For Reference

NOT TO BE TAKEN FROM THIS ROOM

THE EFFECTS OF AMMONIUM PHOSPHATE AND BORON ON ALFALFA (<u>MEDICAGO</u> <u>SATIVA</u> L.) SEED PRODUCTION AND VEGETATIVE GROWTH

John W. Hall

Department of Field Crops University of Alberta





Digitized by the Internet Archive in 2018 with funding from University of Alberta Libraries

https://archive.org/details/effectsofammoniu00john

DVETERAL AN ASTRETTAND

Contraction in the second

had been been along the second of the

THE EFFECTS OF AMMONIUM PHOSPHATE AND BORON ON ALFALFA (<u>MEDICAGO</u> <u>SATIVA</u> L.) SEED PRODUCTION AND VEGETATIVE GROWTH

John W. Hall Department of Field Crops

A THESIS

submitted to the University of Alberta in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE

> Edmonton, Alberta April, 1944

II.C.

sense of a long to dealer

21-12

.

walling and the

And S . 12cm

TABLE OF CONTENTS

.

			Page
Introduction			l
Part	I. 3	Field Experiments	2a
	Lite	rature review	2a
	Mate	rial and methods	10
	Expe	rimental results	12
		Vegetative yield	13
		Discussion	16
		Seed yield	18
		Discussion	21
	Correlation and regression		22
		Discussion	23
Part	II.	Greenhouse Experiments	27
	Lite	rature review	27
	Experiment I		
		Material and methods	30
		Experimental results	33
		Discussion	35
	Experiment II		
		Material and methods	37
		Experimental results	38
		Discussion	40
	Expe	riment III	41
		Material and methods	41
		Experimental results	42

1 hesis 1944 # 9

Endering di nelle

, i

.

-	
	Tobrodocileo
	Serbit. Finds Expected and a second second
	······································
	······································
	······································
	······································
	······································
	······································
	······
12	
	······································
	······································
	······································
	······································
	······································
	······bdecow
	······································

TABLE OF CONTENTS (continued)

	Page
Discussion	44
General Discussion	45
Summary	48
Acknowledgements	49
References	49

-		
	······	
		-

set adjes to set

THE EFFECTS OF AMMONIUM PHOSPHATE AND BORON ON ALFALFA (<u>MEDICAGO SATIVA</u> L.) SEED PRODUCTION AND VEGETATIVE GROWTH

John W. Hall

INTRODUCTION

Alfalfa seed production in the prairie provinces has always been very uncertain. The resulting scarcity of seed has, to a large extent, limited a more extensive use of alfalfa as a hay and pasture crop. The rapid expansion of mixed farming in the parkland area of Alberta has increased the demand for good legumes that produce a large amount of forage and, at the same time, are hardy enough to withstand the severe winters.

Alfalfa in the black soil region produces an abundance of vegetative growth and very little seed. The gray wooded soil zone offers the most satisfactory soil and climatic conditions for alfalfa seed production in Alberta. Up to the present, however, alfalfa seed yields on the gray wooded soils have been too low to make seed production economically possible.

Experimental results have shown that crops on the gray wooded soil make the most satisfactory growth when sulphur is applied to the soil (38).

ALLER DE CREMENTE VI ALL TREERANDE LITT

LEAT .. CHOT

NUMBER OF THE SALE

and continues similary and the bollowing fame attained.

stimute hear very them their. The resulting control prof and bout to A burge tableat, it is a same estemative that it alfords as a burge and mathematical its and the estemative of show table incline the restriction read of therein boundated of show table for good heatmat the read of therein boundated to show table to good heatmat the read of therein boundated the design to a state hims the read of therein boundated the second the same hims the read of the state and the second the same hims the second of the vehicles of the second time of the second to vehicles a second show of the lifetime in the mathematic and the vehicles of the second lifetime in the mathematic and the vehicles of the second second state of the second second to vehicles of the second second second lifetime in the mathematic and the vehicles of the second second second lifetime in the mathematic and the vehicles of the second lifetime the second second

of remtility around on any shift soul. The grap makes well and offsets the mast machinectors will not off wells annihil me for firstly and remtistion in Alberto. By to the intenset, however, diffile seen fields on the for another will be to any to this and fields on the for another will be

Equiviented control controlement of very our torersy wooded and total the Nort sectated org struct wood feights to another to the solt (28). In many districts in Canada and the United States the production of alfalfa hay and seed has been greatly increased and the possibility of a seed crop failure greatly reduced by the application of a small amount of boron to the soil.

It was thought that boron might possibly be a limiting factor in alfalfa production in Alberta and that, combined with an efficient fertilizer, it might increase the hay and seed yield of alfalfa on the gray wooded soil.

Experiments were conducted in the field on gray wooded soil and also in the greenhouse on both gray wooded soil and sand cultures. For this reason the paper is reported in two sections, Part I dealing with the field experiments and Part II with the greenhouse experiments.

- 2 -

In way, theiricks in neuron within the definition of the second s

ide the first first of the intervention of a distribution
intervention in a distribution of the intervention in the intervention intervention
with an artificiant interview in the intervention intervent
and first of all literation on all another intervention intervention

• However and the set of the mean follow of the mean of a set of the set o

PART I

- 2a -

FIELD EXPERIMENTS

Many aspects of seed setting in alfalfa have been studied in an effort to determine the factors responsible for the great variation in alfalfa seed production. These experiments were designed to study the application of various amounts of boron on alfalfa grown on gray wooded soil at two levels of fertility.

LITERATURE REVIEW

A review of literature dealing with factors other than nutrition that affect alfalfa seed setting in the prairie provinces is included here to give a better idea of the complexity of the problem.

R. P. Knowles (17), working at the University of Saskatchewan, found that in the White Fox area of Saskatchewan the leaf-cutter bee (<u>Megachile</u> spp.) was the most important alfalfa-tripping insect. He found a significant correlation between the prevalence of these bees and the amount of seed setting. High temperatures increased tripping. Most of the automatic tripping occurred from 8 a.m. to 4 p.m. Crosspollination produced more seeds per flower tripped than self-

and the main of the state of the second of the

think b manner require require require to the ref. read the comment mean of b comments and the beam of the read mean and read to show the read of an efficiency of the read of the read of show the read of t

int antitizes to a state many in the sub-interment antitizes to a state many in the state of a state math, it is initiated as as in a state inter of a state state is an mobile.

 pollination. A great variation in seed setting among plants of the same strain was also evident.

Lejeune and Olson (18), Silversides and Olson (34), and Jones and Olson (15) studied many factors in an attempt to increase seed setting. They found that tripping was necessary for satisfactory seed production and that bumble-bees tripped practically all flowers visited, while honey bees tripped very few. Mechanical devices increased the number of flowers tripped but decreased seed setting owing to injury to flowers. Crosspollination proved superior to self-pollination.

Sexsmith and Fryer (32) studied the effect of the seasonal age of the plant on the viability of pollen. They determined that temperature and humidity as well as the time of season had no significant effect on pollen viability. The same workers (33) reported a linear relationship between pollentube growth and temperature, the length increasing as the temperature increased from 70°F. to 100°F. Clarke and Fryer (4) found that artificial tripping increased seed setting, but that less than half of the flowers tripped set seed. Although the per cent of sterile pollen was the same for different flowers of the same plant, it varied greatly among different plants from the same strain, but not for the same plant from year to year.

Wyatt, Newton, and Ignatieff (38) applied different fertilizers to the gray wooded soils in Alberta. On a fiveyear average alfalfa hay increases from fertilizers not containing sulphur varied from 529 to 1054 pounds per acre, while increases

- 3 -

politzetion. I start corrected to read region owned cluster, p our secondition was also svideor.

bij dimension in the solution of the solu

i a de devine a la shiar (2 , mangel hi débias

poreiti de la companya de la company Dese antenese atras y se subsenses de la companya d from fertilizers containing sulphur were from 3165 to 3681 pounds per acre. Another experiment with fertilizers applied to alfalfa on the gray wooded soils, reported by White (37), showed that ammonium phosphate which contained 14% sulphur was superior for alfalfa hay and seed production to other fertilizers not containing sulphur. The yield of alfalfa seed in this experiment was, however, too low to make seed production economical.

The application of sulphur to the soil has also produced increases in alfalfa in parts of the United States. Powers (27), at the Oregon Experiment Station, obtained striking increases in the yield of alfalfa by the application of sulphur. Soils of the northwestern states that responded best to sulphur were the residual, calcareous, and basaltic lands. Optimum growth of alfalfa was obtained when the concentration of sulphur in the soil solution was 15 to 30 p.p.m. during the first three weeks of growth and 8 to 15 p.p.m. during the next three weeks. Changing the reaction of arid soils from faint alkalinity to faint acidity by sulphur additions resulted in an increase in concentration of potassium, calcium, and magnesium bases in the soil solution. The application of sulphur increased the drought resistance of alfalfa. This was credited, in part, to a better floculated condition of the soil resulting from an increase in water-soluble calcium. The addition of sulphur to the soil also increased the chlorophyll content of alfalfa by 18%. Powers and Ruzik (28), in a later report from the Oregon station, advocated the application

- 4 -

. and the first and the strength of the streng - dive a love public a sinhing a state of the state of TO AND THE A PART OF THE REAL PARTY AND ALL AND APPENDIX AN read deligions while and de address in our int is and a star the to all the state shows a bull of an established the state of the state solution DE of the and nothing of a solution as of the and a 1000 weather C at 1 and 2 con the 2.10 years while a fi was hire when a class of the state of the state of the - and the state of the sold analysis is a subinvestigation and the second state of the second state cardination and a state of a second contraction of a state The real state of the set of a set of the se the distribution of the state of an internet and and the state and the second of the second second to the second

~~ ~~

of sulphur as phosphates containing sulphur. In 36 field trials, reported in the same paper, alfalfa hay production was increased as much as two tons per acre by the application of 30 pounds of borax per acre, and the sulphur and nitrogen content of the hay were also increased. Chapman (3), in greenhouse experiments with three calcareous soils relatively low in calcium carbonate (3.7% or less) and moderately well supplied with phosphates, found that physiologically acid nitrogen and sulphur fertilizers markedly increased the availability of the phosphates, being particularly effective on the soils lowest in carbonate and highest in phosphate.

Many workers in the United States have reported large increases in the hay and seed yield of alfalfa by small applications of boron to the soil. Boron becomes available very slowly and because of this the total boron content of the soil cannot be used as an indication of a need for boron.

Soil conditions that affect boron availability and the relation between boron and other plant nutrients have been studied in several districts in the United States. Cook and Millar (7), at the Michigan State College, reported that boron deficiency occurred most commonly on alkaline or overlimed soils but also found it occurring on acid soils. They found boron deficiency more often on hilltops and slopes than on low level land. Pervious subsoil layers usually occurred under areas where boron deficiency symptoms were most severe. The boron content of badly leached areas was not much less than that of surrounding areas leached to a lesser extent. They credited the boron

- 5 -

לאחר התכופדה בר שיי הללים שליים, אותי בי הייצון ויבעים "הייריעניא לה סעי ואיר הייזי ברבעי ערים ברבעים לה שעבול דין ברבעים שנותה של ישריסי זה בני סיונו. ביינס שיירי אי ישיעניטנוי דיידך שנותה יהו שיירים בני סיונו. ביינס שייר אי ישיעניטנוי דיידך שנותה יהו שייר ברבעי היים איריים.

An released being bound on a provincial back and notified in several destricts to the definition of the end of the (0), at the trian these there, some an only of according and the analysis of the destrict of the destrict according to available and the destrict of the destrict according to available of the destrict of the destrict according to available of the destrict of the destrict according to available of the destrict of the destrict according to available of the destrict of the destrict and be destrict on a second of the destrict of the destrict and be destrict on a second of the destrict of the destrict and be destrict on a second of the destrict of the destrict and be destricted and the destrict of the destrict of the destrict and be destricted and the destrict of the destrict of the destrict and be destricted and the destrict of the destrict of the destrict and be destricted and the destrict of the destricted and the area in the destrict of the destrict of the destricted and the destrict and be destricted and the destricted and the destricted and the area in the destrict of the destricted and the destricted and the destricted and be destricted and the destricted an starvation of the leached areas to the removal by leaching of the boron as rapidly as it was made available. They determined that the availability of boron is not affected when the pH of the soil is raised with a salt that does not furnish a cation capable of forming an insoluble borate. However, calcium and magnesium fixed boron in the form of insoluble borates in soil with a basic reaction but not in a soil with an acid reaction.

Other workers observed the same relation. Midgley and Dunklee (21) reported that the ability of soils to fix boron depended on the degree of acidity and on the extent to which they had been subsequently limed. Peat moss from Maine, and Vermont A_1 podzol soil fixed very little boron in their acid state. Their ability to fix boric acid increased up to and slightly beyond neutrality when lime was applied in increased amounts. Most neutral soils tested were only slightly affected when similarly treated but, if acidified by leaching similar to podzolization, they fixed large amounts of boron when excessively limed.

Parks and Shaw (23) demonstrated a possible method of boron fixation in the soil by the use of mixtures of solutions of silicon, aluminum, iron, calcium, magnesium and phosphorus with boric acid titrated to reactions varying from a pH of 5.0 to a pH of 9.0. They found that boron fixation was favored by reactions above neutrality, by dehydration and retitration, and by the presence of calcium ions in the mixtures being titrated.

Colwell and Cummings (5) tested calcium, sodium, and potassium metaborates as compared with boric acid as sources of

- 6 -

statew binn all the lower of an an arreated an incoming of the borders whitle is the interval of 1000. They determ the interval and the offer is out of is and the method of 1000 the rate is rised with a said with the a test finding a writed of able of ready which is said with the a test finding a writed is an analyse is a foreight in the solution of a difference is a find of the offer the solution is said the solution of a difference is a find of the solution of in a solution of the solution with a find offer the solution of in a solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the solution of the solution of the solution of the solution. Solution of the sol

and handlar (b) reconserve the line of its of actions of the occurs total add to but degree of bob its and of the extrem to this and the second surgeducting them. The number from the odd terms to grands cold first very tight ones if and to cold allocate to a subsequencing the second to be dat allocate but a still a sected of the day of the total and the second total to a still a sected of the day of the second subsect bar a subsequence of a second to be and a signation of the total of the sected of the day of the second total total to a still a sected of the day of the second signation of the total of the sected of the day of the second still of the total total to a still a sected of the second total of the total of the sected of the day of the second still of the total total total total of the day of the second total of the total of the sected of the day of the second total of the total of the sected of the day of the second total of the total of the sected of the day of the second total of the total of the second of the day of the second total of the total of the second of the day of the second total of the second total of the second of the second total of the second of the second of the second of the second total of the second total of the second of the

intervalue of the second of the second

representation of the construction of the second of the se

+++ () +++

boron in nutrient solutions. They found that, regardless of the source of boron, deficiency and toxicity symptoms appeared at the same time and at the same levels of concentration. Specific conductance tests on calcium, sodium, and potassium metaborates and sodium tetraborate showed that for solutions of all the salts except calcium metaborate the ionic conductance of the boron-carrying anion was the same and corresponded with the value for the H_2BO_3 anion. For the calcium metaborate this value was much lower and that the system was unstable was indicated by a gradual lowering, with aging, of the conductance values and of the pH.

Using Crosby silt loam Jones and Scarseth (16) grew alfalfa in the greenhouse with varying amounts of lime, fertilizers, and boron. The growth of alfalfa was not as good on the unlimed soil with a pH of 5.6 as on the limed soil with a pH of 6.6 and 7.6. Varying the borax application from 0 to 50 pounds per acre in the two series of limed pots produced no definite change in yield. The calcium-boron ratio, however, became lower as the applications of borax increased. This ratio was also consistently higher with the highest pH values resulting from the limed pots. The amount of boron taken up by the plants was in proportion to the amount of boron added to the soil. Less boron was taken up at the higher than at the lower pH values for each rate of borax application.

Marsh and Shive (19), working with corn in nutrient solutions with varying amounts of boron and calcium, found that

- 7 -

the bound of the second of the

- / -

within certain limits the boron content of the substrate did not significantly affect the calcium absorption rates of the plants. The soluble calcium in the corn tissue was determined by the boron content of the plant which was in turn determined by the boron content of the substrate.

Investigations in many parts of the United States have shown that the available boron in soils, especially those heavily limed, is too low for satisfactory alfalfa production. Brown and King (2), in Connecticut, reported 75% more borondeficient plants on soil which had received 9 tons of limestone per acre between 1914 and 1918 than on soil which had received 7.5 tons during the same time. On this land, 20 pounds of borax per acre increased the height of alfalfa by 15%, the yield by 16%, and the boron in the leaves from 21 to 62 p.p.m. Cook (6), in greenhouse experiments with Michigan soil, obtained increases in vegetative growth of alfalfa of 14.4% by the application of two pounds of borax per acre. In Alabama Naftel (22) obtained beneficial results from the application of borax to 15 out of 20 limed soils used. Piland and Ireland (24) obtained very good seed set on alfalfa by the application of 20 pounds per acre of borax, while the untreated plots yielded none.

Baur, Huber, and Wheeting (1), on western Washington soils, found that boron-deficiency characteristics were associated with a restricted supply of moisture. By the application of 60 pounds per acre of borax they obtained an increase of from 1457 to 2200 pounds of hay per acre. In Virginia, Gizzard and

- 8 -

atting security if it is noted a support of the additional if a are at if and the security of a security its the attent of attack. The solution is the astent of the security attacks attent is the become suched of the astent of a security and its entropy is the asteric suched of the astent of a security attacks.

and a start of the second sector is the . Manager de la general des s'energies de sector de sector senter and the first statements of the state of the state ... india statistica and a brain of a data that and a Rear and the set of th and on the block of the state o the second state of the state of the second st

andle, total a secondation of an an of a second and a strain a second a strain a s

Matthews (12) reported an increase of from 289 to 743 pounds of hay per acre by the application of 15 pounds of borax per acre, with a yield of from 82 to 184 pounds of seed per acre from the borax-treated plots and none for the untreated ones.

Dregne and Powers (9) reported that both borax and boric acid gave profitable increases in alfalfa hay on the major soil types of northwestern Oregon. The most profitable rate of application was 60 pounds per acre of boric acid. Powers (26) obtained an increase of 300% by the application of 30 pounds per acre of borax on an old stand of alfalfa on irrigated land. In three other fields an average increase of one ton per acre was realized by boron application. Growth response of alfalfa to one application of borax was maintained over a period of 2.5 years. The addition of boron to the soil increased the boron content of the plants grown in it and slightly increased the protein content. It also increased chlorophyll content 50% and vitamin A content 30%. Piland, Ireland, and Reisenauer (25) applied to 13 alfalfa fields in North Carolina sufficient borax to supply boron at the rates of 0.5, 1.0 and They obtained, by the application of boron, hay 1.5 p.p.m. increases as high as 27% over the check plots and seed increases of 460, 433, and 529 per cent respectively for the three boron applications.

Alfalfa has shown a response to fertilizers on many soils. Vandecaveye and Bond (36), in field trials in both eastern and western Washington, applied nitrogen, phosphorus, and potassium alone and in all possible combinations. Nitrogen

- 9 -

depicters (11) represed to binches of 100s fills to 960 control of her per one are the epilicitic. (b pouls of breat per ones, with a riald of from 85 to 180 control of and on sent from 2.1 birtz-tracket nime and some for the original fonce.

and a solid by the state of the second of the solid state of the second state of the s To activizione and the solution is a solution (20) however -ind a mising of here as a a stand of a make a stand of the the lo unces of the local field an even of the state of the ton for an in reliant to borne application. Court for our a few half of a same table to collect the second significant resident is a perch. The addition of louve as an and instances sign and a break out out of a callade of the second many emmers 31 can visuala M ann 1, 301. - 12 4, 1783 ad, 104 an old len to other of the maker with the constant and in the The second to condition on the second to the second second and the of dos, while and the stand frequent since the box box . The sole to . Looil olimpa

autor and a second of the seco

444 1 may

and phosphorus, when applied together, gave as large an increase as the complete fertilizer and larger than any one applied alone or in combination with any other. The increase over the check, obtained by the application of nitrogen and phosphorus, was 1.3 tons per acre in eastern Washington and 1 ton per acre in western Washington.

Sewell and Latshaw (30) experimented in the greenhouse with different applications of lime, superphosphate, and potash on an acid silt loam soil to determine their effect on the growth and composition of alfalfa. They obtained the largest increase in yield by the application of 450 pounds of superphosphate per acre plus sufficient lime to bring the pH of the soil to the neutral point. Chemical analysis showed that the superphosphate treatments alone did not increase the phosphorus content of the hay but that the combined application of lime and superphosphate did.

MATERIAL AND METHODS

In the spring of 1943 two fields of one-year-old stands of alfalfa on gray wooded soil near Warburg were selected for the experiment.

One field was on the farm of Mr. J. Innes. It had been seeded at the rate of four pounds of seed per acre and, consequently, was a very thin but nevertheless very even stand.

- 10 -

cat game_morent, the entrie i anged et, gam as his and the entries an on the construction of the entries of the entries of the signed of in construction of the entries of the entrement prior is there, as behind to are entries of the entries of the entrement of the last as being and there is a start of the entrement of the last back and there is as a more that the entrement of the last as the is a start of the entrement of the entrement of the last as the entrement.

20.0 million and the second

In her soria, to 1982 and finish in our-post-tool state of sliplin on its, wolded will not state they calestof for the state block.

Dess sector (but the out the 1927 of st.). Subjet. If all

The other field, on the farm of Mr. O. Anderson, had been seeded at the rate of 10 pounds of seed per acre. It was also a very even stand but much thicker than that on the former field.

The practice of light seeding is recommended for alfalfa seed production in Alberta (11). The choice of these two fields allowed a comparison between the light and heavy seeding.

One experiment was established on each field. Each experiment consisted of a 5 x 5 Latin square design with split plots. The five treatments varied only in the amount of borax applied, the rates being 0, 5, 15, 25, and 35 pounds per acre.

To half of each of the check plots and the boraxtreated plots 16-20 ammonium phosphate was applied at the rate of 100 pounds per acre. The other half of each plot was left unfertilized. The fertilized and unfertilized parts were the smallest plot units in the experiment, each having an area of 200 square feet.

The ammonium phosphate (16-20) fertilizer used contained 15% sulphur which, as reported previously (38), is a necessary constituent of a fertilizer for the gray wooded soils.

The borax and fertilizer were applied on May 27, 1943. The amount to be applied to each plot was measured and placed in a container with a perforated bottom and shaken evenly over the prescribed area.

Samples from the plots were harvested on September 20th.

- 11 -

You name thats, as now You of all 1. As after, an Yead seaded th an white of the same at each an able, at Mir and a realy even the 1 bet cast o fairs build this of a former Yead.

The rear is of An or 1, when h reads and A for effective each readers in there is [1]. The product of them be filled with our a subject on return of read nonge second r.

"de et al violant de l'ante de l'ante anne theff. The experimente administre of a six e solo estere la parte dava. For the solation of a six e habe to commit a format en sted, bis solo bride in §, 18, se com la parte an etca.

these (it's it's a sublicity of the two wes a state of the two of or 100 provide por time. We can this of the trians it's the mountally entoritized. The trian the time the third providence was the sublicity it's a state of the state of the state of the state of the 200 square for which is the time of the state of the state of the 200 square for the time.

the manufactor (the first first and and

the module to an arrithm of some first we wanted a later to the second state of the se

the last transition when when were and the to be

The sampler used was a half-inch steel rod bent in the form of a spiral with a diameter of 33 inches. Four samples were taken at random from each plot by placing the sampler on the foliage, turning it until it lay on the ground, and then cutting all the plants inside the circle. The four samples from each plot were bulked and weighed in the field to the nearest five grams. This weight was taken as the vegetative growth produced. The sample from each plot was wrapped in cloth to prevent loss of seed, tagged and allowed to dry.

Threshing was done with a rod-row thresher. The seed was cleaned with a Clipper seed cleaner and then hand-screened to remove any remaining foreign seeds. The samples of seed were then weighed to the nearest tenth of a gram.

To change the yield from grams per plot to pounds per acre the weights were multiplied by the conversion factor of 4.041.

The data obtained from these experiments were analysed according to the method described by Goulden (13).

EXPERIMENTAL RESULTS

The fields were inspected on July 26th. At this time it was quite evident, in both fields, that the application of fertilizer had increased the vegetative growth. The difference between the fertilized and unfertilized plots was, however,

The second state of the bar with a second comment. The second sec

Ou stands the fills room part for an erroral of an and the stand of a stand of the stand of the

The Mark Sabilate from Series and a second meri an Contra advertise to the restory the right of Vertical 1.11.

ST AN LINE STREET

the many paths and ont, to both rists, the sound of a literate of formalizer in the second the second of a second of the second

- 21 -
noticeably greater for the thin stand of the Innes field than for the thick stand of the Anderson field. Besides being more abundant the foliage was a much darker green color on the fertilized than on the unfertilized plots.

Vegetative Yield

The vegetative yield in grams per sample for the different treatments on the Innes field, together with the mean yield in pounds per acre for the fertilized and unfertilized plots, is presented in Table I and the results of the analysis of variance of these data in Table II.

TABLE I

Vegetative yields for the Innes field

	Bor	on - p	ounds	Mean yield			
Fertilizer <u>16-20</u>	none	5	15	25	35	gm. per sample	pounds per acre
100 lb./acre Unfertilized	1594* 175	1746 225	1416 197	1668 188	1846 199	1654 197	6686 795
Mean	884	985	806	928	1022	925	3740

* Each value is the mean of 5 replicates

notice his presents for any idle second of the inner itely inenfor a state elization? The universal field, swidter selectings element the failors was some performance on the factified then of the universities from.

Di Wilstige William,

The reposition yield in control sector for the dirthread brands of the final field , bounder its the test plate is controls for an inclusion and the founds of the, is presided in tells I and the founds, or the cutyels of carbones of brand the following T.

7 250 2

The should be the state of the state of

			1	UP CAL	4 -	 101
181/11000	0000			7.5 	(g).	 191
antra y dia 1005 Marina Mangarit	TAL			Pali	.4841 611	
		Y. U				

I THE PERSON IN COMPANY AND A DECIMAL TO AND A DECIMAL TO

TABLE II

Analysis	of variance fo	r vegetative yield
	for the Inne	s field

Variance due to	D.F.	Mean squares	F
Boron Rows Columns Error (1)	4 4 4 12	72143 199767 34804 42011	1.72 4.75* .83
Fertilizer Fertilizer x boron Error (2)	1 4 20	26542898 61757 57408	463.35** 1.08
Total	49		

** Significant beyond the 5% point

The application of fertilizer had a very pronounced effect on the vegetative growth of the alfalfa in this experiment, as is shown by the highly significant F value for fertilizer in the above table. The mean yield for the fertilized plots was 1654 grams as compared with a mean yield of 197 grams for the unfertilized plots (Table I), with a minimum significant difference of 135 grams. The increase due to the application of fertilizer on this field, converted to pounds per acre, represents a gain of 5891 pounds of vegetative growth per acre.

The alfalfa on this field showed no response whatsoever to the application of boron at any of the rates used. The significant F value for rows (Table II) is evidence that soil conditions were not uniform over the area occupied by this experiment.

7. 10/2

	4 - 6 -		97 K 67
andra andra		CALLET TOTOCA COLLEG LINEB	- 14.4 58.5 50.
norod		. 1604, 1535 92300 0. 4V3	···

Main winede by tot station to fiscion 21:10 years for the fiscion

denie wy see in gewonering as a see in the see

eter at an initiantain it would be any of an initial of atoitstand - walks for our (" one walks when the only a distribution an initiation over on attached the milenergy." The vegetative yield for the different treatments, and the mean yield in grams per plot and pounds per acre for the Anderson field are shown in Table III. The results of the analysis of variance of these data appear in Table IV.

TABLE III

Vegetative yield for the Anderson field

	Boro	n - p	ounds	Mean	yield		
Fertilizer 16-20	none	5	15	25	35	gm. per plot	pounds per acre
100 lb./acre Unfertilized	1042* 535	839 588	1036 718	1022 758	926 571	973 634	3932 2562
Mean	788	713	877	890	748	803	3247

* Each value is the mean of 5 replicates

TABLE IV

Analysis of variance for vegetative yield for the Anderson field

Variance due to	D.F.	Mean squares	F
Boron Rows Columns Error (1)	4 4 4 12	60586 14919 50285 58775	1.03 .25 .86
Fertilizer Fertilizer x boron Error (2)	1 4 20	1436512 26431 11673	123.06** 2.26
Total	49		

** Significant beyond the 1% point

- 15 -

the presenting that are the elitance meaning an

an an over the for peak on the constant of the of the

. I don' of really the except to endiner to alaying

Sal Later

Lind murrebut all add Aletz unlettered

	-		a	No.	1475 	an - sector and a grow we de-	
56000 234 274	•			alle.			
	55	Svi.	ye î Bai			1040L	bank int the
			U's				RP 0

shirt bar 2 10 men out i ebiev John *

AT I THE

EDDOURA I HARES TO FOUNDAUD MARK

to all bounded		L SEREE C V	
		Baran -	
Art - Los	* <u>1</u>		<u>06</u> .
noned = naulitano Nord I Lass = baron (1)		1010012 20002 20022	-(? <u>;</u> *)
1.0.0			

a contractor de la contractor

The vegetative yields for the different treatments on this field followed the same trend as those on the Innes field. The mean vegetative yield of the fertilized plots was 973 grams compared with 634 grams for the unfertilized plots (Table III) with a minimum significant difference between the means of 61, grams.

The application of boron again produced no increase or decrease in the yield of vegetation.

Discussion

On both fields the application of 100 pounds of ammonium phosphate (16-20) per acre increased the vegetative growth of the alfalfa. The increase was, however, greater on the thin stand of the Innes field than on the thick stand of the Anderson field.

A combined analysis of variance of the vegetative yield for the two fields was attempted. The extremely low yield of the unfertilized plots and the relatively high yield of the fertilized plots on the Innes field in comparison with the intermediate yields for the corresponding plots on the Anderson field complicated the analysis. This resulted in the difference between the yield of the fertilized and the unfertilized plots appearing as interaction between fertilizer and field, thus masking the true effect of the fertilizer.

The increase in vegetative growth obtained in this

The investories of the sole or all of the offer and spectaring the first state of the state of t

the shift as the second of all and a solid solid on the

or detection as a later one as appointed no

dolarts :

On Sibe Marke the of Altering C 100 pounds of annoal to pass the Of get norm instruced has remarked/s gravity of the sirator. Its increase was, asserted, gravite unthe bais stead of the inges field them on the built near of bes induction field.

Provide the set of the set o

"In the factor diane, syldnamps- _ sameters of

experiment by the application of fertilizer to alfalfa on the gray wooded soil agrees with the results reported by Wyatt, Newton, and Ignatieff (38) and by White (37).

The high vegetative yield of 6686 pounds per acre for the fertilized plots of the thin stand as compared with the yield of 3932 pounds per acre for the corresponding plots of the thick stand may have been caused by other factors not considered in this experiment. One reason for the difference may be that the alfalfa seed sown at the rate of 10 pounds per acre produced a stand that, owing to crowding and competition between the plants, was too thick to produce maximum returns. Another possible reason for the increased growth on the thin stand may be the fact that each plant there received a larger proportion of the fertilizer than did those on the thick stand and that this added stimulus received by each plant produced more growth than could be realized by a greater number of plants. That the fertilizer produced nutrient conditions more nearly optimum for alfalfa growth on the one field than on the other offers another possible explanation for the difference between the growth response of the alfalfa on the two fields, since the fields were some six miles apart with different cropping histories and were conceivably quite different from each other nutritionally. The application of boron, as shown by Tables I and III, produced no significant effect on the vegetative growth on either of the fields. By examining the mean yields for the different boron treatments it becomes evident that there was no tendency toward

- 17 -

children in his source and the state of the set of mail to be a find the second of a start of the second of the product and the second radia are not added and meeting where the second sector is a costance of the same densed as an and so a second to a second standard and the second standard of the a constant of the second constant and the an increase or decrease in the vegetative yield as the rate of boron application was increased. This fact suggests that further experiments on these fields would fail to show any beneficial effect from the application of boron.

Seed Yield

The seed yield in grams per sample for the different treatments and the mean yield in pounds per acre for the fertilized and unfertilized plots on the Innes field are given in Table V. The results of the analysis of variance of these data are shown in Table VI.

TABLE V

Seed yield of the Innes field

	Bo	con -	pounds	Mean yield			
Fertilizer 16-20	none	5	15	25	35	gm. per sample	pounds per acre
100 lb./ac.	22.0*	23.1	15.9	22.0	24.0	21,4	86.4
tilized	1.0	1.6	0.8	0.9	1.0	1.1	4.3
Mean	11.5	12.3	8.3	11.4	12.5	11.2	45.4

* Each value is the mean yield of 5 replicates

- 18 -

an guadance at terminate is the probabile (2)th to be a seried of entropy of direction and incontract. 2014 then the series a stratization of them is apply and with a three last brandidist without for the stration of entropy.

AL-27 Dend

The need of the state of the second of the state of the s

7 1 1 25

and and so the base

- Jusi							
the in		A sector				2000	50711(0301 07-51
*	. 19	1.12				-0	.00 .31 001
	2.7		¥.4	0.0	0.L	G, L	-lelle
4	. - E			2	6.54	11.5	. Bred
				- 1. W 1			

set to be the first and shares and a

TABLE VI

Variance due to	D.F.	Mean squares	F
Boron Rows Columns Error (1)	4 4 12	28.37 32.24 7.01 11.02	2.57 2.93 .64
Fertilizer Fertilizer x boron Error (2)	1 4 20	5169.41 22.82 16.87	306.46** 1.35
Total	49		

Analysis of variance for seed yield for Innes field

** Significant beyond the 1% point

The seed yield of the fertilized plots on this field showed a remarkable increase over the seed yield of the unfertilized plots. The minimum significant difference between the mean seed yields for the fertilized and unfertilized plots is 2.3 grams, with an actual difference of 20.3 grams in favor of the fertilized plots (Table V). This difference represents an increase of 82.1 pounds of seed per acre.

The application of boron as shown by the analysis of variance (Table VI) had no effect on the amount of seed produced.

The seed yield in grams, obtained from the plots receiving the different treatments, and the mean yield in pounds of seed per acre for the fertilized and unfertilized plots on the Anderson field are shown in Table VII, and the analysis of variance of these results in Table VIII.

 an an antiphonetry and so a		مردور و المرد وردنه ما مرد و ال
 10801 E 100 1	6 *	
15 - 85 	- - -	action action action
 stangete with		
 	-8	2 402

Walk any and shake i to sister the

This is a work of the day

The station of the second of the second of the second seco

TABLE VII

Seed yield of the Anderson field

	Bor	on -	pounds	per ac	re	Mean	yield
Fertilizer 16-20	none	5	15	25	35	gm. per sample	pounds per acre
100 lb. /ac. Unfertilized	13.0* 5.6	9.4 6.2	13.9 8.1	9.4 11.4	10.5 7.8	11.2 7.8	45.5 31.6
Mean	9.3	7.8	11.0	10.4	9.1	9,5	38.6

* Each value is the mean yield of 5 replicates

TABLE VIII

Analysis of variance for seed yield for Anderson field

Variance due to	D.F.	Mean squares	F
Boron Rows Columns Error (1)	4 4 4 12	12.60 24.70 13.88 14.23	.89 1.74 .98
Fertilizer Fertilizer x boron Error (2)	1 4 20	147.58 34.23 18.91	7.80* 1.81
Total	49		

* Significant beyond the 5% point

As in the previous field, the yield of seed was increased by the application of fertilizers. The mean yield of seed for the fertilized plots was 3.4 grams per plot or 13.9 pounds per acre greater than that for the unfertilized plots not nosy in. . To fer out

		4 4 Qu	vin dvi	ngun digiter untu	anantas ana sponta ni na ing aga ga	nes factori come esta della cale dalla	graphenghan di Banderi, ber zij delever gener - gener de - , ed
			an an an an an		-	18300 ABANG NA NO TA D	
5.1 ····	10 402 64 10 10		a anti-uca	at		ênou .	
7:36	* 14	h.a.	1 e 1 e	.81	- B 	13.0° 5.0	. say . 61 000 Basi Lumetat
6.00		E		0.12	1,3	Se n	o aedd

Leuroliter o in blaty non alter pier per "

the second second

illing and the second tray is righted

	երան դեռ փեղել՝ ով խորհի է ֆետի եր տելի՝ վիր հետարանականի հարտես էր տանելի է։	NG COM AN AN AN A COMPANY AND A	n na na an anna anna anna an anna an anna an an
MA- 19			01 201 - 0 90 31
20.1 17.1 20.	11.48 13.48 88.81 88.81		Action State Solid Control Solid Control Sol
100 - 17 7.6 - 19 7.6 - 19	BELTHE		noncy a taxiti - a (2) total
		C P	lator

TOLEN , ST I ANY MAN TUre Frida, b.

An it abs provints that, to plant of some we have an and an here and an entropy of an entropy of the some of the solution of t

(Table VII), with a minimum significant difference of 2.5 grams. The seed yield on the plots in this field was neither increased nor decreased by the application of boron.

Discussion

Under the conditions of this experiment the application of 100 pounds of ammonium phosphate per acre increased the amount of seed produced by alfalfa on gray wooded soil. A similar increase was obtained by White (37) with the application of fertilizer to alfalfa on these same soils.

A comparison of Tables V and VII shows that the unfertilized plots on the thick stand yielded 31.6 pounds of seed per acre, an increase of 27.3 pounds per acre over the unfertilized plots on the thin stand. The application of fertilizer to these fields, however, reversed this order and the fertilized plots on the thin stand yielded 86.4 pounds of seed per acre as compared with 45.5 pounds per acre for the corresponding plots on the thick stand.

These results support the recommendation of a very light stand of alfalfa for seed production in Alberta (11). They also emphasize the importance of suitable fertilizers for satisfactory seed production.

There was no tendency for seed production to increase or decrease even below the level of significance as the rate of boron application was increased. This strongly indicates that

- 21 -

(relda VII). Mañ e ajainas signitizant harmengos et 4.2 ganta. The good gange on and rise in ministration was call in homenwell nor hadressed for the argundation of borne.

o clua dves d

take at low county of characterized an experiment in equipme with at low county of characterized the constrained by end as of each county of the lighter on the could off. singles inspress any officient on the 'SN' which has applied bits of formaliser on a loofs on the counties.

Hilderd plote on the addressed that 21 and 1420 her when when hilderd plote on the addressed that 30 formate of whet we are a barreas of 20.5 course on the one day watertables along an are able around. The endited is an invalidant of these fields, another, contract one of the an analytical first on the that is and fields of a normal of and the endition formation with the second fields of a normal of and the endition of the raise and a second fields of a normal of and the endition of the raise and a second provide on the around of and the end of the raise and a second provide on the around of and the end of the raise and a second on the field of a normal of an around a second on the raise and a second on the field of a second on the around on the raise and a second on the field of a second on the around a second on the raise and a second on the field of a second on the around on the raise and a second on the field of a second on the around on the raise and a second on the field of a second on the around a second on the raise and a second on the field of a second on the around on the raise and a second on the field of a second on the around a second on the raise around a second on the field of a second on the around a second on the raise around a second on the field of a second on the around a second on the raise around a second on the field of a second on the around a second on the field of a second on the around a second on the field of a second on the field of a second on the around a second on the field of a second on the field of a second of a

John and a static for an experimentation of a first light and a static for an experiment of a static for also expective the first an experiment of a static de static astic citor and static.

and the state of t

boron is not a limiting factor in alfalfa seed production on these soils.

A combined analysis of variance for the two fields was attempted but, as with the vegetative yield of the two fields, the extreme seed yields of the fertilized and unfertilized plots on the one field, when compared with the intermediate yields of the corresponding plots on the other, complicated the analysis.

In general, the results for the seed yield appeared to correspond very closely to the results obtained for the vegetative yield.

CORRELATION AND REGRESSION

The correlation and regression coefficients were calculated to determine the relationship between the seed yield and vegetative growth. These are given in Table IX.

TABLE IX

Relation between seed yield and vegetative growth

Field	r_{sh}	b _{sh}
Innes	.949**	.0135
Anderson	.617**	.0109
Combined	.908**	.0132

** Significant beyond the 1% point

- 22 -

strum is art a littlin fernor 'n abreit aved greit in an there pulls.

(A) and the state of the state and the st

Lo source, ou restore for the cost part of an ered to dorrestor vors should be one founds of Line for a should be for

A TEL SIL THE WITHOUT PR

inter a sector of the sector and a sector of a sector and the sector of the secto

6- 10		
6-1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1	4 % × + + + + +	
0070. UTEL. COTO,	The second	alern I alern I ben Toop

Tel a standard and the standard for

The significance of the difference between the correlation coefficients and between the regression coefficients for the seed yield on vegetative yield for the two fields was calculated. The difference in both cases was found to be insignificant. This permitted the calculation of correlation and regression coefficients for the data for the two fields taken together.

The regression lines of the results for each field and for the two fields combined are shown in Figure 1.

To determine whether the seed yield had increased more than could be accounted for by the increase in vegetative growth the seed yield was adjusted, by means of covariance, for differences in yield of vegetative growth. The results of analysis of variance, using adjusted seed yields, are given for the Innes Field in Table IX A and for the Anderson field in Table IX B.

TABLE IX A

Analysis of covariance between seed yield and vegetative growth (Innes field)

many and a second se					
		D.F.	Mean squares	E,	5%
Treatment	+ Error Error	40 31	11.0		
Treatment Treatment	difference	9 8	10.5 6.5		
be-bt		l	42.5	3,86	4.16

.. m

		<u> </u>	
	6 		
1. A.			2- 6





Relation between the seed yield and the vegetative yield

- 24 -



TABLE IX B

Analysis of covariance between seed yield and vegetative growth (Anderson field)

	D.F.	Mean squares
Treatment + Error Error	40 31	12.2
Treatment difference Treatment	9 8	10.3 11.8
b _e -b _t	l	-1.2

Discussion

The positive relationship between seed yield and vegetative growth in this experiment (Table IX) agrees with the relationship found by White (37). The increase of 1.32 grams of seed per 100-gram increase in vegetative growth, obtained in this experiment, is however greater.

The correlation and regression coefficients for the seed yield on the vegetative growth for the combined fields (Table IX) and the regression line (Figure 1) give a more representative value of the relation between seed and vegetation than do the data for either field taken alone. The use of the data for the combined fields eliminates the very short range of values of the vegetative growth from the Anderson field and gives a more even distribution of the yields than was obtained in the Innes field where the yields were concentrated

		-		
				L. L.
			1	

	· · · · ·	
a		
•		

- a consecut

has full have seened if and added and some after

The analysis of variance of the adjusted seed yield for each of the fields (Tables IX A and IX B) shows that the increase in seed yield was a direct result of the increase in vegetative growth.

PART II

27 -

GREENHOUSE EXPERIMENTS

Since only one year's results could be obtained from the field experiments, it was thought that, though greenhouse experimental results are not always reliable when applied to field conditions, some additional data on the boron requirements of alfalfa on the gray wooded soil might be obtained from greenhouse experiments.

It was also desirable to secure more definite information on the boron requirements of alfalfa. For this purpose sand culture experiments were set up. Sand cultures were chosen for controlled nutrition studies to eliminate the difficulties encountered in aerating water culture media and to provide a better support for the plant than could be obtained in the latter type of controlled nutrient culture.

LITERATURE REVIEW

Thornton and Nicol (35) studied the reduction of nodule numbers and growth of alfalfa in sand cultures caused by the addition of sodium nitrate to a complete nutrient solution. The sodium nitrate was added at rates of from 0 to 10 grams per

Loss and you we want of the out of a server of a server of the field strationals, it is how of the your, correstoned as exteriorate from the server book of the serve

- NON - 100 desired) on means when the mile 1000 massion on one monter remains of all 10. The bill monter and all of all 10. The top when we are the line of the line and an for control of a second when a build a mile of the line birs and contering to means and to mile in which and the desired a based angeot on the line of the contering of the area wild a based angeot on the line of the contering in the line of angeot on the line of the contering.

A N LONG THE

The soldier strates, we have a star the point but of the soldier strates which many at strates V area strated which it is the soldier strates, which a trade of the soldier strates and the the soldier strates, which as a serve of the sold of the soldier the soldier strates, which as a serve of the sold of the sold of

- - -

litre of nutrient solution. Increasing amounts of nitrate reduced both the number and the size of the nodules. The volume of bacterial tissue was, however, reduced to a greater extent than was the number of nodules. The mean root weights decreased with increasing doses of nitrate, but the ratio of roots to tops remained constant at all nitrate levels. The alfalfa was grown successfully in the sand culture solutions for 100 days.

Schroeder and Walker (31) grew garden peas in sand cultures with varying concentrations of a complete nutrient solution. The concentrations were 0.1, 1, 3, and 5 times the concentration which had proven to produce satisfactory growth. The nutrient solutions were added to the sand on alternate days and the excess drained off immediately. Plants grown in the nutrient solution of 5 times the strength of the check solution had smaller leaves and were shorter and a darker green in color than the plants grown in the check solution. The plants supplied with the solution of 0.1 times the concentration of the check solution were slightly lighter in color. All other characteristics of the plants grown in the solutions of 0.1, 1, and 3 times the concentration of the check solution were the same.

Eaton (10) grew alfalfa in sand cultures containing varying amounts of chloride and sulphate salts. The alfalfa grown in the control solution used in this experiment produced satisfactory growth during seven months of experimentation. Cook (6) prevented alfalfa yellows and obtained an increase in ---- m

24tes of whether solution, immediate comment is solution reduced into two sums for the size of the veloce. The volume of canterlai theory with a first veloce of a symmet extend to a test the number of comment. The section of terrespect with instanting to a similar. The section of terrespect with instanting to actual a similar to with the veloce to the to tops formized to be the first of the section of size it's as the second size in the site of the veloce. The size it's first to tops formized to be a site of the section of the first of the second size of the test of the section of size it's as the second section of the test of the section of the first of the second section of the test of the section of the first of the second section of the test of the section of the first of the second section of the test of the section of the first of the second section of the test of the second second test of the second section of the test of the second second test of the second test of the second second

visition maximum of signatur and address in a contract gradua () for sustance address and and the one conclusion contract antification (course convector and contract of course) done (4) remember of size contract of contract of the one of the done (4) remember of size contract of contract of the one of the done (4) remember of size contract growth of alfalfa in sand cultures of from 7.61 to 11.90 grams per plant by the addition of .003 grams of Na₂B₄O₇ to 5 kilograms of white quartz sand which had received an otherwise complete nutrient solution. White (37) grew alfalfa to maturity in the greenhouse using water cultures as the nutrient media. The plants grown in solutions containing half as much phosphorus or potassium as the check solution produced less vegetative growth and seed than did those grown in the complete nutrient solution. In this experiment daily aeration of the nutrient solutions was necessary for satisfactory growth.

Reeve and Shive (29) used sand culture experiments to determine the potassium-boron and calcium-boron relationships in plant nutrition. When the nutrient solution contained 0.5 p.p.m. of boron, tomato plants produced satisfactory growth at all concentrations of potassium and calcium used in this experiment. No symptoms of boron deficiency or toxicity were evident in the plants grown in the solutions containing 0.1 to 0.5 p.p.m. of boron with concentrations of potassium from 10 to 500 p.p.m. The plants grown in the solution containing 0.001 and 5.0 p.p.m. of boron, however, showed boron deficiency and toxicity symptoms respectively and in increasing intensity as the amount of potassium in the solutions was increased. Plants grown in solutions containing varying amounts of boron and calcium showed no boron ficierry symptoms when the solutions contained 0.5 p.p.m. of boron with calcium concentrations of between 5 and 500 p.p.m. Boron deficiency symptoms were increased as the calcium content of the solutions containing 0.001 and 0.01 p.p.m. of boron was increased.

- 29 -

Ariorite at straits to and at comments the list to the data of the end that is an interference of the second of mergy bits of the issue of the interference of the second of the second of the data and the second of the minimum of the second of the second of the plants growt is at an at a first of mergy bits of the second of the others have the second of the second of the second of the others have the second of the bits of the second of the others have the second of the bits of the second of the issue and the second of the bits of the second of the issue and the second of the bits of the second of the issue and the second of the bits of the second of the issue and the second of the bits of the second of the second of the second of the second of the bits of the second of the issue and the second of the bits of the second of the second of the second of the second of the bits of the second of the issue and the second of the bits of the second of the issue and the second of the bits of the second of the second of the second of the second of the bits of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the issue and the second of the second of the second of the second of the issue and the second of the second of the second of the second of the issue and the second of the second of the second of the issue an

- V_ ==

or squeeteness tothic buse when 1977 events ware ware and the set of the set Le un and restarted he deer a same set st , lende to Hundred and the second added to an and the second second second and the second secon .a.c. "... in with a with the anishing the state of the state of the and any constant, and a support and any other than the formation and the low subdition was considered. Concertained a link in province in all, it is independent of the province and the within the second problem is an and the restored and the I so other set at the set of the set to set the set of the set of

The boron toxicity symptoms were, however, decreased as the concentration of calcium in the solutions containing 5 and 10 p.p.m. of boron was increased.

EXPERIMENT I

During the winter of 1942-43 an experiment was set up in the greenhouse to test the suitability of local and purified silica sand as media for the growing alfalfa under controlled nutrient conditions.

Material and Methods

Purified silica sand was obtained from the Dominion Glass Company, Medicine Hat, Alberta.

Two-gallon, glazed crocks, with drainage holes, were used for the experiment. Fifteen crocks were filled to within an inch of the top with each of the two sands. This made thirty crocks in all for the experiment.

Four alfalfa plants were dug from the field after growth had ceased in the fall, and were stored in the root cellar until three weeks before cuttings were required. On December 1st stem cuttings were made from the plants. The top portion of each stem was discarded to eliminate some of the variability among the cuttings. For each cutting the basal cut was made through a The botton is stated appressed ward, for more first with an and and subsetfine of elloyer if his set those coast if the a set of set.

1 2 . 10 . 11

During the winter of index 20 noted and on winner and go in the grand way to beat the subtraction of igns, an and that silice seal as medic for the specify direct which when an average conditions.

a coord has allow

Statistics 211160 eductions of the cash 2720 21 a maintener Right conjunct, in 210 on 120, accord.

The state of the s

control to the first, and the sets the root the first, and the root th
node and the terminal cut about one inch above the next node, thus leaving one complete node on each cutting. The cuttings from each plant were kept separate. The basal ends of the cuttings were immersed for 24 hours in a solution of Hormodin A, a liquid root-stimulating substance manufactured by Merck and Co., Rahway, N.J. The strength of the solution used was 1.25 cc. of Hormodin A in 250 cc. of distilled water. White (37) found this strength to give satisfactory results.

One cutting from each of the four plants was transferred from the Hormodin A solution to each crock. Extra cuttings, to be used if any failed to form roots, were transferred to a flat containing local sand.

The nutrient solutions applied to the sand in this experiment were based on solutions advocated by Hoagland and Arnon (14) for water culture experiments. Three different solutions were used: a complete solution containing all the essential elements, one containing all the elements except nitrogen, and one containing all the elements except calcium.

The constituents used to make up one litre of each of the nutrient solutions are given in Table X. Distilled water was used in all cases.

- 31 -

A sublicity and the second second second second backset and a sublicity and a second backset, he has not selected and the second sec

The matrix of the second solution of the second fact of the second fact of the second fact of the second se

ТΑ	BI	E	X
			_

(10) (10)		cc. of stock solution				
Salt	Concentration of stock solution	Complete	Nitrogen- deficient	Calcium- deficient		
KNO3	JM	2.5		2.5		
$Ca(NO_3)_2$	lM	2.5	-	-		
$Mg(NO_3)_2$	lM	-		2,5		
MgS04	lM .	1.0	1	1.0		
KH ₂ PO ₄	lm	0.5	3	0.5		
$Ca(H_2PO_4)_2$.0625M	-	40	-		
Ferric tartrate	0.5%	1.0	l	1.0		
A-Z*	-	1.0	l	1.0		

Constituents of one litre of the plant nutrient solutions

* A-Z solution consists of the required amounts of the trace elements.

For the pots containing each of the sands, the experiment was of a randomized block design as described by Goulden (13). Each solution was applied to ten crocks, five containing silica sand, and five containing local sand. Thus the experiment with each sand consisted of three treatments with five replicates of each.

Every second day for the first two months of the experiment, and twice every three days for the remainder of the time sufficient nutrient solution was added to each crock to permit 200 cc. to drain out. This helped to prevent the accumulation

3 8.56AT

The state of the s

			In the second second	
-utote:		and se	Mosin Su Julianzine	
3.4	ann suis		- <u>17</u> -	227753
	•		12	e (1997) e 2
	Mark sept		1	.s. 0991 207
0.3		n /		_D2:07
5.9			r	105 183
~**			с	34, 00, 10,
		<u>-</u>	Call a sec	harden street
L	1	90 . . L		,

And solution sensible in the realized community of the bracks

>Mu Par Law norm innot and another availant the test of the schedule nent was of a distant was noticed to be model. The schedule (32). Must solve the state of the state of the schedule state and real test into the state of the schedule state and real test of the state of the schedule state and real test of the state of the schedule of sets.

Synce several by in the Wiley of a lost of Annual and the track there when its subenditied at allocients or other when the second of a state the rest is instruct. This say of the ment the solend line of unused salts. As a further precaution against the accumulation of salts each of the pots was flushed with two litres of distilled water every two weeks.

Artificial light to supplement the short winter days was found to be necessary to prevent excessive vegetative growth and to provide conditions under which the plants would produce seed. Artificial light was supplied from 4:30 p.m. to 1:30 a.m.

To prevent algae from growing on the surface of the sand it was necessary to cover the tops of the crocks, leaving openings for the plants.

The flowers on each plant were artificially tripped every second day and the number for each plant recorded. The pods were picked on June 15th, counted, and those from each plant put in separate paper sacks to dry. When they were dry enough to thresh readily, the pods from each plant were threshed by hand and the seeds counted.

The vegetative growth was removed at the same time as the pods and allowed to dry. The weight of the air-dried material from each crock was taken as the vegetative growth produced.

Experimental Results

The vegetative growth and the number of flowers tripped, pods set, and seeds produced for the alfalfa grown in

- 33 -

wiii 20112 20112 20 10 10 10 10 10 2000 10 2000 100
weak foint to the noticelet as the non-and and the chemical to
cronte as to provide conditis to it at both the chemical text
crontes wead. Artificial 2012 2010 10 10 1000 1000 1000
conditis wead.

To provide all a firm of the state of the second of the se

Che fiorere on sech Chint were estivited?" and story whole div not ble where for not of the finite of gaing wate theirs on dute total communic withthe form the story of the estivate of an estimate of the finite of story of the estivate of an estimate of the finite of estimate to the story finite of the finite of the finite estimate to the story finite of the finite of the finite of the finite of the story of the story finite of the finite of the finite of the story of the story finite of the finite of the finite of the story of the story of the finite of the finite of the story of th

the more and the set of the set o

statistic March 17022

and the second of the same of the second second second

All times the Director of All and a state of the state of the state of the

the three solutions in the local and silica sandsare given in Table XI. The results of the analysis of variance of these results for the local sand are shown in Table XII.

TABLE XI

		Number of			
Solution	Vegetation (grams)	Flowers tripped	Pods	Seeds	
Local sand					
Complete Nitrogen deficient Calcium deficient Minimum significant difference	32.8* 29.5 29.0	881 910 887	203 435 252 123	710 1591 919 463	
Silica sand					
Complete Nitrogen deficient Calcium deficient	35.9* 0 5.8	1269 0 276	499 0 77	1654 0 164	

Alfalfa yields for Experiment I

* Each value is the mean of 5 replicates.

TABLE XII

Analysis of variance of the alfalfa yield results for local sand, Experiment I

.Mean squares					
Variance due to	D.F.	Vegetation	Flowers	Pods	Seeds
Replicates Solution Error	4 2 8	34.68 21.22 15.72	51265 3536 145319	10885 75336* 9509	230302 1060867* 133994
Total	14				

* Significant beyond the 5% point

ted born and throw it the form and stilles without their in forthe D. And section of his antiputs of an antiput of the product the still section of his antiput of a star form

I. C. M.

1 and sugar the substitute

 A. 4.	1 197 - 14 - 1 - 1 - 1 - 10 - 10 - 10 - 10 -	the laws and a man a	anggan ng kana hala kananananggan (ber ki na ini anggan ng
 		·	da10055
			and a second sec
		D.XR Clur D.Cc D.Cc	<pre>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>></pre>
	Stark O D	•	donision estimation terrestimation contel ad matrice

2.0 15.7

and the second s

 and in the second second				
 	-need,	odecorate.		. 03 000 100 100 LOUIS
	proje Ul	89.34 87.21	10.00	00011021000 111200 12100
				1.6007

and the set of the state of the

The cuttings in the silica sand to which the nitrogendeficient solution was applied produced very little growth and died before the completion of the experiment. The yields, for all factors studied, produced by the complete and calciumdeficient solution on the silica sand (Table XI) were sufficiently different that statistical analysis of the results was considered unnecessary.

Table XII shows that the three solutions when applied to the local sand caused a significant difference in the numbers of pods and seeds produced by the alfalfa. The alfalfa grown in the nitrogen-deficient solution, as shown by Table XI, produced more pods and seeds than the alfalfa grown in either of the other solutions.

Discussion

The fact that the elimination of nitrogen or calcium from the nutrient solution applied to the local sand had no effect on the amount of vegetation or the number of flowers produced was sufficient to show that the local sand contained plant nutrients that rendered it useless for controlled nutrient studies.

As shown by Tables XI and XII the number of pods and seeds produced by the alfalfa grown on the different solutions on the local sand do not correspond with the number of flowers tripped. The greater number of pods and seeds produced by the alfalfa on the nitrogen-deficient solution agrees with field

- 35 -

the deal and the state while and at an large we

And the set of the set

An above in the second second and the second second

- - -

observations. Soils high in nitrogen, as in the black soil area of Alberta, are not as satisfactory for alfalfa seed as are the gray wooded soils which are low in nitrogen. The difference in seed production is, however, usually associated with excessive vegetation on the soils with a high nitrogen content. Since vegetative growth was the same regardless of the solution applied, this experiment would appear to indicate that excessive amounts of nitrogen exert a depressive effect on alfalfa seed setting quite independent of the amount of vegetation produced. Although these results are in no way conclusive they do suggest another approach to this problem.

On the silica sand the failure of the alfalfa plants to grow in the nitrogen-deficient solution and the very limited growth produced by the calcium-deficient solution, when compared with the growth produced by the complete solution, were considered sufficient evidence of the suitability of this sand for controlled nutrient studies.

In this experiment there was a great deal of variation between crocks that could not be accounted for by treatments or replicates. This is shown by the large experimental error in Table XII.

EXPERIMENT II

During the summer of 1943 an experiment was conducted in the greenhouse to determine the effect on the growth and seed

- 36 -

asservations, toult de la discosa, au in en disardel, es of alberts, ser ant an stuidservor, the difference discours d ator motion anite wise the in additions. The difference d read (row-rolos is, honever, and d'arter, in a difference d regenerative rowth and the sume reputive difference does representive rowth and the sume reputive difference does not ritory a ment a depresente at ferminal for an advise of ritory ament a depresente at a first of the second state independent of an example of a first deviation beam results are to an any formative the deviation of ritory and the sume result of the second of the state independent of an any formative the deviation of resolution and any formative at a state of the solution of any formative the deviation of the state independent of any second of the deviation of the state independent of any formative the deviation of the state independent of any formative the deviation of the state independent of any formative the deviation at a second results are to a second of the deviation of the state of the state of the second of the deviation of the state of the deviation of the deviation of the deviation of the state of the deviation of the deviation of the deviation of the state of the deviation of the deviation of the deviation of the state of the deviation of the deviation of the deviation of the state of the deviation of the deviation of the deviation of the deviation of the state of the deviation of the d

on the allow and the relation of the relation of the device of the term of term of term of the term of term of

In this of emission to the end of the second set of fully to between article to the sound of the endowaked for an approximent of radiostas. While is shown of the latent apprilantly, ferent to Table 117.

12 1 1 129/1012

Domine the ground of sits of markine by a markine by a second the big ground of a second second of the big ground of the second second

production of alfalfa of different concentrations of boron and other plant nutrients in the nutrient solution.

Material and Methods

Purified silica sand for this experiment was obtained from the same source as that used in Experiment I.

Alfalfa plants to be used in this experiment were dug from the field in the spring of 1943 as soon as the ground had thawed. They were stored in the root cellar in moist earth until June 11th when they were taken to the greenhouse. Each plant was divided into four parts by splitting the root and crown with a sharp knife.

Glazed, two-gallon, earthenware crocks, with drainage holes, were used in this experiment. Each crock, containing one section of an alfalfa plant, was filled with sand to within one inch of the top.

The standard solution in this experiment was the same as the complete nutrient solution used in Experiment I. The solutions varied in both the concentration of boron and the concentration of all other nutrients taken together. The concentrations of boron were 0.2, 0.6, and 1.8 p.p.m. of the nutrient solution. Concentrations of all other nutrients were 0.5, 1, and 3 times the concentration used for the complete nutrient solution in Experiment I. The different concentrations of boron and of the other nutrients were applied in all possible combinations. production of victories of different contactures of proce and other their correlates in the samplest entrol .

and and Sme infree-

variable chites 100 10r is experiment wis marained and the same southes as 100 000 10 11 11001 mcl 1.

Algorithm plants, a to constitute the second way the from the field is the sprin of the does not not as the parameter themed. They note algorid in the track with the makes would abilitate the literate the ware the to be constant. With algorithm lifeties the four wore the solution for a solution close and lifeties the four work of a splitche for the solution crowe with a solute off.

charact, true size: addit were examine find drevelse united, when and it take simplify a such reads that a section of an execute the types print when when a notice or incluse of the such of the such as a such when when a such or incluse of the such of the such as a such of the such of the incluse of the such of the such as a such of the such of the incluse of the such of the such as a such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the incluse of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the incluse of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the such of the such of the such of the incluse of the such of the incluse of the such of the inclusion of the such of

This made nine treatments in all.

The experiment was of a randomized block design with three replicates of each treatment. In the statistical analysis the variance due to treatments was divided into the variance due to: (1) the concentrations of boron, (2) the concentrations of all other nutrients, and (3) the interaction between boron and the other nutrients.

The other details for the experiment were the same as those for Experiment I except that no artificial light was necessary during the summer. Boron deficiency symptoms are described and illustrated by deTurk (8). This report was used as a basis for recognizing boron deficiency symptoms in the alfalfa in the greenhouse experiments.

Experimental Results

It was found that although the flowers were tripped every second day some self-tripping took place, possibly owing to the high temperatures. As a result of this the data on the number of flowers tripped were discarded.

The vegetative growth and the numbers of pods and seeds produced by the alfalfa in the experiment are given in Table XIII and the results of the analysis of variance of these data appear in Table XIV. . The state the training of a state of the

And a second second

address Latonication

If we not the set of the stand of the stand of the set of the set

previous an anna codar 20 an anna 2 ann an 10 anna 2 anna 2 anna 2 anna 2 anna 2 anna 20 an an 12 anna 2 anna 2 anna 2 an 20 an an 20 an an 12 ann an 12 an 12 an 12 an 12 an 12 anna 2 an 2 an 12 an 1 an 12 an 1

TABLE XIII

Alfalfa yields for Experiment II

	oron in	p.p.m.		
Nutrient solution concentration	0.2	0.6	1.8	Mean
Vegetative yield (grams)				
Low Medium High	39.2* 26.5 26.7	27.9 25.7 20.4	32.3 29.0 20.2	33.1 27.0 22.4
Mean	30.8	24.7	27.1	
Number of pods				
Low Medium High	843 [*] 422 528	438 285 508	528 348 459	603 352 502
Mean	601	410	445	
Number of seeds				
Low Medium High	2715 [*] 1495 2236	1248 1076 1833	1820 1300 1997	1928 1290 2022
Mean	2149	1386	1706	

* Each value is the mean of 3 replicates.

THE LEW

The second state that all and the second states

	- un real of our off		a a aga - 11 - 1	(i)
		1		
L				in the management of the sector of the
				1 The Later aviation av
1. m.		n 7	•	and Line and State
		• ¹¹ =		usedi
				B11.76.530 and
				rol Malan Lata
				Duto-J
				Sime 10 Tenner
	ine in Martin Martin		16.00 2011 2010	Low bed and Dist
			$^{(2)}\mathcal{I} = 0$	

. "With VALUE TO COLLEGE SEC ST HUNRY TON'

TABLE XIV

		Mea	n squares	
Variance due to	D.F.	Vegetation	Pods	Seeds
Replicates Solution Boron Solution x boron Error	2 2 4 16	16.99 259.05 86.38 33.20 110.77	20003 144023 92763 30931 88310	565678 1425738 1320465 286848 1416552
Total	26			

Analysis of variance of the alfalfa yields for Experiment II

The different concentrations of boron or of the other nutrients used in this experiment had no effect on any of the factors of alfalfa growth or on seed production studied in this experiment.

Discussion

In this experiment, as in the previous one, relatively large variations between crocks caused the error in the analysis of variance to be very large. For this reason it was necessary that there be great differences between treatments before any significance could be realized.

The results of this experiment demonstrate the very small amounts of boron necessary for satisfactory growth of alfalfa. They also indicate that the availability of boron was not adversely affected when the concentration of all the other

e type - maket

Andreas of variance of sta wir in sizes.

-	 	6 R - 1- 0	and a strength
	20.82 20.55 20.55 20.97	-	esteclinet noliciae nonos noros z doron reizi
		712.	

autorial de la Acteur y Encondecta de la Sila en la antiautorial de la Sila de la Sila

10202020207

in bills on attack, an if the controls one. Feb (vel)
istre verificant score) control control to append to the control
of inclusion to sever larget. If the control to a source
istre react to grant disformance to react to the control to the control
of the control to control.

and reach of the second of the street of the second of the

salts in the solution was varied within the limits of the experiment.

EXPERIMENT III

As mentioned previously in this paper, only one year's results on the effect of borax and ammonium phosphate on alfalfa vegetative growth and seed production were available. In an effort to obtain further evidence on the effect of these plant nutrients on alfalfa grown on gray wooded soil, this experiment was conducted in the greenhouse during the summer of 1943.

Material and Methods

The plants for this experiment were treated in the same manner as were those used in Experiment II. One section of each plant was placed in a two-gallon, glazed crock filled to within an inch of the top with gray wooded soil. The drainage holes in the crocks were stoppered to prevent the loss of nutrients.

This experiment consisted of twenty-seven crocks. Ammonium phosphate was applied at the rates of 0, 50, and 100 pounds per acre, and borax at the rates of 0, 10, and 30 pounds per acre. The experimental design was the same as for Experiment II. The borax and fertilizer were applied in all possible will be to be actually we wath a work when he had a we have a second

The States

is a second of the second of the second seco

secility as an effect of the off a model provide to a price vegetative growing and the as well a well with the off and without to details fortune any basis of a well of the off and the of avectable on their first a power of the off and the off a second to of an establish is the off officient to be details of the officient and contracted is the off officient to be details of the officient.

The control of the static sector will be a subname control as and there and it would be the of and, has a low the tare of the state of the state to distant in the of the state of the state of the sector of the state was donesed as it as a ward of the

ending operized confidence: here = and form : becaute operations and and a set a set a set and encode are sets, so a solution when when the of a set b proved recovers. We supervise of tests are set are in a set and a set are and a set operate set in a set of the set operation of the set operate and it. If a before we construct the set operate of all operations. combinations, making a total of nine treatments with three replicates of each. In the analysis of variance of the results, the variance due to treatments in general was divided into its component parts: the variance due to rate of application of fertilizer, that due to the rate of application of boron, and that due to the interaction between the two.

The amount of borax and fertilizer to be applied to each crock was determined by the area of the surface of the soil. The correct amount was weighed on a precision balance, dissolved in distilled water, and the solution applied to the soil.

Distilled water was supplied to the soil as required. The flowers were tripped every second day and the number recorded. When the pods were ripe the plants were treated

as in Experiment I.

Experimental Results

As in Experiment II, self-tripping took place and the data on the number of flowers tripped had to be discarded.

The vegetative yield and the number of pods and seeds produced by the alfalfa on the gray wooded soil in the greenhouse are shown in Table XV. The results of the analysis of variance of these data are given in Table XVI.

- 42 -

in itest is, noted is total of live to energy of live to the of the endroles of the terms of the results, the portenes are to the tracted of non-out we that ites ite sourceast percet the to the to toke of the policelos of tertifiers, that the to the terms of and the spectres items, we tertifiers, that the to the terms of and the sector of home, we

Fire consets of formal and forthiller to analythic to and order and interval to the analytic provide of the party and concert anoint for mained or a credition between, firem welte distribute water, we had coduced analytic to be well.

Wintified wotar was away in the woll as repliced, in Tioward wore stimed every cash have no concurse ber reported, was in a more wire the the lists wire brooked as in speciment i.

a funda a fanda falsa

As to acceding 11, self-antiple, contract on the self-antiple, contract on the self-antiple on the size of the self of the sel

TABLE XV

Alfalfa yields for Experiment III on gray wooded soil

The section of the se	Borax,	pounds 1	per acre			
(16-20)	none	10	30		Mean	
Vegetative yield	gm. per	plant)				
No fertilizer 50 lb./acre 100 lb./acre	13.5* 12.5 14.9	13.5 12.4 13.3	12.7 11.3 16.4		13.2 12.1 14.9	
Mean Minimum significar	13.6 nt differ	13.1 ence	13.5	v	1.6	
Number of pods per	plant					
No fertilizer 50 lb./acre 100 lb./acre	365* 358 371	397 310 249	377 300 155		397 329 258	
Mean	365	319	277			
Number of seeds per plant						
No fertilizer 50 lb./acre 100 lb./acre	1516* 1309 1356	1578 1313 737	1455 1050 363		1517 1224 819	
Mean	1394	1209	956			

* Each value is the mean of 3 replicates

I des later with the

	Ar			4
	<u>172</u>		A	
	an hai	an in set to other open from a	8000	
		3 C	a	La carena
5.51	ŕe	×	. 7 5	as his is a fi
- *	- 8		19 10	
	a.=C		1.0.16	Cash.
£1				
			- garras - Jos 1000 agerrador	
	935		163	
				5920
			The state	
		1	101.00	2021-0101-0
	1.15		Line .	In the same
			1072	CLASS .

selections for more and and and the

- -

TABLE XVI

	to D.F.	Mea		
Variance due to		Vegetation	Pods	Seeds
Replicates Fertilizer Boron Fertilizer x boron Error	2 2 2 4 16	8.04 17.79* .80 4.10 3.17	28165 33172 17216 10752 19915	530838 1105324 435001 202450 367836
Total	26			

Analysis of variance of the alfalfa yields for Experiment III with gray wooded soil

* Significant beyond the 5% point

The amount of vegetation produced by the alfalfa on the gray wooded soil was the only factor studied that was affected significantly by the application of fertilizer. (Table XVI). The application of ammonium phosphate at the rate of 100 pounds per acre, as shown by Table XV, significantly increased the vegetative growth above that produced by the alfalfa on the soil which had received no fertilizer or only 50 pounds per acre.

The application of borax to the soil had no significant effect on either the vegetative growth or the seed yield.

Discussion

In this experiment, the increase in vegetative growth resulting from the application of ammonium phosphate (16-20)

IV - SIRL

and the stand of the sumption to similarly

1 1011			y	THE PORT
			0000	intitation totol totol totol totol totol
			7 19-	

a la riving 1990 and 1

- Will de la stratage en la sonne o containstage son

. The termination of the second state of the second and the first state of

MALLEN DE / 7

Contraction of sub-stock and straight of such a

the first state of the structure for the state of the sta

to gray wooded soil is in direct agreement with the results obtained from the field experiment reported in this paper and also with the results obtained by other workers (38 and 39).

Although the fertilizer had no significant effect on seed production in this experiment, there was a definite trend toward a reduction in the amount of seed produced as the rate of fertilizer application was increased (Table XV). If the experiment had contained more replicates this difference would no doubt have been significant.

Although the vegetative growth and seed yield of the plants receiving the different applications of borax did not differ significantly, there was a definite trend, as shown in Table XV, toward a reduction in seed yield as the rate of application of borax was increased.

GENERAL DISCUSSION

The large increase in both seed and hay production resulting from the application of ammonium phosphate (16-20) containing 15% sulphur to two fields of alfalfa on gray wooded soil is a good indication of the necessity of fertilizers for satisfactory crop production on this type of soil. Only one year's results are reported here, but they are substantiated by results reported by other workers. Over a five-year period Wyatt et al (38) obtained an increase of 3165 pounds of alfalfa In Lower wir Wile de name is and is all all alle de being dat in Lower wirdt al Andrewer Handlin al Main and avait Main (1966) . An alle de being and an alle de being and alle and alle de being . An alle de being alle de beneficier and man alle.

dects reducts for equivality a quarter for the start please reducts for thirds a clinic and the start Mittee similation for, four one of fertilion form, is and is fible IX, samer's reduct - is some form as it and application of meetings to starter.

energina (1.1. internation

The terms is not a construction of a construction (a second and construction from the specific free of a construction of a construction construction (a construction) is a construction of a construction construction of a construction of the off-and off-and the construction construction of the off-and the second the free construction construction of the off-and the second the free construction construction of the off-and the second the free construction construction of the off-and the second the free construction construction of the second the off-and the construction construction of the off-and the second the off-and construction construction of the second the off-and the construction construction of the second the off-and the off-and construction construction of the second the off-and the construction construction of the second the off-and the off-and construction construction of the second the off-and the off-and construction construction of the second the off-and construction construction of the second the second the off-and construction construction of the second the off-and the second the off-and construction construction of the second the off-and the second the off-and construction construction of the second the off-and the second the off-and construction construction of the second the off-and the second the off-and construction construction of the second the off-and the second the off-and construction construction of the second the off-and the second the off-and the second the off-and the second the off-and the second the second the off-and the second the off-and the second the off-and the second the off-and the second t hay per acre by the application of ammonium phosphate (16-20) to gray wooded soil. White (37) reported increases in both hay and seed production by the application of fertilizers to alfalfa on the same farms on which the field experiments reported in this paper were conducted. The seed yields obtained by White were, however, much lower than those obtained in this experiment. This indicates that other factors besides nutrition play an important part in the failure of alfalfa to produce a satisfactory yield of seed and that economic increases in seed production can be realized by the application of fertilizers only if the other environmental conditions are favorable. This fact is demonstrated in the greenhouse experiment with alfalfa on gray wooded soil. The application of ammonium phosphate at the rate of 100 pounds per acre increased the vegetative growth but showed a tendency to decrease the seed yield.

In the field experiment, increased vegetative growth was accompanied by an increase in seed production. This relationship is the same as that found by White (37) and indicates that, within the limits of these experiments, nutritional conditions favoring vegetative growth also favor seed production.

The increase in seed production on the Anderson field was directly due to the increase in vegetative growth. This relationship also held for the Innes field. The very low seed yield from the unfertilized plots on this field indicates that one or more nutrients were sufficiently low to prevent satisfactory seed formation. The lack of sulphur in the soil has a detrimental effect on seed formation and, since, as

- 46 -

The first of a store of the store of the set of the store of the store

~ ~~

shown by Wyatt <u>et al</u> (38), the gray wooded soils of Alberta are in general very low in sulphur, it is quite probable that sulphur was the limiting factor in seed production on the unfertilized plots.

The comparatively high yield of seed from the fertilized plots on the thin stand over that produced by the thick stand is in accordance with practices recommended by Fryer (11) for alfalfa seed production in Alberta.

The apparent depressive effect of an excessive amount of nitrogen on seed production, obtained in the sand culture experiment with local sand, agrees very well with general field observations in Alberta. Soils high in nitrogen do not lend themselves to satisfactory seed production. Contrary to field observations, however, low seed production was not accompanied by excessive vegetative growth.

The boron requirement of alfalfa, as shown by the controlled nutrient studies, is very small since 0.2 p.p.m. of boron was as effective for vegetative growth and seed production as were concentrations of 0.6 and 1.8 p.p.m. Under the conditions of this experiment the availability of boron was not greatly affected by the concentration of the other salts in the nutrient solution, since no symptom of boron deficiency was evident on the alfalfa receiving 0.2 p.p.m. boron regardless of the concentration of the other salts. in personal forming but (38), the process of the original of the second of the second

list all and the fact of the fact of

The second s

- - -

SUMMARY

48 -

1. The application of ammonium phosphate (16-20) to alfalfa on gray wooded soil at the rate of 100 pounds per acre increased both the vegetative growth and the seed production.

2. Alfalfa seeded at the rate of 4 pounds per acre, and fertilized at the above rate produced more hay and seed than alfalfa seeded at the rate of 10 pounds per acre and receiving the same treatment.

3. On the thick stand the increase in seed production was due to the increase in vegetative growth, while on the thin stand the increase in seed production was greater than could be accounted for by the increase in vegetation.

4. The application of borax, at the rates of 5, 15, 25, and 35 pounds per acre, to alfalfa on gray wooded soil had no effect on either the vegetative growth or the seed production over that produced by the plots receiving no boron.

5. Local sand contained enough plant nutrients to render it useless for controlled nutrient experiments.

6. Alfalfa growing in local sand in the greenhouse produced less seed when nitrogen was included in the nutrient solution added to the sand than did alfalfa grown in sand to which solutions containing no nitrogen were added. 1. "The spatialization of second which the side of strains of pairs souther said as to take of the second rest increased, have been been pairs of the second second second be as a second strain of the second se

C. Mifaire medic above a very or a very provider, and fortilized at the event series of the set of the set of the site of the second set of the set of the set of the the second set of the set of the set of the set of the the second set of the the second set of the the second set of the set of

3. Set us the state state on the track of the set state of the set is the set is the set is state is a set is substate the set is set is set is a set of the set is set is a set of the set of the set is set of the set

3. 20 an attained at arrow at the relation of the transmission at 20 th the second second

5. Found again good to a to all along one of the states.

b. Attractive excepts for good which to be compared with the second with the second with the second with the second to be a second to be a
7. Alfalfa grown in silica sand to which nutrient solutions were added showed no signs of boron deficiency or toxicity with concentrations of boron of 0.2, 0.6, and 1.8 p.p.m.

ACKNOWLEDGEMENTS

The writer wishes to express his sincere gratitude to Dr. J. R. Fryer for his assistance and guidance both during the course of the experiments and in the preparation of the manuscript. Thanks are also expressed to Dr. A. G. McCalla for help and constructive criticism in the statistical treatment of the data.

REFERENCES

- BAUR, K., HUBER, G.A., and WHEETING, L.C. Boron deficiency of alfalfa in western Washington. Wash. Ag. Exp. St. Bull. 396. 1941.
- BROWN, B.A. and KING, A. Soil conditions under which alfalfa responded to boron. Soil Sci. Soc. Amer. Proc. 4:310-313. 1939.
- 3. CHAPMAN, H.D. Effect of nitrogenous fertilizers, organic matter, sulphur and colloidal silica on the availability of phosphorus on calcareous soils. Jour. Amer. Soc. Agron. 28:135-145. 1936.
- 4. CLARKE, A.E. and FRYER, J.R. Seed setting in alfalfa. Sci. Ag. 11:38-43. 1930.
- COLWEIL, W.E. and CUMMINGS, R.W. Chemical and biological studies on aqueous solutions of boric acid and of calcium, sodium, and potassium metaborates. Soil Sci. 57: 37-51. 1944.

L'A DE L'ANDI

No arthur libes to another the start the start the tebe. 1. 1. If you for the solitoners and atheness both the to the control of the angette-miss of it the presentation of the annusorigit. Normal Are the subtract to be, s. 6. scale for take

the boundreakling articles in the eldfillericki brackwait of doer

- Milk, e., hiddle, J.A., and shirting, J.F. sites and intervent.
 A structure in white in a structure in a structure.
- abben, a.e. in allal, ... onic cutably a under a its airoite response to coroal act on ... or. here, here, its ... arthtic. icon.
- Ould Lip, 5.0. And a of state must result that, from to motors, and me to estimate and at on the result fitter of solutions of the relationships and he. The communication here, 39:125-115, 1130.
 - Theory, L.L. and March. J.C. on Anaphy 20 million. 201.
 The Theory, Theory, Theory, 19 million.
 - Ochanic, ... and ... Area, Area or educe to interiorization of the second second

- 6. COOK, R. L. Boron deficiencies in Michigan soils. Soil Sci. Soc. Amer. Proc. 2:375-382. 1937.
- 7. _____ and MILLAR, C.E. Some soil factors affecting boron availability. Soil Sci. Soc. Amer. Proc. 4: 297-301. 1939.
- 8. DeTURK, E.E. Hunger Signs in Crops: A Symposium. Amer. Soc. Agron. and Nat. Fert. Assoc., Washington D.C. pp. 241-258. 1941.
- 9. DREGNE, H.E. and POWERS, W.L. Boron fertilization of alfalfa and other legumes in Oregon. Jour. Amer. Soc. Agron. 34:902-912. 1942.
- EATON, F.M. Toxicity and accumulation of chloride and sulphate salts in plants. Jour. Ag. Res. 64:357-399. 1942.
- 11. FRYER, J.R. Growing legumes for seed and forage. Mimeographed copy of speech, July 20, 1943.
- GIZZARD, A.L. and MATTHEWS, E.M. The effect of boron on seed production of alfalfa. Jour. Amer. Soc. Agron. 34:902-912. 1942.
- 13. GOULDEN, C.H. Methods of Statistical Analysis. Revised Ed. Burgess Pub. Co. Minn. Minnesota. 1937.
- HOAGLAND, D.R. and ARNON, D.I. The water-culture method for growing plants without soil. U. of Cal. Ag. Exp. St. Circ. 347. 1938.
- 15. JONES, L.M. and OLSON, P.J. Seed setting in alfalfa, III. Sci. Ag. 23:315-322. 1943.
- 16. JONES, H.E. and SCARSETH, G.D. The calcium-boron balance in plants as related to boron needs. Soil Sci. 57:51-25. 1944.
- 17. KNOWLES, R.P. The role of insects, weather conditions, and plant character in seed setting of alfalfa. Sci. Ag. 24:29-51. 1943.
- 18. LEJEUNE, A.J. and OLSON, P.J. Seed setting in alfalfa. Sci. Ag. 20:570-573. 1940.
- 19. MARSH, R.P. and SHIVE, J.W. Boron as a factor in the calcium metabolism of the corn plant. Soil Sci. 51:141-151. 1941.
- McLARTY, H.R., WILCOX, J.C. and WOODBRIDGE, C.G. A yellowing of alfalfa due to boron deficiency. Sci. Ag. 17:515-517. 1937.

- A MARK , i.e. al unit i.e. Sono istration i al anti-
 - In. Then, i.e. a substant addition from a substant of the second seco
 - 181 Doubler, 1.0. Double of areas from the second of a second of the sec

- 14. South and the set of the set
- 12. Marsh, S.F. and S.Y. 2000 and a Marsh and S. Marshall and S Marshall and S. Marshall an

- 21. MIDGLEY, A.R. and DUNKLEE, D.E. The effect of lime on the fixation of borates in soil. Soil Sci. Soc. Amer. Proc. 4:302-307. 1939.
- 22. NAFTEL, J.A. The influence of excessive liming on boron deficienty in soils. Soil Sci. Soc. Amer. Proc. 2:383-384. 1937.
- 23. PARKS, P.Q. and SHAW, B.T. Possible mechanisms of boron fixation in soil: I. Chemical. Soil Sci. Soc. Amer. Proc. 6:219-223. 1941.
- 24. PILAND, J.R. and IRELAND, C.F. Application of borax produces seed set in alfalfa. Jour. Amer. Soc. Agron. 33:938-939. 1941.
- 25. and REISSENAUER, H.M. The importance of borax in legume seed production in the south. Soil Sci. 57:75-85. 1944.
- 26. POWERS, W.L. Boron in relation to soil fertility in the Pacific north west. Soil Sci. Soc. Amer. Proc. 4:290-296. 1939.
- 27. The role of sulphur in plant nutrition. Jour. Amer. Soc. Agron. 23:371-373. 1930.
- 28. _____ and RUZIK, C.V. Twenty-two years of soil fertility investigations in the Willanette valley, Oregon. Oregon State Coll. Ag. Exp. St. Bull. 387. 1941.
- 29. REEVE, E. and SHIVE, J.W. Potassium-boron and calcium-boron relationships in plant nutrition. Soil Sci. 57:1-14. 1944.
- 30. SEWELL, M.C. and LATSHAW, W.L. The effects of lime, superphosphate, and potash on reaction of soil and growth and composition of alfalfa. Jour. Amer. Soc. Agron. 23:799-814. 1931.
- 31. SCHROEDER, W.T. and WALKER, J.C. Influence of controlled environment and nutrition on the resistance of garden peas to Fusarian wilt. Jour. Ag. Res. 65:221-248. 1942
- 32. SEXSMITH, J.J. and FRYER, J.R. Studies relating to fertility in alfalfa (Medicago sativa L.). I. Pollen viability as affected by seasonal age of plant. Sci. Ag. 24:95-100. 1943.
- 33. Studies relating to fertility in alfalfa (<u>Medicago sativa</u> L.). Sci. Ag. 24:143-152. 1943.

- % Windows and an art int the transmission of ange algorithm of burgary in well. collect. 200, name, proc. collect.
- Intra, J.I. the Latine.comparis that a tool to be deficients in soils. coll -pt. -nd. -rr. stor. ': 0 -384. 1437.
- N. PELMER, A. M. LOLDI, J.T. Sopier in the of investigation deal and in all these rooms must be specified.

 - 45. realized to behavior to annot company in the state outcomes. Soci or in the company in the set of the company.

 - And a second of the second sec

 - 1011 The second se

100

And which and the said of a second se

- 35. THORNTON, H. G. and NICOL, H. Reduction of nodule numbers and growth produced by the addition of sodium nitrate to lucerne in sand cultures. Jour. Ag. Sci. 26:173-188. 1936.
- 36. VANDECAVEYE, S.C. and BOND, L.V. Yield and composition of alfalfa as affected by various fertilizers and soil type. Jour. Amer. Soc. Agron. 28:491-505. 1936.
- 37. WHITE, F.H. The effect of commercial fertilizers on alfalfa (<u>Medicago sativa</u> L.) seed production on the gray wooded soils of Alberta. Univ. of Alta. M.Sc. Thesis, Apr. 1942.
- 38. WYATT, F.A., NEWTON, J.D., and IGNATIEFF, V. Wooded soils and their management. Univ. of Alta. Coll. Ag. Bull. 21, 3rd ed. 1941.

- a side of the second second



