Figure 5. Parkerizing effect on mild steel

Left. Medium coating on specimen exposed to 9.3–29.9–0 solution at 175° F. *Center.* Heavy coating on specimen exposed to 10–10–10 at 200° F. *Right.* No coating on specimen exposed to 9.3–29.9–0 at room temperature

Table XI. Corrosion of Mild Steel by Liquid Mixed Fertilizer at Elevated Temperature

Grade	Test Conditions[a]	Temp., ° F.	Corrosion Rate, Mils Penetration per Yr.
8–8–8	B, C	165	1.6
	B, C, E	175	0.1
10–10–10	A, D	200	0.7
	A, D, G	200	0.7
12–12–0	B, C	175	2.1
	B, C, E	165	0.2
6–18–6	B	175	5.1
	B, E	165	0.3
8–24–0	B, E	175	0.2
	B, F	165	18.1
	B, G	175	7.7
	B, F, G	170	22.7
9.3–29.9–0	A	175	7.6
	A, G	175	8.4
	A, F	170	22.1

[a] A, mole ratio $NH_3:H_3PO_4 = 1.55$. B, mole ratio $NH_3:H_3PO_4 = 1.69$. C, supplemental nitrogen (if any) supplied as ammonium nitrate. D, supplemental nitrogen (if any) supplied as urea. E, inhibitor (0.1% $Na_2Cr_2O_7$) added to solution. F, solution aerated at the rate of 0.02 cubic foot per minute. G, specimen welded.

Table XII. Corrosion of Stainless Steel by Liquid Mixed Fertilizer

Grade	Test Condition[a]	Temp., ° F.	Corrosion Rate, Mils Penetration per Yr. Type 430	Type 316
8–8–8	A, C	Room	0.01	
10–10–10	A, D	Room	0.1	
	A, D	200	0.07	0.01
	A, D, G	200	<0.01	<0.01
	A, D, G[b]	200	1.3	0.7
9.3–29.9–0	A	175	0.02	
12–12–0	A, C	Room	0.9	

[a] A, mole ratio $NH_3:H_3PO_4 = 1.55$. C, supplemental nitrogen (if any) supplied as ammonium nitrate. D, supplemental nitrogen (if any) supplied as urea. G, specimen welded. [b] Specimen heat treated (after welding and machining) at 1950° F. for 9 minutes, then water-quenched. No further sanding or buffing of specimen was performed.

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Received for review November 1, 1957. Accepted April 12, 1958. Division of Fertilizer and Soil Chemistry, 132nd Meeting, ACS, New York, N. Y., September 1957.

GLASS AS A BORON SOURCE

Effect of Composition and Reactivity of Borosilicate Glass on Boron Status of Alfalfa

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A BORON CARRIER capable of moderately slow release of boron to a boron-deficient soil under crop stress is a recognized need. Ground borosilicate glass, obtained by quenching the melt in water and called frit in trade (*9*), is of special interest because its reactivity—i.e., the rate of nutrient release within soil—may be adjusted over a wide range by altering composition.

Exploratory vegetative tests in this laboratory and elsewhere (*7*) show that certain glasses will eliminate a boron deficiency condition of a soil. The influence of a slightly reactive glass persists. Boron content of alfalfa remains in the same range for 2 or more years. Furthermore, toxic levels are not reached in the crop even when the amounts of boron contained in glass applications are considerably above the upper limit for borax. These advantages have recently led to some commercial-scale use, but there still remains the problem of characterizing the influence of glasses with sufficient exactness to facilitate most effective utilization of their properties.

The variation in boron content of a crop as caused by seasonal differences in growth conditions greatly complicates

Response of alfalfa grown on Evesboro soil to additions of 48- to 100-mesh borosilicate glasses of varied composition has been compared to that of borax under greenhouse conditions. Application of boron, in the form of moderately reactive glasses, decidedly reduced within-season variation in boron content of the crop—at high levels, boron contents were lower and, at low levels, they were higher than in equivalent borax treatments. Modification of seasonal variation is related to reaction of boron carriers with soil medium.

evaluation of a boron fertilizer material. Under field conditions, according to Stewart and Axley, boron content of alfalfa may vary as much as 300% in a single season (*10*). With the regularity of watering a crop in greenhouse experiments, variation is less erratic, but it is not reduced in magnitude. Carrier-types can be compared realistically only as they interact with seasonal factors. However, the breadth of variation which does occur underscores the need for maintaining the same conditions for all cultures in a test program—especially with respect to soil moisture—to avoid possible bias, which may or may not be evident in the data eventually obtained.

In a greenhouse experiment of the present investigation, six glasses, selected to represent a broad range of reactivity as varied by chemical composition alone, were compared, using borax as a soluble reference material. Basically, the conditions of experimentation were essentially the same as in a previous investigation (*7*) except for some modification in the method of watering the crop made in an effort to maintain greater uniformity in soil moisture. Alfalfa was grown on a coarse-textured soil to which the test materials had been added. The effects of the treatments are evaluated from the response obtained in yield and boron content of the crop.

Culture Preparation and Management

Soil and Basal Fertilization. The culture medium consisted of 7.5-pound amounts of Evesboro sandy loam contained in No. 10 plastic-coated metal cans. The soil was limed with equimolar quantities of calcium hydroxide and magnesium oxide, equivalent in total to 2200 pounds of calcium carbonate per acre (weight basis), and equilibrated in a moist condition for 7 weeks (final pH = 6.5). It was then fertilized with the equivalent of:

	Pound/Acre (Area Basis)
Nitrogen	200
Phosphorus pentoxide	300
Potassium oxide	200
Copper sulfate pentahydrate	5
Zinc sulfate septahydrate	5
Manganese dichloride tetrahydrate	15
Molybdenum trioxide	1

Shortly after the fourth harvest, supplemental fertilizers equivalent to 100 pounds of potassium oxide, 100 pounds of phosphorus pentoxide, and 20 pounds of nitrogen per acre, were added. The chemicals used for basal fertilization were substantially boron-free.

Boron Carriers. No boron was added to six of the cultures, which served as controls. All other treatments were triplicated. In separate series, the 48- to 100-mesh sieve size of each glass and recrystallized borax were mixed individually with the soil cultures in amounts equivalent to certain specified quantities of pure borax containing 36.52% of boron trioxide. The chemical composition of the glasses, determined by analysis, are given in Table I in order of decreasing boron trioxide to silicon dioxide ratio. No crystalline material was detected in any sample of glass by microscopic examination.

Crop. Ranger alfalfa was grown for six consecutive harvests; the cuttings were made at the stage of two thirds in bloom. Yields and boron contents of the crop were determined on an oven-dry basis (65° C.).

Soil Moisture Control. Special effort was made to maintain as nearly as possible the same average moisture level in all cultures during the growth season. The crop was inspected daily at 2-hour intervals, at which times four particular pots, and frequently others as well, were weighed to gage the rate of moisture loss. Water was added, however, only at such times as differences in the relative dryness of individual cultures could be readily discerned. The amount of water then added was varied according to the need. At the first and last part of each week, the system of watering was altered for one interval. Only cultures showing evidence of dryness were watered; those not watered were marked and watered with reduced amounts later when they reached a comparable state of dryness. The latter procedure prevented cases in which soil moisture remained continuously at a high level over an extended period of time.

Experimental Precision. Coefficients of variation, calculated from mean square error in analyses of variance, are given in Table II. The indicated order of precision was of the usual magnitude. There was, however, much less fluctuation in estimated error in the several harvests. Maximum values of the coefficients for both yield and boron content of the crop were only about one half as large as those which often occurred in previous boron studies.

Analytical Methods

Boron content of plant tissue was determined by the curcumin method, as described by Dible, Truog, and Berger (*6*). Procedures followed in determining the compositions of the glasses were *o*-phenanthroline (*8*) for iron, Versenate titration (*4*) for calcium and magnesium after separation from manganese by carbamate extraction (*5*), and ASTM standard methods (*1*) for other constituents.

Vegetative Response

Visual Observations. Deficiency symptoms occurred in the controls with no added boron and in treatments of glass 215-A, equivalent to 10 to 40 pounds of borax per acre. Glass 215-A, however, reduced the severity of deficiency at all levels. Treatments with other glasses or with borax in the same range of application were not deficient or toxic at any time.

The partial dependency of deficiency on seasonal factors was exhibited by the data. Visible damage—at first only slight—gradually increased to become most extensive in the third and fourth growth periods, but was less prominent in the fifth, and was not observed in the sixth.

Yield. Additions of either the glasses or borax produced significant increases in yield in certain harvests (Table III). Glass 215-A did not increase yields as much as other carriers, but otherwise there were no significant differences between materials or levels of treatment.

The occurrence and magnitude of yield increase, produced by the addition of boron, varied with season much like that of deficiency symptoms. Differences between the controls and boron treatments first developed in the third harvest, became progressively greater in the fourth and fifth harvests, but less in the sixth. The levels of significance varied accordingly. Differences in the third harvest were significant in many cases, but only at the 5% level; in the fourth, significant in most cases at the 1% level; in the fifth, usually significant at the 1% level by a wide margin; and in the sixth, significant in many cases, but again only at the 5% level of confidence.

Boron Content of the Crop

The level of boron in the crop varied with season in a usual manner. The

Table I. Chemical Composition of the Test Glasses, as Shown by Average Results of Duplicate Determinations

Glass	SiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	B_2O_3	B_2O_3/SiO_2 Ratio
	Constituent, %									
176-B	47.09	5.11	0.07	0.01	1.52	0.05	2.57	16.81	25.21	0.54
3134	45.52	0.92	0.51	0.16	17.62	0.44	0.42	10.05	22.78	0.50
176-E	50.33	6.78	0.15	0.02	3.10	0.13	3.15	15.91	20.24	0.40
176-F	50.47	7.01	0.08	0.01	3.37	0.10	2.73	15.16	19.45	0.39
176-C[a]	51.75	8.11	0.15	...	4.33	0.12	3.46	14.95	15.68	0.30
215-A	64.04	5.53	0.07	0.01	2.46	0.10	2.64	7.92	16.25	0.25
Mean deviation	0.20	0.10	0.004	0.001	0.03	0.03	0.06	0.12	0.11	

[a] Glass 176-C in a previous experiment (7) was from a different melt and was slightly different in composition.

Table II. Estimated Error of Means of Triplicate Measurements

Harvest	Coefficient of Variation, % Yield	Boron content
1	5.4	8.9
2	4.2	5.7
3	5.7	7.7
4	5.4	8.1
5	4.0	5.7
6	6.7	7.1

Table III. Influence of Boron Treatments on Alfalfa Yields

Carrier	Treatment: Amount added, lb./acre	Borax equivalent, lb./acre	Yield of Consecutive Harvests, G./Culture[a] 1st	2nd	3rd	4th	5th	6th	Total
None			2.73[b]	2.84[b]	2.53[b]	2.60[b]	3.55[b]	4.48	18.73
Borax	5	5	2.99	3.28	2.96	3.29	5.42	5.77	23.71
	10	10	3.00	3.09	3.12	3.91	5.00	5.48	23.60
	20	20	2.76	3.14	3.35	3.80	5.59	6.05	24.69
	40	40	2.59	2.86	3.01	3.49	5.20	5.52	22.67
Glass									
176-B	14.5	10	2.66	2.85	3.14	3.67	5.27	5.54	23.13
	29.0	20	2.33	2.59	2.93	3.44	4.39	5.25	20.93
	57.9	40	2.77	2.89	3.23	3.53	5.27	5.76	23.45
3134	16.0	10	2.66	3.10	3.32	3.83	5.34	5.32	23.57
	32.1	20	2.47	3.01	3.23	3.63	5.45	5.92	23.71
	64.1	40	2.63	2.92	3.39	3.92	5.24	5.37	23.47
176-E	18.0	10	2.80	2.84	3.00	3.62	5.36	5.88	23.50
	36.1	20	2.42	2.80	3.08	3.57	5.17	5.66	22.70
	72.2	40	2.80	3.05	3.15	3.57	5.45	6.02	24.04
176-F	18.8	10	2.74	2.97	2.83	3.39	4.88	5.20	22.01
	37.6	20	2.37	2.78	3.08	3.66	5.68	5.72	23.29
	75.1	40	2.90	2.97	3.23	3.82	5.38	5.69	23.99
176-C	23.3	10	2.92	3.05	3.26	3.86	5.18	5.84	24.11
	46.6	20	2.79	2.82	3.22	3.67	5.22	5.61	23.33
	93.2	40	2.42	2.95	3.12	3.58	5.16	5.32	22.55
215-A	22.5	10	2.70[b]	3.02[b]	2.83[b]	2.86[b]	4.52	5.25	21.18
	44.9	20	2.65[b]	2.74[b]	2.85[b]	3.09[b]	4.11[b]	4.84	20.28
	89.9	40	2.74	2.80	2.76[b]	2.98[b]	4.19[b]	5.34	20.81
LSD at 1%			N.S.	N.S.	N.S.	0.70	0.75	N.S.	3.54
LSD at 5%			N.S.	N.S.	0.50	0.53	0.57	1.04	2.68

[a] Oven-dry weight (65° C.). [b] Deficiency symptoms observed.

general nature of the results are illustrated by the borax series (Figure 1). There was a steady decrease during the first five harvests, followed by an increase in the sixth. In comparison to minimal values of the fifth, boron content was as much as four times as high in the initial harvest and double in the final harvest.

The suppression of boron content by seasonal factors was in accord with the visible evidence of deficiency and the magnitude of differences in yield (Table III). The inordinate decreases from very high values down to about 20 p.p.m. of boron or vice versa were, in themselves, of no consequence relative to vegetative response. They are, however, indicative of the small, but critically important corresponding growth-limiting suppression of boron content in the controls.

The over-all effect of the carriers may be compared in various ways by averaging results for all harvests. Such a comparison is made in Table IV by means of the increase in average boron content relative to that obtained with borax at the 40-pound level of application. The values so obtained provide a measure of performance, which in the case of the glasses serves as an index of chemical reactivity. The order of reactivity for the glasses was the same as that of the boron trioxide to silicon dioxide ratio (Table I). Glasses 176-B and 3134 increased average content of the crop slightly more than did borax and, therefore, possess high reactivities. The reactivities of the other glasses, which increased crop boron by lesser amounts, are classified as either moderate or low by reason of a difference in performance relative to that of borax in certain harvests.

Table IV. Chemical Reactivity of the Glasses

Material Added to Soil	Average Boron Content of Six Harvests of Crop: P.p.m.	Increase relative to that of borax, %	Relative Reactivity of the Glass
None	12.5		
Glass			
176-B	85.1	107	High
3134	82.3	103	High
Borax	80.1	100	
Glass			
176-E	69.8	85	Moderate
176-F	55.0	63	Moderate
176-C	37.4	37	Low
215-A	16.9	7	Very low

Glasses *vs.* Soluble Reference. The boron contents produced by highly

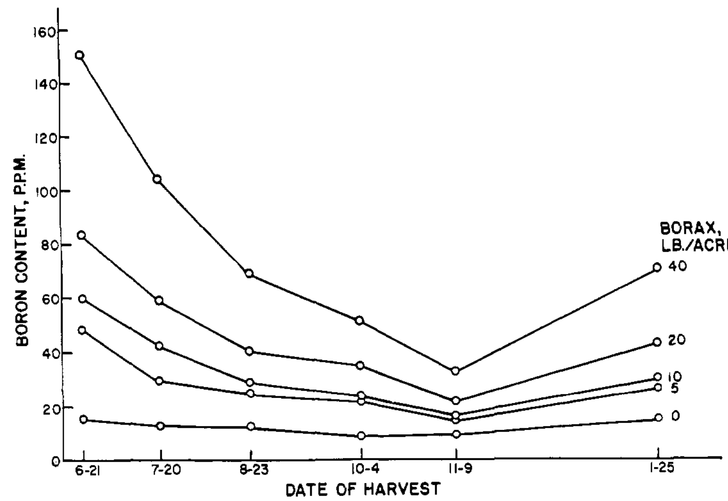

Figure 1. Variation in boron content of alfalfa at different levels of borax application

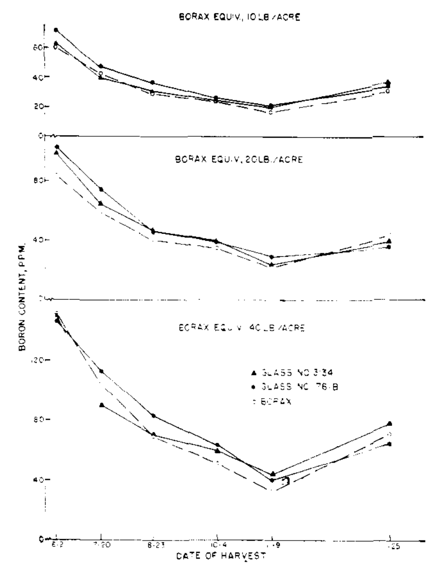

Figure 2. Effect of carrier type on boron content of alfalfa. Highly reactive glasses compared with borax at equal application

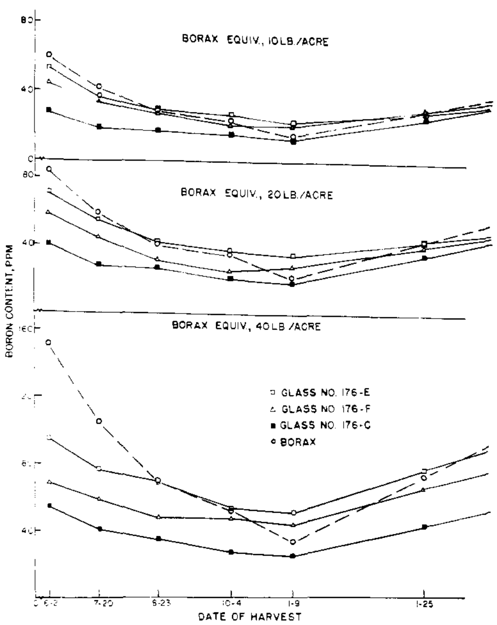

Figure 3. Effect of carrier type on boron content of alfalfa. Moderately and lowly reactive glasses compared with borax at equal applications

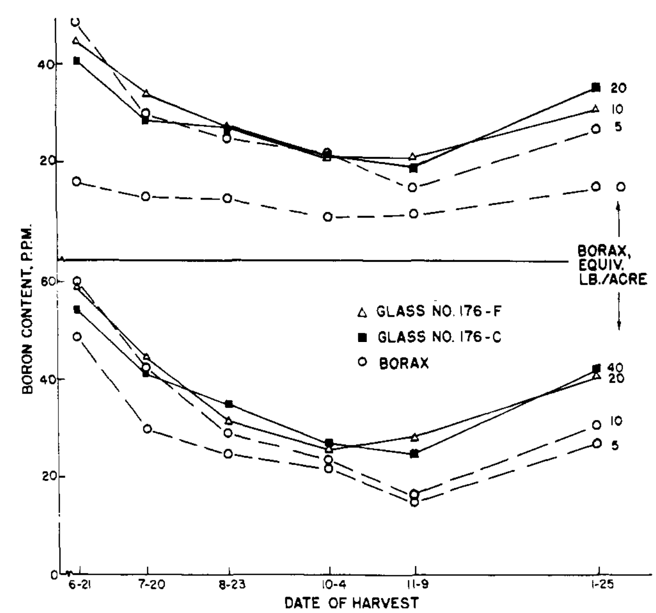

Figure 4. Effect of carrier type on boron content of alfalfa. Moderately and lowly reactive glasses compared with borax at near-equal initial boron contents

reactive glasses (176-B and 3134) are compared graphically with those produced by equivalent additions of borax in Figure 2. The tendency toward somewhat higher boron contents from glass treatments was fairly consistent; otherwise there was very little difference.

The incorporation of boron in moderately reactive glasses (176-E and 176-F) for use in soil treatment decidedly reduced seasonal variation, so characteristically large in borax fertilization. The boron content of the crop (Figure 3) was lower initially, but decreased less rapidly in the following harvests to become higher in the fifth harvest than that of the reference material. In the general rise occurring in the last harvest, the rate of increase with respect to time was greater in the case of borax at each level of application. These results indicate that values for borax would again exceed those for the glasses when higher boron contents are induced by seasonal factors.

The variation caused by seasonal factors may be viewed as a cyclic process. The effect of moderately reactive glasses was to diminish the amplitude of peak and minimum values or to damp fluctuation in the crop during a single cycle under greenhouse conditions. Presumably, the relative behavior would be the same under field conditions where ordinarily several such cycles occur in the course of a single season.

Glass 176-C produced boron contents in the crop parallel to those of the moderately reactive glasses (Figure 3). However, the level attained was always lower than that obtained with borax at equal application, even when boron contents were lowest. The performance of 176-C differed from that of a moderately reactive glass, which under certain circumstances will cause boron content of the crop to exceed that produced by an equal amount of readily soluble boron. The feebler performance of glass 176-C by this measure characterizes it as a carrier with low reactivity.

The performance of glasses of different reactivities can be compared profitably at suitable applications, chosen so that at the first harvest, the curves for the glasses lie between those of an interval of borax application, as illustrated in Figure 4. The effect on boron content during the course of the whole season was about the same for glass 176-C

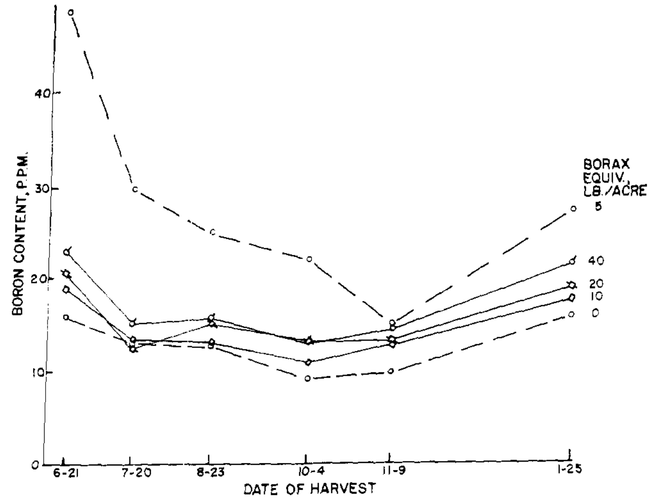

Figure 5. Effect of carrier type on boron content of alfalfa. Very lowly reactive glass 215-A (solid lines) compared with low applications of borax (dashed lines)

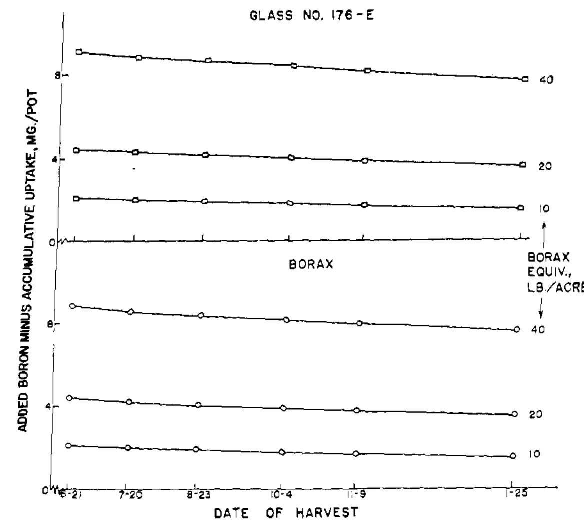

Figure 6. Apparent change in supplemental supply of boron with time. Fertilization with moderately reactive glass (upper part) and with borax (lower part of figure)

at the 20- and 40-pound levels of application as it was for glass 176-F at the 10- and 20-pound levels, respectively. That is, when application is increased to compensate for lower reactivity the effect relative to seasonal factors becomes substantially the same.

The influence of very lowly reactive glass (215-A) on boron content is depicted in Figure 5. Average increase in boron content was only 2, 3, and 4 p.p.m. at applications equivalent to 10, 20, and 40 pounds of borax per acre, respectively. These small gains in crop boron, though not sufficient to overcome deficiency entirely, were responsible for the significant favorable effect on yield (Table III). At this low order of performance, fluctuation with season was relatively small.

Relationship of Boron Content of Crop to Soluble Supply

Effect of Seasonal Factors. The withdrawal of boron from the soil by the crop is generally presumed to affect the boron level of the soil and, consequently, the boron content of the harvested crop. Where supply has been elevated by the addition of soluble boron, it is possible to deduce a measure of this effect in terms of supplemental boron present in the soil. With this purpose in view, soluble boron provided in borax treatments, corrected by subtracting accumulative uptake, is plotted against growth period in the lower part of Figure 6. The curves slope gently downward with time, indicating a steady, but small, decline in boron supply of the soil. Presumably, crop response to the falling supply would be registered in slightly lowered boron contents in the successive harvests.

The near-linear change in supply does not offer a satisfactory explanation for the very nonlinear variation in boron content of the crop (Figure 1). Total decrease in supplemental boron in the first five harvests ranged from only 19 to 10% in the 10- to 40-pound applications, respectively. Yet the corresponding decrease in content of the crop was 73 to 78%, respectively. The disproportionately large decrease in boron content in early harvests would appear to have been caused, largely, by factors of seasonal nature, not primarily by depletion of supply. The rise of boron content in the last harvest to double that of the fifth harvest would necessarily relate to such other causes.

Effect of Slow Release from Glass. Cursory examination of the base data would indicate that the glasses restricted the level in the crop in early harvests by the retention of boron in undissolved particles. A glass would thereby conserve its supply and could provide higher levels of soluble boron in later harvests than in the case of equivalent borax treatments. This view seems plausible, but analysis of the data shows that the kinetic reaction of the glass with the soil medium exerts a very substantial influence which greatly modifies this simple explanation.

Correction of supplemental supply with respect to accumulative uptake in glass treatments yields a measure of potential supply from a glass. The typical near-linear results obtained with moderately reactive glasses are illustrated in the upper part of Figure 6. The effect of crop removal on total supply was substantially the same for Glass 176-E as it was for equivalent borax treatments, depicted in the lower part of the same figure. As such, the fact that the glass produced higher boron contents in the fifth harvest (Figure 3) cannot be explained, satisfactorily, in terms of conservation of supply by a glass. Even if all the boron originally contained in glass 176-E had been released in soluble form by the time of the fifth harvest, the supplemental supply provided would not have been at any level of application over 1% greater than that in equivalent borax treatments. Yet the glass treatments at this time produced boron contents in the crop which ranged from 39 to 60% greater than those produced by borax at equal levels of treatment. Similarly, if all the boron contained in the less reactive glass 176-F had been released when the fifth harvest was taken or before, the supplemental supply provided would have been only 4 to 6% greater than those of corresponding treatments in the borax series. This largest possible difference in soluble supply, even if actually reached, would not appear to be of sufficient size to cause boron contents to be 28 to 30% higher than in the borax series, as was the case.

The mechanism responsible for this circumstance appears to relate to the reaction of soluble boron with the soil medium. Boron when added to the soil is partially removed from solution by sorption processes (*2, 3*). A readily soluble form after a period of time would become indistinguishable from the native supply and subject to the same forces which vary the relationship between soil solution and total extractable boron. On the other hand, boron released by a glass, though subject to the same forces, would present, continuously, an unbalanced situation relative to sorption processes of the soil which are, according to preliminary laboratory tests with this soil, slow in attaining a steady state condition with respect to soil solution. Withdrawal by the crop, which proceeds competitively, is thereby favored and it minimizes effects of sorption by soil.

Effectiveness of Glasses

A general idea of effectiveness of the glasses relative to that of borax can be obtained by inspection of boron response curves (Figures 2 to 5). However, a large difference in boron content when boron contents are high may be no more

Table V. Relative Effectiveness of Glasses

Glass		Borax equivalent, lb./acre	Ratio of Borax to Glass Application at Equal Response in Boron Content of Crop						Maximum Change in Relative Effectiveness, Ratio of 5th/1st	
Reactivity	Number		1st	2nd	3rd	4th	5th	6th	Single treatment	Material mean
High	176-B	10	1.49	1.30	1.65	1.23	1.84	1.23	1.2	1.3
		20	1.28	1.34	1.21	1.24	1.66	0.70	1.3	
		40	0.96	1.10	1.26	1.33	1.33	0.88	1.4	
High	3134	10	1.11	0.89	1.17	1.06	1.65	1.46	1.5	1.3
		20	1.22	1.12	1.22	1.32	1.19	0.84	1.0	
		40	1.00	0.85	1.02	1.23	1.52	1.12	1.5	
Moderate	176-E	10	0.72	0.80	1.09	1.31	2.20	0.94	3.1	3.1
		20	0.73	0.88	1.07	1.18	2.20	1.01	3.0	
		40	0.58	0.69	1.00	1.04	1.79	1.08	3.1	
Moderate	176-F	10	0.44	0.67	0.81	0.46	1.85	1.05	4.2	3.9
		20	0.48	0.57	0.63	0.60	1.57	0.89	3.3	
		40	0.34	0.49	0.63	0.87	1.47	0.88	4.3	
Low	176-C	10	0.19	0.19	0.21	0.27	0.36	0.47	1.9	3.0
		20	0.19	0.23	0.39	0.24	0.72	0.69	3.8	
		40	0.19	0.24	0.38	0.33	0.63	0.48	3.3	
Very low	215-A	10	0.05	0.02	0.02	0.07	0.27	0.04	5.4	4.4
		20	0.04	0.01	0.05	0.08	0.16	0.07	4.0	
		40	0.03	0.02	0.03	0.04	0.11	0.06	3.7	

important with respect to application than a small difference at low levels of response. In order to circumvent this inherent difficulty, the performance of glasses must be considered in terms of relative effectiveness which may be expressed numerically as the ratio of borax application to glass application at equal response in boron content of the crop (Table V).

Maximum change in relative effectiveness with respect to time, shown in the right hand columns as a ratio of effectiveness in the fifth harvest relative to that of the first, divides the glasses into two main groups. The ratio for highly reactive glasses was 1.3 ± 0.2, while for other glasses it was 3.6 ± 0.6. As the value is greater than one in each case, a similarity in behavior is indicated. Thus, release from the highly reactive glasses may not be regarded as immediately complete, though it was too rapid to offer any real improvement over readily soluble boron. The constancy of the ratio for the other glasses shows that their ability to damp cyclic seasonal fluctuation is not altered substantially as the scale of reactivity is descended to very low values.

Relative effectiveness of boron contained in the moderately reactive glasses was reduced to about one half at the first harvest, but increased to become as much as double that of a readily soluble form at the fifth harvest. At the lower reactivities of glasses 176-C and 215-A, the magnitude of effectiveness was about one fifth and one twentieth that of the reference material, respectively. Accordingly, their effect relative to season was somewhat less important.

Effect on Range of Application. The use of moderately reactive boron glasses in lieu of borax for fertilization of soils would extend the limits of application by virtue of the reduction of maximum values and the increase of minimum values for boron content of the crop. By measure of relative effectiveness of these glasses at uniform particle size of 48- to 100-mesh, the indicated effect on range of application was to approximately double the upper limit and to reduce the lower limit to about one half.

Acknowledgment

The authors wish to thank J. A. Naftel of the United States Borax and Chemical Corp. for the samples of glass studied and relevant rate of solution data, A. J. Engel for helping adapt analytical methods to meet the special needs, and W. E. Wettling in completing much of the laboratory work.

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Received for review December 6, 1957. Accepted March 12, 1958. Division of Agricultural and Food Chemistry, 132nd Meeting, ACS, New York, N. Y., September 1957.

PLANT ESTROGENS

Isolation of a New Estrogen from Ladino Clover

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Estrogenic compounds, including genistein, biochanin A, and formononetin, have been isolated from subterranean clover (*Trifolium subterraneum*) (*4*) and red clover (*Trifolium pratense*) (*12*). In certain strains of subterranean clover, the estrogenic content, mainly genistein, has been sufficient to affect reproductive performance of grazing ewes adversely and to cause genital and mammary stimulation in wethers (*7*).

In a recent review of plant estrogens,