data from the previously drip-irrigated strip (Table 3) show that the salinity level did not exceed that which was obtained after leaching by sprinkling (Table 5), except in the 0-5 cm layer where the problem of salinity increases following drip-irrigation. Although leaching of the strips was not advantageous, leaching of the spaces significantly increased plant growth and yield. Thus, after a fall melon crop, leaching may be desirable, particularly in the area between the cultivated strips.

Salt accumulation distant from the drip lateral is problematic, regarding total concn and relative concn of the various ions. In this regard, these points are important: water obtained from the Yotvata pipeline contained at least 14 meq Na/liter, and due to the nature of water distribution by the drip method and duration of irrigation, the distance of ion movement will differ from season to season, and the relative concn of the ions will also differ over this distance. This aspect is important where evaporation and salt accumulation is high. Preliminary results show the SAR in the 0-5 cm layer increases with distance from the emitter, due to an increase of Na in relation to Ca + Mg (Table 6). This condition is liable to cause dispersion of soil aggregates and to seal the upper soil layer. It is possible that these factors were partly responsible for the poor results obtained in the spaces compared to the strips.

The problem of sanitation may arise if crops are repeatedly located on the same strip, especially if they are the same or closely-related crop. This aspect is also being examined in a separate experiment.

Table 5. Soil analysis (1:1 soil-water extract) in the 2 perpendicular strips after being leached by sprinkling with 200 mm of water and prior to seeding of the corn.

Sampling location	Soil depth (cm)	E.C. (mmhos/cm)	Cl (meq/L)	Na (meq/L)
In the previously drip-irrigated strip	0-5	1.96	7.5	7.8
	15	1.39	4.6	5.2
	30	1.54	5.2	5.5
	45	1.75	5.9	6.9
In the previously non-irrigated spaces	0-5	1.98	4.7	5.5
	15	2.62	6.2	8.8
	30	1.99	4.1	6.0
	45	1.63	4.1	5.7

Table 6. Soil analysis (1:1 soil-water extract) following harvest of the drip-irrigated corn crop.

Sampling location	Soil depth (cm)	E.C. (mmhos/cm)	Cl (meq/liter)	Na (meq/liter)	Ca+Mg (meq/liter)	SAR
In the corn rows	0-5	2.39	5.7	7.6	30.7	1.93
	15	1.18	5.0	5.9	27.6	1.70
	30	1.06	4.6	5.2	7.7	2.86
	45	1.08	4.4	5.0	7.4	2.72
Between the corn rows	0-5	29.60	382	200	196	22.00
	15	4.40	21.9	21.6	48.4	4.39
	30	3.88	15.8	14.0	41.5	3.09
	45	3.77	13.8	14.7	41.1	3.22

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Fumigation of Soil Strips through a Drip Irrigation System[1]

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Additional index words. tomato, *Lycopersicon esculentum*, methyl bromide, broomrape, *Orbanche* spp.

Abstract. **In the Arava desert of Israel, a drip-irrigation system was used to fumigate the soil with methyl bromide for weed control prior to seeding tomatoes. Treatments employed were 2 non-fumigated controls, one with and another without plastic covering, and 3 fumigant applied treatments, all with plastic covering but differing in method and time of aeration. Tomato yields and weed control were significantly higher in fumigated soil although within the various methyl bromide treatments weed control results were similar. Testing for uniformity of methyl bromide gas flow revealed considerable differences in residual bromine occurring between the beginning and the end of the drip lateral. By using an inlet pressure of 0.5 – 1.0 atmospheres, minimal pressure drop along the line was achieved.**

Numerous studies have shown the effectiveness of methyl bromide in controlling nematodes, soil fungi, weeds, parasitic plants and soil insects (1, 3, 8), and many crops produce greater yields after soil fumigation (2, 4, 6, 7). However, methyl bromide does not totally eradicate all pests. Some weeds (e.g. *Malva, Erigeron* and certain legumes) are unaffected, as are a number of soil-borne diseases. Nevertheless, its effectiveness is sufficiently broad to justify its use in most cases. An important advantage of methyl bromide for weed control is the reduced danger of a residual effect compared to many other herbicides. A disadvantage is that the continued use on the same field may favor a multiplication of resistant weeds.

There are indications that increased crop yield after methyl bromide fumigation is due not only to the direct control of diseases, parasites and weeds, but also to the enhanced uptake of important minerals. Segelman (8) suggested that while fumigation destroys the nitrification bacteria, their regeneration is rapid due to the suppression of competing bacteria populations. McCants, et al. (5) reported there was a reduction in the efficient utilization of ammonia fertilizer after soil fumigation possibly due to reduced nitrification bacteria populations.

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A limited number of vegetable crops, mainly of the *Solanaceae* family are produced in the Arava desert of Israel. These are frequently planted on the same field year after year. It is also customary to apply large amounts of manure brought in from other regions. After a few growing seasons yields drop and fields become weed infested. Soils are usually fumigated to eradicate weeds and pathogenic organisms. Row crops are drip-irrigated, and the cultural practices of tillage, irrigation, and fertilization are restricted to the wetted strip (10). Under these conditions it was considered worthwhile to explore and study the possibility of accurately applying the fumigant within this strip by means of a drip-irrigation system.

The study was conducted at the Eilot Regional Council Experiment Farm at Yotvata, Israel, on a loamy sand during 1971-72. Six replicates of the following 5 treatments were examined using a randomized block design:

1. No fumigation, no ground cover (Control A).
2. No fumigation, transparent polyethylene cover as a mulch throughout the entire season (Control B).
3. Fumigation, plastic cover removed for aeration 2 days before seeding.
4. Fumigation, plastic cover; holes cut into the plastic cover (where plants were to be located) 2 days after fumigation, and the cover removed 2 days before seeding.
5. Fumigation, plastic cover; complete removal of cover 2 days after treatment, 17 days before seeding.

The drip emitters used had a minimal discharge of 2 liters/hr and were spaced every 0.5 m along the lateral. Each lateral was 42 m long, and the lines were 1.8 m apart. Each plot was 20 m long, of which 10 m was used for data measurements. The polyethylene was 0.03 mm thick and 1.1 m wide.

Fumigation was carried out on August 22, 1971, using the hot gas method. Methyl bromide in compressed liquid form was passed from the cylinder through an evaporator consisting of coiled tubing immersed in water heated to 70-90°C, from which the gas passed directly into the drip system. Gas transfer was carried out at an arbitrarily selected pressure of 2.5-3.0 atm and the amount applied was based on 60 kg of fumigant per 0.1 ha of treated surface area.

On Sept. 10, 1971, 19 days after fumigation, tomatoes (*Lycopersicon esculentum* mill. cv Arava S-5) were sown in double rows, one row on each side of the drip lateral. Plants were later thinned to 40 cm in the row.

Weed and broom-rape populations were counted. Tomato yields were weighed from 6 pickings. The residual content of methyl bromide in the soil was determined in laboratory tests. Tests were also made to determine the optimum pressure required at the head of the system in order to obtain the smallest possible pressure differences throughout the laterals and thus guarantee uniform distribution of the fumigant.

The effect of the different treatment effects on the cumulative yield during the picking season are shown in Table 1. The effect of soil fumigation was cumulative and persisted throughout the entire season. The 3 fumigation treatments were significantly different from the 2 non-fumigation controls, and the difference increased with each succeeding picking. However, there were no significant differences between the fumigation treatments themselves.

To evaluate weed control, the following were counted in each plot over a 2 m length: *Malva* spp., *Chenopodium* spp., *Amaranthus* spp., *Tribulus* spp., and *Orbanche* spp. (broom-rape). Since broom-rape control was an important objective of the fumigation treatments, populations of these plants were counted at specific distances from the drip lateral (Table 2).

No significant differences in total weed count occurred between the various fumigation treatments, that is, the method of soil aeration after the methyl bromide application had no effect on the results. It is of practical importance that the method of aeration after methyl bromide application had no effect on weed counts. Weed counts were discontinued in the non-fumigated plots since the weeds were uncontrolled and had to be removed to allow tomato plants to produce a yield. Broom-rape sensitivity to methyl bromide fumigation was evident by the significant difference in the total number of broom-rape plants between treated and non-treated areas.

Leaf tissue microelement content comparisons were made between fumigated and non-fumigated plants. Methyl bromide treatment significantly increased Fe and Zn uptake and resulted in a more desirable Fe/Mn ratio in the plant tissue (Table 3).

No significant differences due to fumigation were found in soil microelement content. Consequently, it appears that methyl bromide treatment increased Fe and Zn availability to the plant. The difference in the Fe/Mn ratio is attributed to the change in Fe content rather than Mn. The importance of this parameter has been pointed out by Stile (9). Indeed, plants growing in the non-treated plots were chlorotic, whereas those growing in the treated soil had a healthy appearance.

Soil tests made after methyl bromide treatment showed residual soil bromine content differences of 20% between the beginning and the end of the lateral. To correct such differences, a trial was conducted using a 50 m line with 100 two-liter/hr emitters. Various pressures were applied at the inlet, and the pressures at the center and end of the

Table 1. Soil fumigation effects on cumulative tomato yield.

	Cumulative tomato yield (kg/plot)						
	Treatment no.						
Date	1	2	3	4	5	SD	F-value
Jan. 24	0.14	0.64	4.97	2.88	2.47	2.33	4.12*
Feb. 4	3.01	1.96	12.61	9.49	9.83	4.91	5.38**
Feb. 18	10.48	6.77	31.26	27.22	31.11	11.52	6.32**
March 3	17.18	16.97	63.09	61.99	68.64	6.17	17.92***
March 15	34.58	23.70	82.64	88.86	95.55	17.94	20.71***
March 27	39.22	26.27	91.50	99.17	103.80	18.58	23.02***

*, **, ***Significant at the 5%, 1%, and 0.1% level, respectively.

Table 2. Soil fumigation effects on total weed and broom-rape populations.

Weed type	Distance from lateral (cm)	Treatment no. 1	2	3	4	5	SD	F-value
Total weeds		47.33	69.33	20.67	11.17	16.17	23.39	6.69**
Broom-rape	5	5.17	0.50	0.17	0	0.17	3.59	2.31
	10	3.50	15.00	0.17	0.17	0	14.69	1.16
	20	7.67	36.67	0.17	0	0.50	19.92	3.85*
	30	13.17	51.17	0	0	1.00	39.43	1.89
	40	8.17	25.83	1.83	0	0	6.60	16.55***
	50	16.50	14.00	0	0.17	0.50	19.38	1.10
	60	1.17	0.50	2.67	0.50	1.33	2.45	0.78

*, **, *** Significant at the 5%, 1% and 0.1% level, respectively

lateral were measured (Table 4). As the inlet pressure was increased, there was an increase in the pressure gradient along the line. In order to achieve a minimal pressure drop of about 10%, inlet pressures between 0.5 to 1.0 atm should be applied. Methyl bromide had no apparent effect on the plastic tubing of the system.

Fumigation increased tomato yields considerably over that obtained in the control. In addition to beneficial effects on weeds and broom-rape control, fumigation increased the Zn and Fe levels in tomato leaves. The greater mineral uptake in the fumigated treatments probably was due to increased availability, and improved root functioning after elimination of pathogenic influences and broom-rape competition.

If a crop is irrigated with a drip system, fumigation of soil strips on which plants are growing is possible by passing methyl bromide through the drip laterals. A system designed to distribute water uniformly would also distribute gas satisfactorily if proper pressure were used.

Improper fumigation may occur if there are leaks in the tubing or fittings, or if emitters are plugged. Fumigant may not reach high areas on poorly levelled fields. Careful removal of the plastic cover will avoid soil recontamination.

While this method of fumigation appears to be a suitable technique for soil treatment where drip irrigation is mainly used, it need not be the only method. If total field eradication of a disease or weed is required, other methods can be employed. However, the simplicity and convenience of this method and its low cost does enable the farmer to use it frequently and whenever circumstances justify its use.

Table 3. Soil fumigation influence on microelement content in tomato leaves.

Element	Content in leaves (ppm) Treated plots	Control plots	Significance
Cu	12.3	12.5	n.s.
Zn	24.7	20.3	*
Fe	115.0	90.8	**
Mn	28.2	28.2	n.s.
Fe/Mn	4.1	3.3	**

*, ** Significant at the 5% and 1% level, respectively; n.s. = not significant.

Table 4. Pressure (atm) differences in a 50 m drip lateral with 100 two-liter/hr emitters during the flow of methyl bromide.

Inlet	Center	End
0.5	0.45	0.45
0.8	0.6	0.6
1.0	0.9	0.9
2.0	1.5	1.5
2.5	1.8	1.0
3.0	2.5	2.0
4.0	2.0	1.8

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Effects of Ethephon on Yield and Quality of Winter Squash, *Cucurbita maxima* Duch.[1]

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Abstract. **(2-Chloroethyl)phosphonic acid (ethephon) applied at 2- to 4-leaf stages on winter squash cultivars 'Boston Marrow', 'Golden Delicious' and 'Hybrid 530' resulted in pistillate flowers at most early nodes, but these generally aborted. Ethephon applications usually resulted in greater numbers of marketable squash which tended to be smaller in size. The only instance of a significant yield increase occurred on 'Golden Delicious' with 2 applications of 150 ppm ethephon. Earlier appearing nodes on ethephon treated plants produced marketable fruit and harvest, based on external color, could have been made up to a week earlier. Presently, ethephon seems to be of limited commercial promise for winter squash under Arkansas conditions.**

Since 1963, winter squash has been produced in the Arkansas River Valley near Van Buren and in Northwest Arkansas for the baby food industry. Weather delayed plantings have resulted in unprofitable crops. In later plantings, squash usually bloom and set fruit under high temperature, longer daylength and higher solar radiation; conditions which favor fewer pistillate flowers. Cultivars and/or cultural methods that would assure good yields when later plantings are necessary would be valuable. Various cultivar and cultural studies have been conducted (1,2). Differences in yield performance exist among cultivars in later plantings, but for most cultivars both fruit no. and yields are lower compared to earlier planting dates (1), primarily due to the production of fewer pistillate flowers.

Ethephon has shown promise for increasing yields for various cucurbits through sex expression changes. In monoecious cucumber (*Cucumis sativus* L.) conversion from staminate to pistallate flowers at most nodes has been widely reported (3, 6, 8). In gynoecious cucumber cultivars ethephon results in more fruit being set and an apparent slowing of fruit growth, with the net effect of a greater yield of the more valuable smaller size grades (4, 8). Lippert et al. (5) reported that ethephon altered sex expression toward more pistillate flowers and also resulted in pistillate flowers occurring on the main stem in muskmelon (*Cucumis melo* L.), although no commercial benefit resulted. Tompkins and Smay (9) reported increased early set and early yield in summer squash (*Cucurbita pepo* L.) from use of ethephon. We are unaware of any published studies on the use of ethephon on winter squash, (*C. maxima*).

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