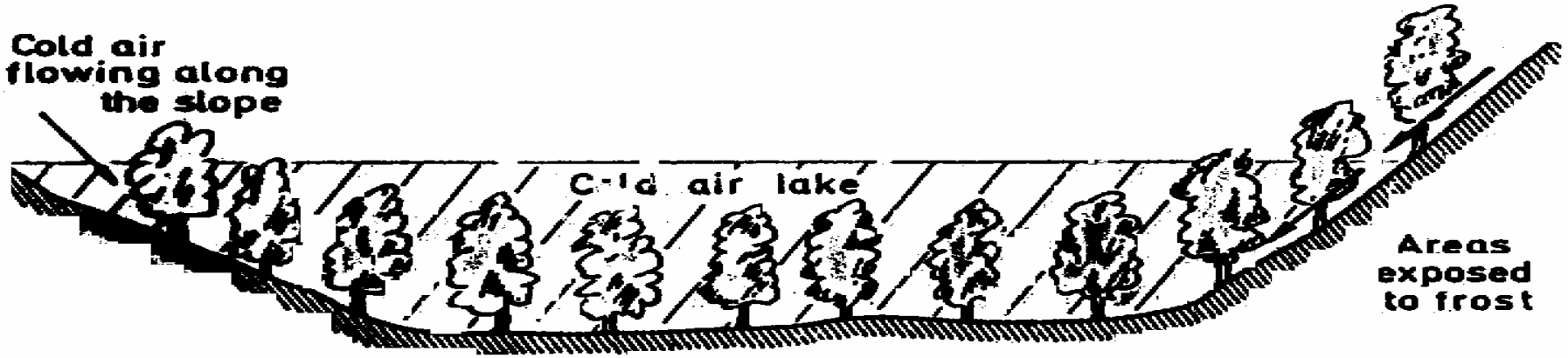
Potato's Kfar Saba 6 -9.2.97


Shfaim-mango
10.2.97

Mango-effect of the slope (topography)

3 - 8.2.89 ,5.1.89

Moshav Mishmeret



Cold air lake and danger of frost

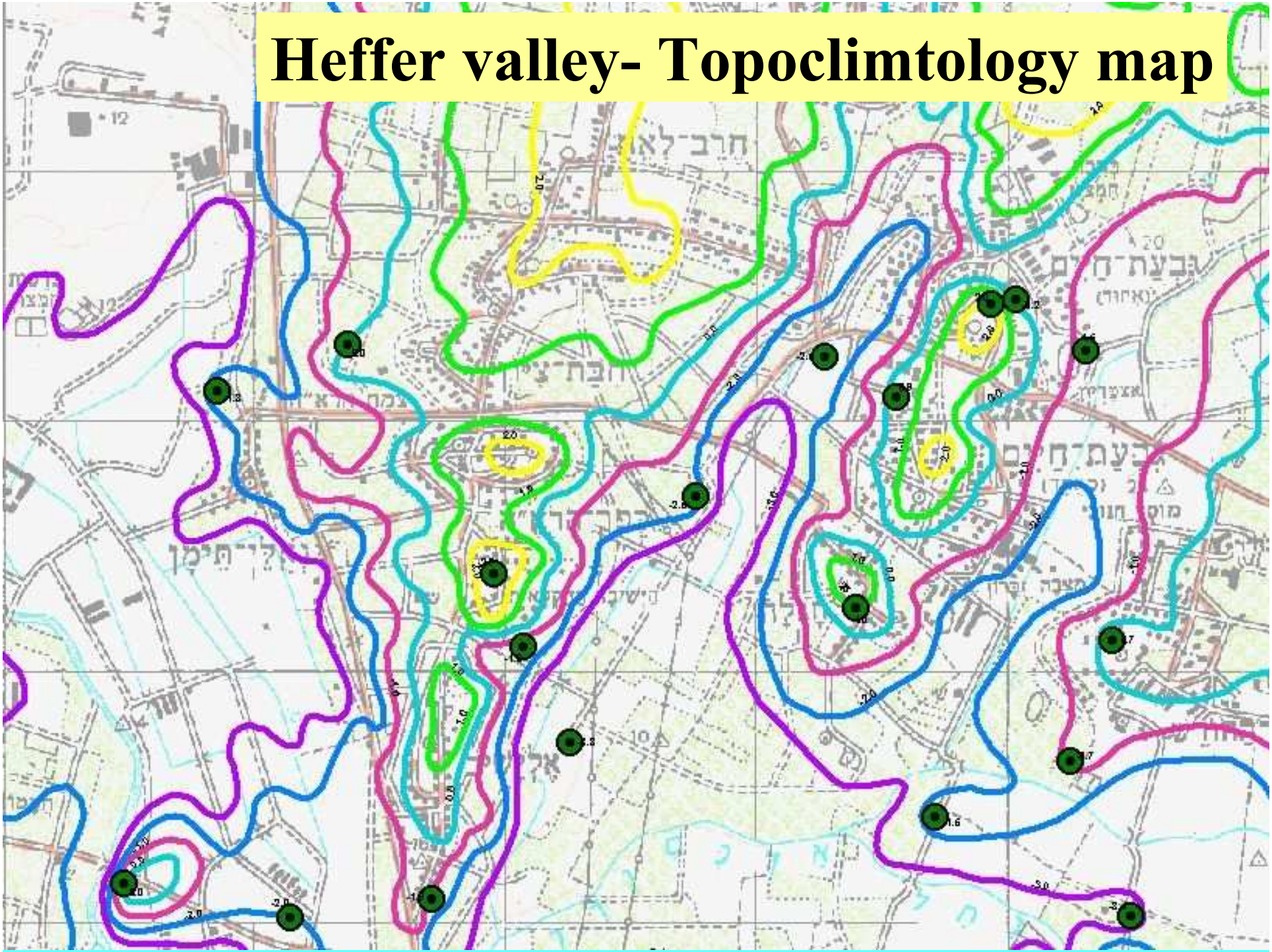
Passive methods protecting orchards from frost

- Topoclimatical mapping- In order to examine the influence of a regions topography on the minimum temp' regime, an agro- topoclimatological survey must take place. Low lying Areas with poor air drainage, have the highest frost frequency.
  - Don't plant trees in frost prone areas !!!
  - Choice of crop according to it's resistance level.
- Weeding around trees.
- Covering young tree trunks with an insulation layer up to a height of 30 c"m.
- Creating openings through natural wind breakers allowing the flow of air past the low end of the field.

Criteria's for choosing radiation cooling nights

- The minimum screen temp' (2m') is 5° and below.
- The difference between the screen and the topoclimatic station (0.5m') is 0.9° and above.
- Low cloudiness' less than 3/8.
- Wind up to 3 knots (1.5m/s).

Heffer valley- Topoclimtology map



Average annual amount of low temperatures and there Duration In reference to Bet Dagan.

Topoclimatology Iso lines										Temp' Celsius
									Element	
-3	-2	-1	0	1	2	3	4	5		
75	57	41	28	16	8	4	2	1	Cases	< 5
490	338	214	128	66	34	17	6	3	Hours	
34	22	12	6	3	1	1	עד אחד	0	Cases	< 2.5
171	97	50	25	11	4	2	1	0	Hours	
8	4	2	1	1	עד אחד	0	0	0	Cases	< 0
34	17	6	3	1	עד אחד	0	0	0	Hours	
4	2	1	1	עד אחד	0	0	0	0	Cases	< -1.0
17	6	3	1	עד אחד	0	0	0	0	Hours	
2	1	1	עד אחד	0	0	0	0	0	Cases	< -2.0
6	3	1	עד אחד	0	0	0	0	0	Hours	

Active methods protecting crops from frost

- Heating- special orchard heaters, or making local fires using liquid or solid fuels. A very expensive and inefficient method.
- Air mixing- Very useful but costly method.
- Irrigation- the most effective and cost worthy method:
  - Sprinklers- spraying water over the canopy.
  - Micro sprinklers inside the canopy.
  - Watering under the canopy- less effective but still better than nothing.
- Shade nets- Help slowing down the radiation cooling process.

Active methods

The effect of sprinklers, protecting crops from frost

Moshav Mishmeret **8 -10.2.97**

Irrigation application rates above the canopy During different temp' & wind conditions

Irrigation rate	Wind	Air temp'
m"m/hour	M/sec	Celsius
2.5-2.1	0.5	-3.5--2.5
3.5-2.5	2.5-1.4	
4.6-3.5	0.5	-5.1--4.7
5.6-4.6	2.5-1.4	
6.6-5.6	0.5	-8.8--7.2
7.6-6.6	2.5-1.4	

Wind mill – Kibutz Ortal (Golan heights)

Protecting frost damages in green houses

- Passive methods:
- Locating green houses according to the topoclimatological conditions.
  - Building with the right type of materials.
  - Placing thermometers inside and outside of the greenhouse.
- Active methods:
  - Monitoring weather conditions. (thermometers & met office)
  - Open irrigation system during the afternoon.
  - Open sprinklers when temp' outdoors drops to 2 c°.
  - Opening and closing of the greenhouse.