INTERACTIVE EFFECTS OF TEMPERATURE AND SALINITY ON SUGARBEET (BETA VULGARIS L.) GERMINATION

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Stand establishment of sugarbeets (Beta vulgaris L.) is one of the most important problems faced by Arizona growers, especially at the lower elevations where soil temperatures are high at planting time. The combination of high salinity and high temperature is frequently associated with reduced germination and seedling emergence. Two or more irrigations following planting are usually required for stand establishment.

With increasing pumping lift and energy costs there is a need to reduce irrigation in field crop production. At planting time irrigation is used to supply moisture for germinating seeds and to reduce salinity and temperature in the seed zone. This research was conducted to better understand the interaction of temperature and salinity on sugarbeet germination.

LITERATURE REVIEW. -- Sugarbeets are sensitive to salt in the seedling stage, although they are more tolerant during later growth stages (Bernstein, 1964). Ayers and Hayward (1948) reported that sugarbeet germination was reduced 50% at 6 mmhos/cm ECe at 21 C. These researchers also noted that soil salinity slowed the rate of seedling emergence.

Radke and Bauer (1969) found that the highest rate of seedling emergence for sugarbeets occurred over the soil temperature range 25-33 C, while highest root weights occurred at 25 C. Francois and Goodin (1972) found that salinity had little effect on germination when temperatures were 10-25 C but inhibited germination at temperatures above 25 C. The adverse effect of salinity on germination was accentuated by increases in temperature from 25 to 40 C.

In field studies at the University of Arizona Mesa Branch Experimental Farm, Nelson and Dennis (1970) observed that highest root and sugar yields were obtained when sugarbeets were planted in September when good stands were obtained. Temperatures at seed planting depth average 30 to 35 C during September and 5 to 10 C less in October in central Arizona.

MATERIALS AND METHODS. -- The effect of all combinations of 4 salt concentrations and 6 temperatures on seed germination of 3 cultivars of sugarbeet were studied. Germination was accomplished by saturating Whatman filter paper in distilled water containing 0, 2, 4, or 6 mg/l of NaCl

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and CaCl in equal proportion by weight. These amounts of salt produced salinity concentrations of 0, 2000, 4000 and 6000 ppm by weight, respectively. The filter paper was placed above and below 50 sugarbeet seeds in 10 x 1.5 cm petri dishes. The dishes were then sealed with masking tape and incubated in darkness at a constant temperature for 10 days. These temperatures were 15, 20, 25, 30, 35, or 40 C.

Sugarbeet seeds were selected from the monogerm cultivars HH21, S445H, and USH9B1 (2 entries). One USH9B1 selection (Lot A) was taken from high-germination elite seed and the other (Lot B) from commercial planting seed. Germination counts were made on days 2, 4, 6, 8, and 10 from the time of experiment initiation. A seed was considered to have germinated when a healthy radicle extruded 3 mm from the seedball. If more than one radicle emerged from a seedball, only one was counted. Speed of germination was determined using the method suggested by McGuire (1962). His procedure takes into account the number of days required for complete germination.

The study was conducted using a factorial experimental design with four seed entries, three replications, four salinity levels, and six temperatures. Main effects and interactions of cultivar, salinity, and temperature were statistically analyzed.

RESULTS AND DISCUSSION. -- The interactive effects of temperature and salinity on percent and speed of germination are illustrated in Fig. 1 and 2. Salinity had only a small effect on percent germination at temperatures below 25 C. At these temperatures reduced germination primarily occurred at the highest level of salinity.

At higher temperatures, salinity had a marked depressive effect on germination. Temperatures of 30 C and above in combination with 2000 ppm or more salt severely reduced the speed of germination, Fig. 2. Additionally, temperatures of 15 and 20 C slowed the speed of germination somewhat.

The effects of salinity and temperature on germination percentage and speed of germination for three sugarbeet cultivars are presented in Tables 1 and 2, respectively. The elite USH9B1 (Lot A) seed had a germination of 94% at 20 C and 0 ppm salt; while that used commercially in the same year by growers (Lot B) had a 89% germination rate. The germination percentage for the cultivar S445H and HH21, under the same temperature and salinity conditions, were 94% and 73%, respectively.

The cultivar having the highest germination percentage (S445H) also usually germinated most rapidly. Its superiority was maintained at most of the temperature and salinity regimes. In contrast, the cultivar HH21 had the lowest germination percentages and slowest speed of germination. The two entries of USH9B1 were intermediate in response to salinity and temperature regimes imposed. Seed having high initial germination rates performed better overall when stressed by salinity and high temperature.

The cultivars used in this study performed differently under the temperature and salinity conditions imposed, but these differences cannot be strictly attributed to genetic differences among the cultivars. Seed lot quality had a confounding effect on germination response.

The findings in this study suggest three management options for good stand establishment where high temperatures and salinity adversely affect germination, such as in the lower desert valleys of Arizona. The first option is to delay planting until early to mid-October when soil temperatures have moderated. This delay in planting results in a lower yield potential but reduces stand establishment problems caused by high soil temperatures and salinity. Secondly, the salinity levels in the seed zone can be reduced by leaching before seedbed preparation. When this is done, adequate stands are likely, even when soil temperatures average 30 C or above at seed planting depth. The third option for growers is to apply frequent alternate row post-plant irrigations to cool the soil and dilute salt concentrations. The application of several post-plant irrigations is usually effective in obtaining full stands but this greatly increases the cost of stand establishment.

SUMMARY

The interaction of salinity and temperature on sugarbeet germination was studied. Major deleterious effects occurred when temperatures exceeded 25 C. Seed having a high germination percentage at 20 C and 0 ppm also performed best when subjected to temperature and salinity stress.

Sugarbeet growers can reduce problems associated with high temperature and salinity by leaching salts from the seed zone prior to planting, by delaying planting until temperature moderates, or by using frequent post-plant irrigations to cool the soil and dilute the salt concentration in the seed zone.

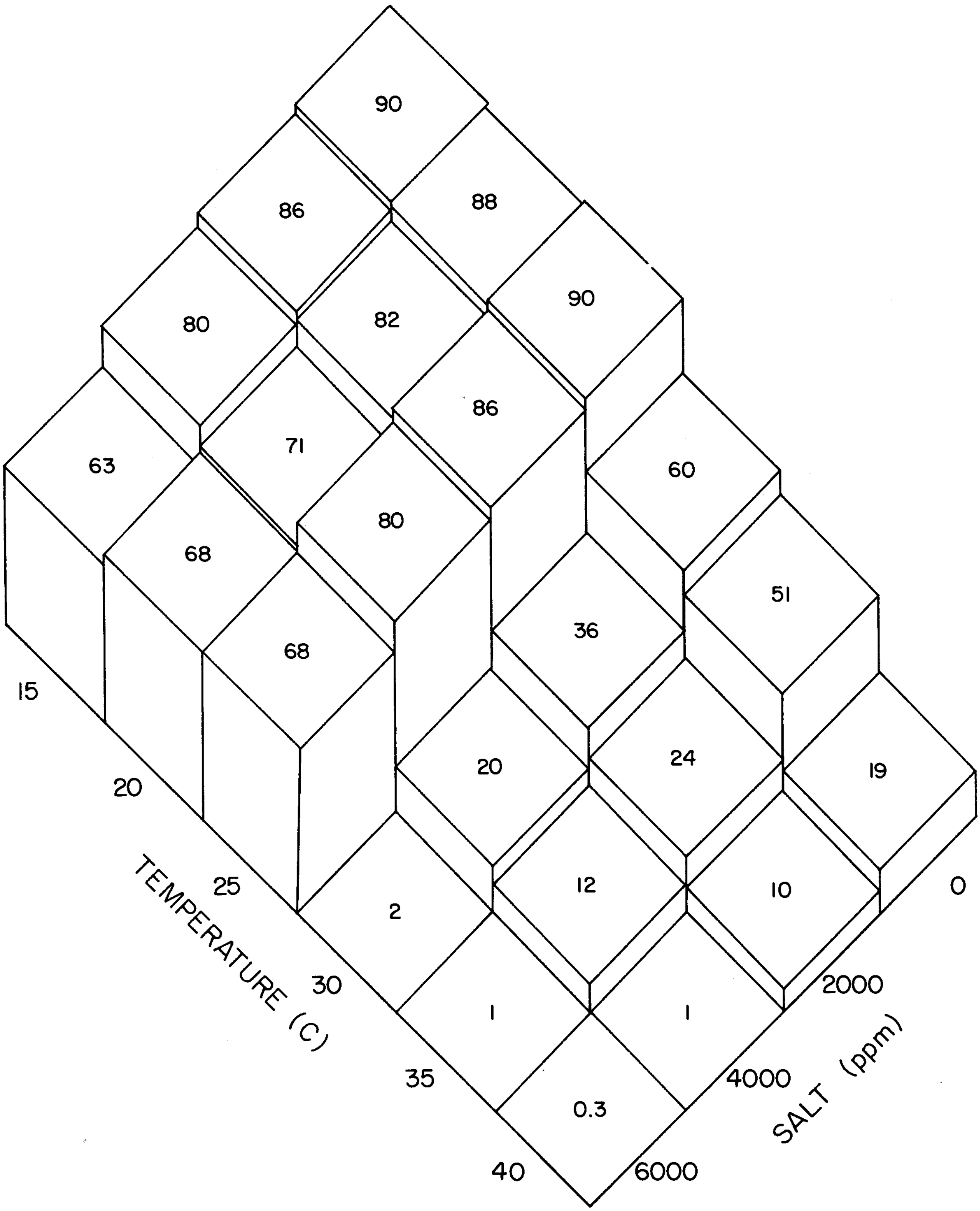

Fig. 1. Graph showing the effect of temperature and salinity on germination of sugarbeet seed.

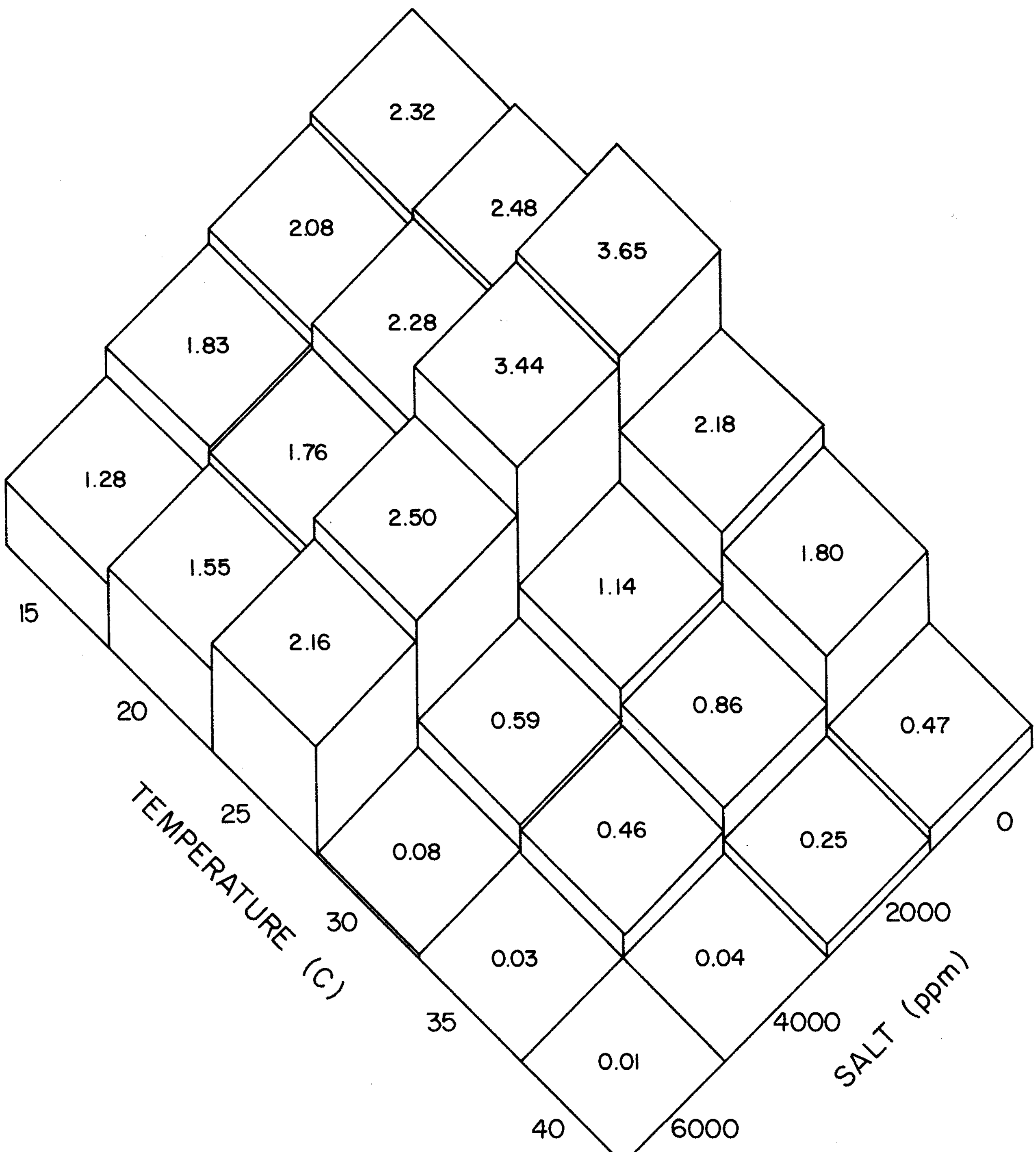

Fig. 2. Graph showing the effect of temperature and salinity on the speed of germination of sugarbeet seed. High values indicate a rapid and low values a slow speed of germination.

Table 1. Effect of temperature and salinity on germination percentage of three sugarbeet cultivars.[1/]

Temperature (C)		Salinity (ppm) 0	2000	4000	6000
	15	97.3 a[2/]	92.0 bc	88.6 c	60.6 f
	20	94.0 ab	96.0 a	59.3 f	69.3 e
USH9B1	25	92.6 bc	88.0 c	84.0 d	80.6 d
(Lot A)	30	67.3 e	44.0 g	16.0 i	3.3 j
	35	58.6 f	36.6 h	6.0 j	0.0 k
	40	18.6 i	16.6 i	3.3 j	0.0 k
	15	86.0 a	78.0 bc	76.6 c	66.0 e
	20	89.3 a	81.3 b	70.0 d	60.6 f
USH9B1	25	90.6 a	86.0 a	86.6 a	63.3 ef
(Lot B)	30	52.0 g	24.6 i	14.0 j	1.3 l
	35	36.0 h	12.6 j	6.6 k	1.3 l
	40	6.0 k	0.6 l	0.6 l	0.6 l
	15	93.3 a	95.3 a	92.0 ab	78.0 e
	20	94.6 a	92.6 ab	88.0 bc	76.0 e
S445H	25	94.0 a	94.6 a	93.3 a	91.3 ab
	30	84.6 cd	58.6 f	35.3 g	4.6 j
	35	82.0 d	36.0 g	24.6 h	2.0 jk
	40	34.6 g	20.0 i	0.6 k	0.6 k
	15	84.0 a	77.3 b	62.0 d	46.0 f
	20	72.6 b	60.0 d	68.0 c	66.6 c
HH21	25	82.6 a	76.0 b	54.6 e	37.3 g
	30	38.0 g	16.6 i	13.3 ij	0.6 k
	35	27.3 h	10.6 j	11.3 j	1.3 k
	40	15.3 ij	1.3 k	0.0 k	0.0 k

1/ Two seed lots of USH9B1, the currently used cultivar in Arizona, were evaluated.

2/ Percentages followed by the same letter are not significantly different at the 5% level according to Student-Newman-Keuls Test.

Table 2. Effect of temperature and salinity on speed of germination of three sugarbeet cultivars.[1/]

Temperature (C)		Salinity (ppm) 0	2000	4000	6000
	15	2.53 abc[2/]	2.11 cd	1.91 cd	1.14 defg
	20	2.69 abc	2.68 abc	1.35 de	1.57 cd
USH9B1	25	3.58 a	3.27 ab	2.31 bcd	2.74 abc
(Lot A)	30	2.17 bcd	1.25 def	0.48 efgh	0.10 gh
	35	1.89 cd	1.21 defg	0.19 fgh	0.0 h
	40	0.34 efgh	0.35 efgh	0.08 gh	0.0 h
	15	2.17 abc	1.84 cd	1.71 cd	1.41 cdef
	20	2.53 abc	2.01 bcd	1.75 cd	1.33 cdef
USH9B1	25	3.16 a	2.88 ab	2.06 bcd	1.36 cdef
(Lot B)	30	1.65 cde	0.60 efg	0.42 fg	0.04 g
	35	1.13 defg	0.48 fg	0.16 g	0.03 g
	40	0.13 g	0.03 g	0.03 g	0.01 g
	15	2.74 ef	2.75 ef	2.42 efg	1.67 fgh
	20	2.97 def	3.01 def	2.58 efg	1.80 fgh
S445H	25	5.03 ab	5.62 a	4.33 bc	3.87 cd
	30	3.88 cd	2.29 fg	1.11 hi	0.14 j
	35	3.47 cde	1.54 ghi	1.21 hi	0.06 j
	40	1.13 hi	0.59 ij	0.03 j	0.03 j
	15	1.85 bc	1.60 bcd	1.27 bcdef	0.91 bcdefg
	20	1.75 bc	1.44 bcde	1.37 bcdef	1.51 bcde
HH21	25	2.82 a	1.98 b	1.28 bcdef	0.69 cdefg
	30	1.00 bcdefg	0.41 defg	0.34 efg	0.02 g
	35	0.70 cdefg	0.20 fg	0.27 efg	0.03 g
	40	0.28 efg	0.04 g	0.0 g	0.0 g

1/ Two seed lots of USH9B1, the currently used cultivar in Arizona, were evaluated.

2/ Values followed by the same letter are not significantly different at the 5% level according to Student-Newman-Keuls Test.

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