CALCIUM PHOSPHORUS RELATIONSHIP IN CANNING PEAS

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A thesis submitted for the degree of
Master of Science in Agriculture

The University of British Columbia

April 1938

Approved.
(Plant Nutrition)

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Calcium-phosphorus Relationship in Canning Peas

In a series of experiments conducted three years ago, the writer (15) found that plants grown in a nutrient solution high in phosphorus showed the same external symptoms as those shown by plants grown in calcium deficient solutions. This led the writer to ponder on the relationship of calcium to phosphorus under the usual conditions of growth and to decide to study the relationship existing between calcium and phosphorus in the plants and the calcium and phosphorus in the soils growing them.

Since canning peas are an important crop in British Columbia, it was decided to use this crop for the study of the calcium-phosphorus relationship.

Review of Literature

A description of calcium deficient pea plants was given by Day (6) who described them as being shorter than normal with the lower leaves chlorotic and the youngest leaves curled and tough. She does not mention the effect upon the seeds. Sayer and Nebel (14) found that the cells in calcium deficient plants were physiologically older than those not so deficient. This they interpreted as an indication of disturbed metabolism. Low potassium, they stated, caused similar physiological aging. They also found a calcium-potassium ratio in the pea seeds. The calcium decreased as the potassium increased and made the peas more tender. Musbach and Sell (11) reported a similar finding and attributed the tenderness to a reduction of calcium in the seed coats. Street (17) observed that the absorption of calcium and to a large extent that of magnesium bore a reciprocal relation to that of potash. Morgan (10) reported a relationship between the quantities of potassium and magnesium present and the amounts of calcium taken up by the plants.

Nightingale, Addams, Robbins and Schemerhorn (12) found that tomato plants grown in calcium deficient solutions were unable to assimilate nitrogen as nitrate and such plants accumulated carbohydrate as a result. If the plants were placed in darkness they were able to assimilate the nitrates. Hibbard's work (8) on peas showed that an accumulation of nitrogen in plants grown in short light conditions was proportional to the amount of calcium present. On the other hand Street (17) has stated that peas grown in short light periods showed a high percentage of nitrogen and concludes that the only factor which influenced the nitrogen content was the amount of light. Parker and Truog (13) in their work on fodder plants found that grasses, which are tolerant to acid soils, had a low calcium-nitrogen ratio and that legumes and other plants which are sensitive to acid soils have a high calcium-nitrogen ratio. This led them to conclude that calcium entered into the composition of proteins as a plant food element.

Protein metabolism, they stated, probably produces many acids and consequently the calcium is needed to remove the acids from the cell sap. Boswell and Jodidi (5) found that phosphorus and potassium fertilizers increase the protein content of peas and therefore advanced maturity.

Fonder (7) consistently found greater amounts of calcium than of magnesium in peas and that the growing pea plants greatly reduced the amounts of calcium and magnesium in the soil.

Musbach and Sell (11) observed that all fertilizers reduced calcium and increased phosphorus in the seed coats. Parker and Truog (13) found that phosphorus did not bear so great a relation to nitrogen as does calcium.

Boswell has done much work on the composition of peas from the standpoint of carbohydrate content and quality. In one paper (2) he reported that in the ripening of peas there was a rapid decrease in sucrose with an increase in starch and a slow decrease in total nitrogen. He concluded that a low sugar and a high starch content were characteristic of poor quality in peas. In two later papers (3), (4) he reported that high temperature had an effect on both yield and quality of peas by reducing the period for growth and by increasing the formation of starch. Bisson and Jones (1) worked on this problem and found that the seeds gained in weight up to the thirty-second day of development. After this period the peas lost weight because the water loss was greater than the gain in sugars. They found that sucrose reached a maximum about the thirty-second day (about harvesting time) and then fell off rapidly. The peas gained in protein, starch and ash throughout the whole growing season.

Materials and Methods

In order to obtain results that could be compared, it was necessary to use the same variety of peas and to pick them at the same stage of maturity. The bulk of the pea canning crop in British Columbia is composed of four or five varieties with such characteristics that they come into maturity at different times. The use of the different varieties and the practice of sowing the same variety on different dates, usually one to two weeks apart, results in a succession of fields maturing. It was found that peas of the variety Perfection were used extensively in this province and that in the areas to be studied there would be peas of this variety maturing at the same time.

On August 2, 1937, samples of peas and soil were taken from farms located in the lower Fraser Valley area of British Columbia. The farms from which samples were obtained were located near Matsqui and on Barnston Island which is in the Fraser River down stream from Matsqui.

On August 5, 1937, samples were taken from farms situated on Sea Island, Lulu Island and Westham Islands. These Islands are included in the broad term "Delta area".

Cutting of the peas in each field had just commenced on the day the samples were taken.

In sampling, the sample of soil was taken first and then the sample of peas. A two inch auger was used to obtain the soil to a depth of eighteen inches. This depth was chosen as Weaver and Bruner (18) show that the pea plant has the greatest proportion of feeding roots within this depth. Immediately after sampling the soil the pods of the plants nearest the hole were picked. Since it was impossible to weigh the peas with any accuracy in the field, the peas were left in the pods while transporting them to the laboratory. Thus loss of water from the peas before weighing was prevented. Each sample was placed in a clean paper bag clearly marked with the field and sample number.

The samples were taken to the plant nutrition laboratory of the University of British Columbia where the analysis of them was made during the 1937 - 38 session. Upon arrival at the laboratory the peas were shelled, weighed and placed in an oven at 65 - 70° C. and dried to constant weight. When dry, the peas were ground up finely and sealed in glass jars. The soil samples were air dried and stored carefully until a convenient time for testing them. The methods of Spurway (16) were followed with one change. It was the use of an extracting liquid made by dissolving 100 grams of sodium acetate in 500 c.c. of distilled water with 200 c.c. of glacial acetic acid added and the whole made up to a litre.

Soil reaction was determined with the La Motte pH tester. A mechanical analysis was made by thoroughly mixing 2.5 grams of soil with 10 c.c. of water in a 15 c.c. graduated centrifuge tube and centrifuging for five minutes at 2750 r.p.m. The volume of each fraction was measured and the percent composition of the soil calculated from the measurements.

Upon the dried and pulverized pea material analyses were made for reducing sugars, total sugars, starch, protein, phosphorus, potassium, calcium and magnesium. The methods used are described in the following paragraphs.

Carbohydrates

Two grams of the dry, ground plant material were placed in a folded filter paper in a small Soxhlet extraction apparatus. 50 c.c. of alcohol of 90% strength were placed in the flask and the extraction process carried on for four hours. The alcohol extract thus obtained was then transferred to a 400 c.c. beaker, the residue and apparatus were washed with hot distilled water and the washings added to the extract. The volume in the beaker was about 300 c.c. Heating the extract in the beaker on a water bath until the volume was about half effectively removed the alcohol. The solution was then made up to 250 c.c. with distilled water. Carbon (Eastman Kodak) specially prepared for such purposes, was used in clearing the solutions. Half a gram of the carbon was boiled with the solution for one minute and filtered off while hot with suction.

Of the cleared solution, 100 c.c. was saved on which to make the total sugar determination. The rest was used in the reducing sugars determination. The extract was titrated into 5 c.c. of boiling Fehling's solution according to the Lane and Eynon method. The 100 c.c. portion saved, was boiled with 10 grams of citric acid for 10 minutes, cooled and neutralized with 40% sodium hydroxide and as the volume was under 100 c.c. water was added to make up the volume. Titration was carried out as for reducing sugars and calculated the same way. The factor 0.95 was used to determine the sucrose in the total sugars.

The residue from the alcoholic extraction was weighed and 1 gram taken for the starch determination. The 1 gram was placed in a 250 c.c. erlenmyer flask and heated for two and a half hours under a reflux condenser with 20c.c. of concentrated hydrochloric acid and 200 c.c. of water. After digesting the solutions were cooled and neutralized with 40% sodium hydroxide and made up to 250 c.c. It was then filtered and titrated against 10 c.c. of Fehling's solution according to the method of Lane and Eynon. Starch or rather acid hydrodizable carbohydrates were expressed as starch by multiplying the amount of glucose by the factor 0.91

Protein

One half a gram of the ground dry peas was digested in a Kyeldahl flask with 5 grams of a mixture of potassium sulphate and copper sulphate (4:1) and 15 c.c. of concentrated sulphuric acid. Heating was continued for about half an hour after the solution cleared and the dense white fumes above it had disappeared. When the flask was cool 200 c.c. of water were added. A spoonful of pumice, a piece of wax and 70 c.c. of almost saturated sodium hydroxide were also added. The ammonia thus formed was distilled off and collected in 20 c.c. of 0.089 normal hydrochloric acid. Methyl orange was added to the receiving flasks and this served as the indicator in the titration with tenth normal sodium hydroxide. Protein was calculated by multiplying the total nitrogen cound by the factor 6.25.

Phosphorus

Three tenths of a gram of the dry material were brushed into a 100 c.c. Kjeldahl flask, 1 c.c. of perchloric acid (60%) was added, and the mixture heated very gently but increasing the heat as the "popping" subsided. When the liquid in the flask was clear, the heat was removed and the flask allowed to cool. When cold 20 c.c. of distilled water were added and the contents of the flask made faintly alkaline to phenolphthalein with 40% sodium hyrdoxide and then just slightly acid with hydrochloric acid 1N. The solution was then washed into a 100 c.c. graduated flask with several rinses of water and made up to volume. A 10 c.c. aliquot was mixed well with 1 c.c. ammonium molybdate, 0.5 c.c. of a 20% sodium sulphate solution and 0.5 c.c. of 0.2% solution of hydroquinone, and let stand for forty-five minutes. Standards containing various amounts of phosphorus were treated in like manner. The standard having a color intensity nearest to that of the unknown was chosen for comparison with the unknown (or the extract) in the Klett colorimeter.

Ash Constituents

Two grams of the ground peas were ashed in the electric furnace at a temperature not above 700° C. The organic matter was first charred by heating on a hot plate at a medium heat until there were no more fumes given off. When the ash and crucible were at constant weight the ash was digested with hot hydrochloric acid. First with 2.5 c.c. of concentrated acid and then three times more with 10 c.c. each time of half normal acid. Finally the crucible was washed out with hot water and the wash added to the extract. The whole was made up to 100 c.c. Upon this extract determinations for potassium, calcium and magnesium were made.

Potassium

To 5 c.c. of the sample 5 drops of sodium cobaltionitrite reagent and 2 c.c. of ethyl alcohol were added and mixed. The solution was allowed to stand for 20 minutes for the suspension to develop, which was then compared in the colorimeter with a standard similarly treated.

Calcium.

5 c.c. of ammonium oxalate were added to 5 c.c. of the ash extract and diluted to 25 c.c. This was boiled for 10 minutes, colled and made up to 25 c.c. again. The white

suspension was compared in the colorimeter with a standard which received similar treatment.

Magnesium

The solution from the calcium test was filtered to remove the calcium precipitate. To the filtrate 10 c.c. of sodium acid phosphate were added and the mixture made strongly alkaline with ammonium hydroxide. The test tube containing the solution was shaken thoroughly and then let stand for half an hour. The suspended precipitate was compared with a standard solution of magnesium in the Klett colorimeter.

A second determination of each sample was made and agreed closely with the first. The mean of the determinations are shown in the following tables.

Results.

The results of the soil analysis are shown in tables 1 and 2. They do not show striking differences except in the amounts of calcium present and in the proportion of clay. Soil D was found to be extremely dry. Soil E showed signs of poor drainage in that the surface was hard and caked in the low spots.

Table No. 1

Analysis of soil samples from the Delta and Valley areas.

Area.	Locality.	Sample No.	Nitrates ppm.	Ammonia ppm.	Nitrites ppm.	Phosphorus ppm.	Calcium ppm.	Potassium ppm.	Magnesium ppm.	pH.
VALLEY	Matsqui	A1	2	2	-	1	150	10	1	5.9
		A2	2	10	-	1	150	20	1	6.0
		A3	2	10	-	1	150	20	1	5.7
		A4	2	2	-	1	150	20	1	5.9
		B1	-	10	-	½	150	-	1	5.3
		B2	-	10	-	½	150	-	1	5.7
		B3	-	10	-	½	150	-	1	5.5
	Barnston Island	C1	1	2	-	½	150	10	½	5.7
		C2	1	2	-	½	150	10	½	5.3
DELTA	Sea Island	D1	2	3	-	½	100	5	-	4.6
		D2	5	10	-	½	100	20	-	4.6
	Lulu Island	E1	2	10	5	-	-	-	1	4.4
		E2	2	10	12	-	-	-	1	4.6
	Westham Island	F1	2	2	-	½	20	10	1	5.0
		F2	10	2	-	½	20	10	1	5.3
		G1	2	2	-	1	40	5	1	5.7
		G2	5	2	1	½	40	5	1	5.5

Table No. 2

Mechanical analysis of soils

Area.	Locality.	Sample No.	Colloidal %	Fine Clay %	Clay %	Silt %
VALLEY	Matsqui	A1	3.80	48.1	28.9	19.2
		A2	1.89	35.8	28.3	34.0
		A3	2.12	29.8	61.7	6.38
		A4	6.65	26.6	62.3	4.45
		B1	4.17	43.8	35.4	16.63
		B2	4.00	50.0	42.0	4.0
		B3	1.94	19.6	72.6	5.86
	Barn-ston Island	C1	4.40	11.1	35.5	49.0
		C2	9.00	18.1	27.3	45.4
DELTA	Sea Island	D1	3.30	5.0	28.4	63.3
		D2	3.90	9.6	13.4	73.1
	Lulu Island	E1	3.50	10.5	21.0	65.0
		E2	6.30	8.8	15.8	70.1
	Westham Island	F1	8.00	11.3	12.9	67.8
		F2	3.30	8.3	21.7	66.7
		G1	3.80	15.4	17.3	63.5
		G2	5.00	16.6	28.4	50.0

Table No. 3

Dry weight and ash content of peas.

VALLEY AREA				DELTA AREA			
Locality	Sample No.	Dry matter %	Ash % dry matter	Locality	Sample No.	Dry matter %	Ash % dry matter
Matsqui	A1	35.7	3.11	Sea Island	D1	38.6	2.97
	A2	41.5	2.60		D2	37.8	3.02
	A3	39.8	2.85	Lulu Island	E1	41.8	3.90
	A4	36.6	2.72		E2	37.3	3.35
	B1	49.3	2.87	Westham Island	F1	37.9	3.00
	B2	39.1	2.67		F2	35.5	3.07
	B3	41.0	2.45		G1	33.8	3.10
Barnston Island	C1	33.0	2.87		G2	34.5	2.60
	C2	42.8	3.00				
Average		39.9	2.79	Average		37.1	3.12

Table 3 gives the dry matter and ash content of the pea samples. The dry weight is close for both the areas but the ash content is higher for the peas grown in the Delta area.

Table No. 4.

Pea constituents calculated on dry weight basis.

Area	Locality	Sample No.	Sucrose g/100g	Starch g/100g	Total Carbohydrates g/100g	Protein g/100g	Phosphorus mg/100g	Potassium mg/100g	Calcium mg/100g	Magnesium mg/100g
Valley	Matsqui	A1	1013	42.5	52.8	24.6	1500	14.1	44	34.6
Valley	Matsqui	A2	5.98	51.7	57.6	22.0	1330	34.7	32	22.9
Valley	Matsqui	A3	7.5	54.6	62.1	22.4	1380	17.0	64	25.6
Valley	Matsqui	A4	5.24	24.6	29.8	24.8	730	15.2	96	28.8
Valley	Matsqui	B1	6.85	53.6	60.4	23.3	960	17.2	45	25.3
Valley	Matsqui	B2	0.00	62.7	62.7	26.6	1450	7.4	70	33.00
Valley	Matsqui	B3	0.00	55.2	55.2	24.7	980	22.2	69	19.6
Valley	Barnston Island	C1	12.4	34.8	47.2	22.2	1160	23.2	54	24.8
Valley	Barnston Island	C2	14.2	38.2	52.4	24.3	1250	13.3	130	11.7
Average for Valley			6.94	46.4	53.8	23.8	1193	18.2	67	25.1
Delta	Sea Island	D1	14.3	29.9	44.2	25.7	1200	13.3	32	14.8
Delta	Sea Island	D2	20.1	30.8	50.9	24.6	1260	14.1	37	20.6
Delta	Lulu Island	E1	23.2	29.6	52.8	20.3	1240	15.4	60	56.0
Delta	Lulu Island	E2	20.4	33.0	53.4	19.6	1160	13.9	50	54.5
Delta	Westham Island	F1	26.9	26.9	53.8	25.4	366	5.5	54	62.
Delta	Westham Island	F2	26.1	26.6	52.7	25.4	640	9.1	54	60.
Delta	Westham Island	G1	22.2	33.7	55.9	25.4	827	9.6	110	60.
Delta	Westham Island	G2	17.4	42.5	59.9	25.2	193	13.5	35	47
Average for Delta			22.5	32.8	52.9	23.9	860	11.8	54	46.8

Table No. 5.

Pea constituents calculated on a fresh weight basis.

Area.	Locality.	Sample No.	Sucrose g/100g	Starch g/100g	Total Carbo-hydrates g/100g	Protein g/100g	Phosphorus mg/100g	Potassium mg/100g	Calcium mg/100g	Magnesium mg/100g
Valley	Matsqui	A1	3.68	15.2	18.9	8.87	535	5.03	15.7	12.3
		A2	2.48	21.5	23.9	9.13	552	14.4	13.3	9.5
		A3	2.97	21.7	24.7	8.92	549	6.77	25.5	10.2
		A4	1.92	9.0	10.9	9.09	267	5.57	35.1	10.5
		B1	3.38	26.4	29.7	11.5	473	8.49	22.2	12.4
		B2	0.00	24.5	24.5	10.4	567	2.89	27.3	12.9
		B3	0.00	22.6	22.6	10.1	402	9.1	28.3	8.05
	Barnston Island	C1	4.08	11.5	15.6	8.98	383	7.65	17.8	8.19
		C2	6.09	16.3	22.4	10.4	535	5.68	55.7	5.0
Average for Valley			2.73	18.7	21.6	9.7	484	7.28	26.7	10.0
Delta	Sea Island	D1	5.52	11.5	17.0	9.92	464	5.14	12.4	5.71
		D2	7.60	11.6	19.2	9.3	464	5.33	14.0	7.79
	Lulu Island	E1	9.70	12.4	22.1	8.48	518	6.44	25.1	23.4
		E2	7.60	12.3	19.9	7.31	433	5.18	18.6	20.3
	Westham Island	F1	10.20	10.2	20.4	9.63	139	2.06	20.4	23.7
		F2	9.25	9.5	18.7	9.02	227	3.23	19.2	21.3
		G1	7.6	11.3	18.9	8.70	279	3.24	37.2	20.3
		G2	6.05	14.5	20.7	8.60	66	4.66	12.1	16.2
Average for Delta			7.94	11.6	19.6	8.8	323	4.41	17.6	17.2

Tables 4 and 5 show the results of the analysis of the peas calculated on a dry weight basis and a fresh weight basis. The figures indicate that the peas from the Valley area have a higher starch content but a lower scurose content than the peas from the Delta area. The protein and total carbohydrates contents are the same for both areas. The Delta peas show lesser amounts of Phosphorus potassium and calcium than the Valley peas. Magnesium is high in the Delta grown peas.

It is of interest to set forth the analysis of peas given by Hodgman (9). His figures are compiled from various publications of the United States Department of Agriculture.

For peas they are:

Carbohydrates	15.%
Protein	7.%
Phosphorus	.13%
Calcium	.026%

In the following pages the results of analysis found in this report are compared with those of Hodgman.

Discussion

Soils. What effect the larger proportion of clay in the Delta soils has upon the peas grown on the soils can not be decided from the results obtained here.

The Valley soils are only slightly acid and should be good soils for pea growing. The Delta soils vary in acidity.

Those with very acid soils should be poor pea soils. This will be discussed later in connection with phosphorus in the peas.

The only Delta soil showing a good supply of calcium had been limed two years previously and had been given an application of superphosphate the year before. It is interesting that this soil shows low amounts of phosphorus. The acidity of the soil causing the phosphorus to be precipitated out cannot explain this point as the peas from this soil show large amounts of phosphorus, in fact, larger amounts than peas from less acid soil show.

In the fields showing very acid reactions the peas were wilted, brown in color with some dead. The proportion of dead plants was not excessive but noticeable. One soil (D) was extremely dry even to a foot in depth. The surface of the soil was hard and caked. No indication of poor drainage was found in this soil as was found in soil E. Soil E showed signs of having been flooded. The small depressions in the field were devoid of peas and grew nothing but a multitude of weeds. The surface in these hollows had the typical appearance of soil on which water had collected and slowly dried off. The hard brick-like cakes were separated by wide deep cracks. In this soil there were found present nitrites, another indication of flooding and poor aeration.

The nitrogen supply was found to be low but as the pea has the nitrogen fixing tubercles in its roots which exchange with the plant fixed nitrogen for carbohydrates, this apparent low supply of soil nitrogen is not serious. Soil E, as has been pointed out, showed the presence of considerable amounts of nitrite. This in itself is not serious but indicates poor aeration and poor drainage.

<u>Pea Analysis</u> - The percentage of dry matter listed in table 3 is approximately the amounts reported by Boswell (4). The amount of ash material is low compared with the results of Bisson and Jones (1) if an average is taken for the whole, but if the results are divided into the two groups of Delta and Valley it is seen that the peas from the Delta area have a higher percentage of ash constituents than the Valley grown peas. This higher amount nearly is equal to that given by Bisson and Jones. Street (17) found that high magnesium in the nutrient solution caused low crude ash but that high potash and calcium caused high crude ash. Without exception magnesium is present in the Valley soils and may have an influence on the ash materials of the peas grown on them. This influence of the magnesium is probably of greater power than the influence of the calcium present. However, the writer found that the peas having the higher magnesium content had the lower ash percentage. Whether this is opposite to Street's observations cannot be ascertained since Street did not analyse his peas for magnesium.

Carbohydrates

The results of this investigation are opposite to those of Street's investigation in that the soils showing magnesium produced peas not highest in sucrose but highest in starch. However, peas highest in magnesium were found highest in sucrose and peas highest in potassium were found highest in starch.The cause of this higher starch in the Valley peas may also be the higher temperatures prevailing in the valley area during the later part of the growing season (3)(4). The Provincial climatic reports record the temperatures around Matsqui as being two to five degrees Fahrenheit higher than around Steveston (centre of the Delta area). Thus the conclusion must be drawn that the Delta area produces a better quality pea for canning purposes.

The total carbohydrates are the same in the peas from the Valley and from the Delta areas. The carbohydrates found in peas from both areas are high compared with those of Hodgman and of Boswell (4).

Protein

Hodgman's value for protein content of peas is much lower than any shown for protein in table 5. The high amount of protein in the peas used in this investigation cannot be caused by a large supply of nitrogen in the soil. Results of the soil analysis show them to be low in this nutrient element. Calcium may be the influencing factor in those peas from soils well supplied with lime, since Nightingale and co-workers and

Parker reported the need of calcium for nitrogen metabolism. However, this can hardly be the case since the peas from the Delta soils which are not so well supplied with calcium also show a high amount of protein. The protein content of the pea seems to bear no relationship to the calcium content of the pea. No definite cause for the high amount of protein can be found unless the climatic factors give this effect.

An interesting point to observe is that peas from soils containing nitrites have the lowest amounts of protein. No conclusion can be made on this point since there are only two such cases occuring. It is probable that the poor condition of the soils showing nitrites had some effect upon the nitrogen supply of the plant, possibly by inhibiting the activity of nitrogen fixing organisms.

Ash constituents.

Phosphorus and calcium - Since the parts analysed were the seeds, it is not surprising to find that most of the samples have a high phosphorus content. What is surprising is that the phosphorus content found in analysing these peas is three times as great as the phosphorus reported in peas by Hodgman. This large amount is hard to account for.

The soil analyses show the soils to be low in phosphorus. In those soils which are plentifully supplied with calcium it may be kept out of solution as a calcium salt. In the other soils not so well supplied with calcium it may be held as aluminium salts. Aluminium was not present in any of the soils, not even in the extremely acid soils. (Spurway's test for aluminium is reputed to be unsatisfactory since it to often shows low amounts of the element.)

There is a relationship between the amount of calcium in the soil and the amount of phosphorus in the plants' seeds. This may be caused by the factors mentioned in the preceding paragraph. The relation seems quite definitely between the calcium of the soil and the phosphorus in the peas. Acidity of the soil is not an important factor since the very acid soils grew peas with higher amounts of phosphorus than some of the soils with less acid reaction.

The results as shown in table 5 do not show any relationship between phosphorus content of the pea and the calcium or magnesium content of the pea. The only relationship that can be stated conclusively is that soils with a good supply of calcium yield peas containing greater amounts of phosphorus than do soils with a poor supply of calcium.

Potassium and Magnesium - These two elements have been described as having similar effects on plants. Street showed the effects of magnesium and potassium upon carbohydrates. The influence if any of these elements on the other constituents of peas cannot be seen in these results. There is, however, little connection between the amount of magnesium available in the soil and the amount in the pea.

Conclusions

From these results it may be concluded that peas of better quality for canning are grown in the Delta area of the Fraser River of British Columbia since such peas have a higher sucrose content than peas grown in the valley area. Another conclusion may be made that peas grown on soils well supplied with calcium have a higher phosphorus content than do peas grown on soils not so well supplied with calcium.

Summary

Samples of peas of the variety Perfection were collected with samples of the soils they grew on from farms located in the Fraser Valley area and the Delta area of Britihh Columbia. The samples were analysed, the soils for the usual nutrient elements, the peas for sucrose, starch, protein, phosphorus, calcium, potassium and magnesium. The results were tabulated in several tables. It was found that the Delta area produced the better quality peas, and that soils well supplied with calcium produced peas high in phosphorus.

ACKNOWLEDGMENTS

Appreciation is herein expressed for the patience and kindness shown the author by Dean Clement, Dr. G. H. Harris, under whose direction the project was carried out, and other members of the staff.

The writer wishes to express his thanks for the help in collecting samples given by Mr. Harold Pearson and Mr. Wilbert Smith.

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