metabolism of photosynthates in 'Golden Delicious' is more rapid and possibly continues at lower temp than in 'Delicious'.

In earlier reports it was concluded that watercore development is the result of a reduced capacity of the fruit to metabolize translocated photosynthates[3] (4, 7). The unmetabolized photosynthates, of which sorbitol is a major component, accumulate in the intercellular spaces increasing the osmotic concentration resulting in a water-soaked condition of the tissues, especially in and near the vascular bundles[3] (7). Kollas[3] showed that leaves were necessary on limbs for watercore development in the fruit, and that early maturing apple varieties when grafted on 'Delicious' trees developed watercore early in the season long before leaf senescence occurred. The fact that leaves are necessary on a limb for watercore to develop in the fruit implicates the tree in the process, but it is likely the leaves only provide photosynthate which is translocated to the fruit where it accumulates as a result of a loss of enzyme activity in the fruit.

In 'Delicious' and other late maturing cultivars, it appears that low night temp coupled with warm days predispose the fruit to watercore development. Results of the present experiment indicate that metabolism of photosynthate (sorbitol) in the tree is markedly reduced at temp below $0^{o}C$ and accumulates in the sap of the tree at the time of watercore development in the fruit, as occurred in 1970 (Fig. 1); or after watercore development, as occurred in 1972 (Fig. 3). We concluded that sorbitol accumulation in the tree sap is independent from sorbitol accumulation and watercore development in the fruit. However, if the climatic and tree conditions favor early leaf senescence, sorbitol and other metabolites may accumulate in the fruit and limb sap at the same time and accentuate the watercore condition.

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Effect of Water Table Depth on Yield of Cabbage, Squash, and Tendergreen

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Abstract. Cabbage, *Brassica oleracea,* var. *Capitata* L.; squash, *Cucurbita pepo* Alef.; and tendergreen, *Brassica perviridis* Bailey were grown at various water table depths in sheltered soil tanks on a fine sandy loam and a loam soil to evaluate the effects of high water table and soil type on growth and yield of these vegetable crops. Yields of the 3 species increased with water table depth to a depth of 76 to 102 cm. On both soil types the 15-cm water table depth caused considerable yield reduction and chlorosis for the 3 species. For maximum yields deeper water table depths were needed with loam than with sandy loam soil. Yield of cabbage was not significantly increased at water table depths greater than 30 cm in either soil. Squash yield was highest at water table depths of 61 to 76 cm in the fine sandy loam and 91 to 102 cm in the loam soil. Tendergreen yield was not significantly increased by water table depths greater than 61 cm in either soil.

Although the water table depth required for optimum growth of field crops varies with species and soil type, a water table depth of 80-150 cm is usually required (Williamson and Kriz, 1970). Data available for horticultural crops suggest that max yields may be obtained with water table depths between 30 and 150 cm, depending upon species and soil physical properties. In a heavy clay soil, van Hoorn (1958) obtained max yield of beans at a water table depth of 150 cm. Williamson (1968) obtained the max yield of stringbeans, *Phaseolus vulgaris* L., at the deepest water table (78 cm) in a fine sandy loam. Goins et al. (1966) in a greenhouse experiment found that the water table depth required for max snap bean yield depended upon the soil type. For a loam, loamy fine sand, and silty clay loam, yields were max at water table depths of 15, 46, and 80 cm, respectively. Yields of tomato, *Lycopersicon esculentum* Mill., vines increased significantly with increasing depth to water table from 15 to 80 cm (Goins et al., 1966). There were no differences among the soil types - loam, loamy fine sand, and silty clay loam.

Van Hoorn (1958) found that the max yields of potatoes, peas, and sugarbeets in a heavy clay soil were obtained at water table depths of 60, 90, and 150 cm, respectively. Goins et al. (1966) found that the water table depths required for max yields of sweet corn, *Zea mays* L. var. *rugosa,* grown in loamy fine sand, silty clay loam, and loam were 30, 80, and 80 cm, respectively. Cook et al. (1953) found that soil properties may greatly influence the degree of plant tolerance to different water table levels.

Our objective was to evaluate effects of high water table and soil type on growth and yield of cabbage, squash, and

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tendergreen in a field lysimeter experiment.

Materials and Methods

Experiments were conducted at Raleigh, N. C. during 1968 and 1969 in soil tanks sheltered from rainfall. The soil tank installations were described by Williamson (1964) and Williamson and van Schilfgaarde (1965). In the first installation the sheltered tanks, 0.84 m^2 in area and 0.91 m deep, were filled with a mixture of 40% Norfolk fine sandy loam and 60% Seneca fine sandy loam in 1959. In the second installation the sheltered tanks, 0.84 m^2 in area and 1.22 m deep, were filled with Bayboro loam soil in 1960. Bulk densities for the fine sandy loam and Bayboro loam were 1.30 and 0.80 g/cm^3, respectively. The soil tanks have been continuously used for water table experiments since installed. The soil was fertilized before transplanting or seeding each crop in accordance with the recommendations of the North Carolina Soil Testing Laboratory.

Three crops were grown in each soil type each year. The crops were: cabbage, 'Early Jersey Wakefield'; squash, 'Early Prolific Straight Neck'; and tendergreen. Cabbage plants were transplanted in each tank on March 5 of each year and subsequently thinned to 4 plants. Squash were seeded in each tank on June 6 of each year and subsequently thinned to 4 plants. Tendergreen seed were broadcast in each tank on August 29 of each year. Tanks were drained after each crop was harvested and small surface applications of water were made during stand establishment. Water table levels were established for cabbage the third week after transplanting and for squash and tendergreen the second week after seeding. Water tables in tanks containing fine sandy loam were maintained at 15, 30, 46, 61, and 76 cm below the soil surface. Additional levels of 91 and 102 cm were maintained in the Bayboro loam. Beginning the third week after planting, 2.5 cm of water were added weekly to the soil surface to simulate average rainfall. Treatments were replicated 4 times in a randomized complete block design for each soil type. For a given soil type, the same randomization was used for each crop year.

Table 1. Yield of cabbage as influenced by water table depth.

Water table depth, cm	Yield per tank: Fine sandy loam Yield (g)^z	Fine sandy loam Rel. yield	Loam Yield (g)^z	Loam Rel. yield
15	1433	0.24	328	0.05
30	5909	0.98	5848	0.89
46	5695	0.94	6096	0.93
61	6034	1.00	6130	0.93
76	5798	0.96	6234	0.95
91	–		6527	0.99
102	–		6562	1.00
LSD $_{.05}$	706		725	
LSD $_{.01}$	956		973	
C.V.%	14		13	

^{z}Combined analysis for both years. Interaction of years x depth was not significant.

Table 2. Yield of squash as influenced by water table depth.^{z}

Water table depth, cm	Fine sandy loam 1968 Yield (g)	1968 Rel. yield	Fine sandy loam 1969 Yield (g)	1969 Rel. yield	Loam Yield (g)	Loam Rel. yield
15	96	0.02	479	0.13	854	0.19
30	2559	0.49	1786	0.49	1794	0.40
46	3392	0.65	2429	0.66	2486	0.56
61	5220	1.00	2815	0.77	2866	0.64
76	5050	0.97	3660	1.00	3292	0.74
91	–		–		3824	0.86
102	–		–		4472	1.00
LSD $_{.05}$	1523		792		665	
LSD $_{.01}$	2136		1110		892	
C.V.%	30		23		23	

^{z}Combined analysis for both years. Interaction of years x depth was not significant.

Table 3. Yield of tendergreen as influenced by water table depth.

Water table depth, cm	Fine sandy loam Yield (g)^z	Fine sandy loam Rel. yield	Loam 1968 Yield (g)	1968 Rel. yield	Loam 1969 Yield (g)	1969 Rel. yield
15	1991	0.70	2324	0.53	2588	0.74
30	2398	0.84	3706	0.84	3022	0.86
46	2470	0.87	3973	0.90	2708	0.77
61	2575	0.90	3904	0.88	2675	0.76
76	2846	1.00	3929	0.89	3222	0.92
91	–		4268	0.96	2981	0.85
102	–		4424	1.00	3498	1.00
LSD $_{.05}$	329		569		528	
LSD $_{.01}$	466		780		723	
C.V.%	13		10		12	

^{z}Combined analysis for both years. Interaction of years x depth was not significant.

Cabbage was harvested May 30, 1968 and 1969. Squash fruit was harvested 7 times each year between July 15 and August 15. Five harvests of tendergreen leaves were made each year between September 23 and December 2 by cutting all plant materials at 5 cm above the soil level. Weight data presented for squash and tendergreen represent total yield for the crop irrespective of the number of harvests.

Results and Discussion

The primary detectable effect of water table treatments on cabbage during the growing period was the very slow growth and some chlorosis for plants at the 15-cm water table depth. Squash plants were about the same size at all water table depths except those grown at 15 and 30 cm were smaller and their lower leaves became chlorotic. Tendergreen grown at a 15-cm water table depth produced small and slightly chlorotic leaves.

Analysis of variance of weights of harvested plant material showed that differences due to water table depths were significant at the 0.01 probability level for both years, both soils, and all 3 species with the exception of the 1969 tendergreen crop on loam soil which showed a significant difference to water table depth at only the 0.05 level. Cabbage yield obtained at the 15-cm water table depth was about 25% of that at other depths for the fine sandy loam (Table 1). Increasing the water table depth below 30 cm did not significantly increase cabbage yield in either soil (Table 1). The yield on the loam soil did tend to increase progressively as the water table depth increased from 30 to 102 cm. Williamson et al. (1969) showed that the oxygen concentration in this loam soil was very low where the water table was maintained 15 cm below the soil surface.

Yields of squash (Table 2) tended to increase as depth to water table increased for both soils. In the fine sandy loam, a water table depth of 61 to 76 cm was required for max yield. On the loam soil, yield was max at the 102-cm water table, but this yield was not significantly greater than that at the 91-cm water table depth.

Yields of tendergreen (Table 3) grown on both soil types were considerably reduced for the 15-cm water table depth. For the fine sandy loam, yield was not significantly increased by water table depth greater than 61 cm. For the loam soil in 1968 the yield was not significantly increased by water table depths greater than 46 cm; however, in 1969 yields increased as the depth to water table increased to at least 76 cm.

Results obtained in these experiments agree with those presented by Goins et al. (1966) in that yields were generally influenced by soil texture as well as by water table depths, and the minimum water table depth required for satisfactory yield varied with species. Williamson et al. (1969) found that root growth of millet was greatly reduced where water tables were maintained at 15 and 30 cm below the soil surface. Low yields of cabbage, squash, and tendergreen in tanks with a 15-cm water table depth were probably due to the effects of a reduced root system and the effects of low soil O_2 on several physiological processes in plants, including nutrient uptake. It appears that with proper management, many horticultural crops can be grown at a higher water table than can most field crops.

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Stimulation of Lettuce Seed Germination at High Temperatures by Ethephon and Kinetin[1]

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Abstract. 'GL 659' and 'Vanguard' lettuce seed lots germinated almost completely at 30°C when treated with ethephon (100 mg/liter). Similar treatment at 35°C failed to release seeds from dormancy. Kinetin treatment (10 mg/liter) at 35°C was only moderately effective in breaking heat dormancy, but when ethephon and kinetin were combined at this temperature, the interaction was synergistic and germination was almost complete. The preincubation time requirement at 25°C before maximum germination could occur after transferring to 35°C was nearly eliminated by treating seeds with the ethephon-kinetin mixture. 'Calmar' seeds, which had a lower heat tolerance, could not be induced to germinate completely at high temperature by any treatment.

High temp dormancy of lettuce seed complicates winter lettuce production in southwestern irrigated desert regions. In early fall plantings seed bed (wet soil) temp exceeding 27°C tend to interfere with germination and development of uniform, vigorous stands, the extent of interference depending on the excess over 27°C and the relative lengths of exposures to temp above and below. Germination of even the most heat tolerant cultivars is seriously reduced when the imbibition temp is held constant at 30°C, and at a constant 35°C, germination usually does not occur. Chances for success in current efforts to mechanize lettuce production and harvesting could be increased by development of practical means to improve the germination of lettuce seed under heat stress.

Chemical seed treatments to enhance germination have been the subject of much research, but until recently only thiourea (13) and kinetin (9, 10, 11, 12) have been shown to have any effect on heat induced dormancy of lettuce. Abeles and Lonski (1) found that ethylene, CO_2 or a combination of the 2 could increase the germination at 30°C of photosensitive lettuce, and concluded ethylene action occurred in the initial stages of germination. Negm et al. (7) subsequently showed not only that ethylene increases the fraction of seed that germinates, but that a combination of ethylene and CO_2 can induce complete germination of lettuce seed at 35°C at any time after imbibition and that an interaction between the 2 gases is required. Skinner et al. (11) found that kinetin could stimulate the germination at 30°C of photosensitive lettuce seed and demonstrated that gibberellin and kinetin acted synergistically to increase the germination rate. Porto and Siegel (9) overcame with kinetin the dormancy induced by heating dry seeds to 75°C for 1 hr. Pauli and Harriott (8) increased the germination and subsequent emergence of 'GL 659' and 'Climax' by soaking seed for 8 hr in a kinetin solution containing nutrients. Smith et al. (12) reported that max effects could be obtained with a 3 min dip in 100 mg kinetin/liter followed by washing and drying.

Ethephon [(2-chloroethyl)phosphonic acid] decomposes slowly at pH 4-6 releasing ethylene. Upon absorption into plant tissue ethephon apparently releases ethylene which may then enter into a variety of physiological reactions. Dormancy in peanut and strawberry seeds can be broken by treatment with ethephon (3, 5).

Preliminary tests indicated that germination rate of 'GL 659' seeds in dilute ethephon solutions at 30°C was greater than in water. This suggested that ethephon might be used to investigate ethylene effects on lettuce seed germination at higher temp and point the way toward a practical seed treatment for field use. The following experiments show the effects of ethephon and its interaction with kinetin on the germination of lettuce seed at 30°C and 35°C.

Materials and Methods

Lettuce (*Lactuca sativa* L.) cultivars used and their average lot germination percentages in water at 25°C were: 'GL 659' - 91%, 'Vanguard' - 93%, and 'Calmar' - 82%. Germination was carried out at 30°C or 35°C ± 1°C in polycarbonate Petri dishes containing 2 layers of filter paper moistened with water or test

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