SOME STUDIES ON THE EFFECTS OF THE INCORPORATION OF CERTAIN GROWTH STIMULANTS IN PELLETED SEED ON GERMINATION AND DEVELOPMENT OF THE SEEDLINGS

By

Donald Wilson Newsom

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
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Department of Horticulture

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AN ABSTRACT

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Approved by Robt. L. Carolus.
Major Professor

Data on the effects of pelleting and the incorporation of fungicides, fertilizers and growth stimulants on germination and growth and development of the seedlings were taken.

Seed of sweet corn, cabbage, lettuce and tomato were pelleted. Arasan, cupric oxide, iron chlorophyll, bone char, superphosphate, calcium salt of keto succinic acid, sulfuric acid, potassium nitrate, and dried blood were incorporated singly and in various combinations in the pellets.

The pelleting process consisted of building up the seed to the desired size with a coating material composed of 70 per cent minco clay and 30 per cent cellite. The coating was made to adhere to the seed by spraying with an 8 per cent solution of methyl cellulose having a viscosity rating of 15 centipoises while the seeds were rotated at 45 revolutions per minute in a rolled copper drum. The fungicides, fertilizers, and growth stimulants were added to the seed in the process of pelleting.

Statistical analyses of the data indicated that pelleting did not affect germination, seedling development, nitrate nitrogen, soluble phosphorus or potassium oxide content in the plants, earliness or yield.

Since pelleting had no adverse effect on germination, it will be of considerable value to vegetable growers in that it will allow for precision planting of small seeded crops and eliminate excessive hand thinning. On the basis of this work it would appear to be an economically sound practice from the standpoint of precision planting.

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ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. R. L. Carolus for his direction of the problem, and criticisms in the preparation of the manuscript; to the Associated Seed Growers, Inc., New Haven, Conn., Northrup-King and Company, Minneapolis, Minn., and F. H. Woodruff and Sons, Inc., Milford, Conn. for their contribution of the seed used in this problem; and to Dr. P. Vogelsang, of the Processed Seeds Inc., Midland, Michigan, for demonstration and instruction on the mechanics of the pelleting process.

INTRODUCTION

Seed pelleting is a newly developed process which involves the coating of seed with certain inert minerals as cellite, flyash and feldspar as well as montmorillonite and minco clays, which are made to adhere to the seed by the use of water soluble methyl cellulose applied as a fine spray in a rotary pan. As the size of the seed can be increased up to twenty or more times, precision planting of the smaller seeded vegetables is facilitated. It has been reported (9) that the incorporation of superphosphate, dried skim mild, and dried blood in the pellet is beneficial in some cases. If those materials and other growth promoting substances are found to give consistent benefits when incorporated in the pellet, then seed pelleting may prove to have considerable merit in the production of vegetable crops. This study was designed to determine if certain chemicals produce any stimulation to seedling development when incorporated in pelleted seed. This paper presents the effects of incorporating superphosphate, dried blood, iron chlorophyll, the calcium salt of keto succinic acid, cupric oxide, bone char and potassium nitrate singly and in various combinations in pelleted seed. Germination, green weight of tops, nitrate nitrogen, soluble phosphorus, and potassium oxide content, earliness and yield were used as criteria in determining the effects of pelleting and the incorporation of the various chemicals in the pellet on sweet corn, cabbage, tomato and lettuce.

REVIEW OF LITERATURE

Treating seeds with growth stimulants of various kinds has developed since 1935, following the successful use of hormones in the rooting of cuttings. The procedure has been to apply hormones to dormant seeds; the chemical is then immediately available to the young seedling for what stimulative effect it may have.

Among the early experiments were those of Cholodny (11) in which the growth of wheat and yield of oats appeared to be increased by treating the seeds with hormones. Since then many kinds of seeds have been similarly treated including those of cereals, sugar beets, and other crop plants.

Gracanin (14) found that germination of the seeds of beet, rye, sunflower, Festuca and others was accelerated by treatment with orthophosphoric acid.

Grace (15) dusted seeds of wheat and barley with a number of materials and reported stimulation of both root and top growth. Indoleacetic acid and indolebutyric acid at 2 ppm increased root length 65 per cent and 55 per cent respectively, while a combination of these at a concentration of 2 ppm each increased root length 102 per cent.

McRostie, et al (19) treated seed of winter wheat with indoleacetic and naphthaleneacetic acids at 2 to 10 and 10 to 100 ppm respectively and obtained significant differences in straw production, yield and nitrogen content of grain.

Bonner (5) reported that soaking pea seeds in a concentrated solution of Vitamin C caused subsequent seedlings to increase in dry weight 35 per cent over the controls.

There have been other reports of growth increases with individual plants. Swartly and Chadwick (26) found a significant increase in the percentage of germination of 11 out of 41 kinds of seeds after treatment with naphthaleneacetamide plus thiourea. In a few crops (sorghum, peas and navy beans) Allard et al (1) report that concentrations of 0.01 to 0.1 ppm of 2-4 dichlorophenoxyacetic acid were somewhat stimulating to early seedling growth.

Mitchell (20) used different concentrations of indoleacetic, naphthaleneacetic and indolebutyric acids, indoleacetamide and naphthaleneacetamide as seed treatments but his results failed to show that these materials had any effect on total plant growth, time of flowering, or yield.

Bartholomew (3) conducted experiments with seed dusting chemicals under a wide variation of soil conditions to determine their ability to increase yields of soybeans, rice , corn, cotton and sorghum. No significant increases were obtained as a result of seed treatment in 13 of the 14 experiments and it was concluded that seed treatment with the plant growth stimulants could not be recommended as a general practice.

Youden (30) describes a set of experiments in which he treated wheat and soybean seeds with growth substances. Wheat and soybean seeds were treated in the dry state with indoleacetic acid, naphthaleneacetic acid, and indolebutyric acid, talc and Rootone* and grown in sand and soil in the greenhouse and in the field. The concentration of the organic compounds in the talc preparations, as well as the proportion of powder to seeds was adjusted to cover the range from 0.5 to 240 ppm of active substance by weight of seeds. In a series of 10 experiments,

*Commercial preparation

observations were made on the germination, seedling height, fresh weight of tops, yield of grain, and root systems, but in no instance did the germination and growth of the treated lots exceed the controls.

Barton (4) soaked non-dormant seeds of twenty-nine different species and varieties of farm, garden, and flowering plants and grasses in a wide range of concentrations (1.2 to 320.0 mg per liter of water) of three different growth substances (naphthaleneacetic, indoleacetic and indolebutyric acids) and grew them to maturity in soil. Except for higher concentrations which in some cases inhibited growth or caused malformations, the treatments had no effects, either on germination or final yield. She also treated seeds with several proprietary plant hormone preparations, mainly talc-dust mixtures, with similar results.

Various mechanical and chemical treatments have been used in breaking dormancy in seeds. Rose (23) found that the hard-coated seeds of legumes, lettuce, mustard, okra, and snapdragon could be made to germinate more quickly by being blown against needle points.

It was found by Jones (17) that the seed coats of Nelumbo lutea do not absorb water after soaking in water for 18 months at room temperatures, but that when the seed coats were broken without injury to the embryo, the seeds quickly germinated.

Deuber (12) and Bramble (6) showed that the dormant seeds of sugar maple, Norway maple and certain varieties of oats could be stimulated into germination by treatment with solutions of thiourea and ethylene chorohydrin and the vapors of ethylene chlorohydrin.

Baldwin (2) improved the germination of seeds of Picea rubra by immersion in absolute alcohol.

Harrington (16) reported that seeds of redtop, parsnips, celery, orchard grass, bluegrass, Bermuda grass, and Johnson grass germinated much better with favorable alternations of temperature than at constant temperatures.

The supply of oxygen is an important factor in germination, and it is generally considered that the increased germination from some treatments may be caused by the favorable effect upon the diffusion of oxygen through the membrane of the seed. Moringa (21,22) noted that seeds of cattail, which germinated poorly or not at all in air, germinated promptly when the oxygen supply was decreased by diluting the air with 48 to 80 per cent hydrogen or nitrogen.

According to Shuck (24,25), lettuce seed is in a physiologically unstable condition that makes it particularly sensitive during germination to the effects of light, moisture, and temperature. In the laboratory, germination is promoted by the exposure of the seeds to light, by the use of a very moist substratum, and by starting the germination at a low temperature. The light requirement was satisfied by continuous exposure to light under germinating conditions or by exposing the moist seeds to light before placing them in a dark chamber. He concluded that light causes certain photochemical changes within the seed. Shuck (24,25) believed that there is a growth-inhibiting substance in lettuce seed, since after a sufficient number of seeds had been germinated in the dark on a cotton medium for 10 days, the germination of similar seed was completely inhibited on this medium; but when the medium was washed in water and again used as a substratum, 98 per cent of a similar lot of seeds germinated.

Thompson (28) found indications that immaturity at the time of harvest is an important factor contributing to the dormancy and light sensitivity in lettuce seed.

Flint (13) found that the red, orange, and yellow rays of light were the most effective in promoting the germination of lettuce seed, while the blue, green and violet rays inhibited germination. He found further that non-light-sensitive seeds could be made sensitive by subjecting them for a period, while moist, to blue light and then drying.

Vogelsang (29) has suggested that the incorporation of substantial quantities of the more insoluble fertilizer materials and small quantities of minor elements in pelleted seed may stimulate growth of subsequent seedlings.

Carolus (9) states that experiments have shown that increasing the phosphate concentration in the area near the germinating seed has proven to be a distinct advantage in many situations and that the use of organic nitrogen carriers and powdered skimmed milk has proved beneficial in some cases by stimulating bacterial activity in the neighborhood of the germinating seed. He further states that the addition to the coating materials of plant growth regulating materials and other stimulants to promote rooting and rapid emergence has shown considerable promise.

McGuffey (18) working with pelleted seed containing various fungicides, fertilizers and plant growth stimulants found that the germination of melon and cucumber seeds was benefited noticeably, while the germination of pelleted wax and green beans was only slightly better than that of the non-pelleted seed. North Star, Golden Hybrid and Golden Security sweet corn seed pelleted with 1.5 per cent arasan and 3 per cent chloranil showed increases in germination of 16 per cent

5 per cent and 31 per cent respectively, above that not pelleted but treated with 1.5 per cent arasan and 3 per cent chloranil.

Burgesser (8) states that numerous tests in experimental plots and in test plantings have failed to show significant benefits from addition of various fertilizers up to amounts toxic to the seed. He further states that the various growth stimulating chemicals have not consistently given significant benefits. These results are not strictly comparable to those of McGuffey (18) since the methods of pelleting used by these investigators differed greatly.

Carolus (9) reports that pelleting resulted in not only higher germination in corn and more rapid seedling development, but also earlier harvest. In one observation, seed which was not pelleted germinated slowly and the seedlings showed poor vigor and a purpling of the leaves associated with phosphorus deficiency. Pelleted seed in which superphosphate had been included germinated better and the seedlings showed more vigor and no symptom of phosphorus deficiency. Pelleted tomato seed produced plants that were more vigorus and earlier maturing than plants produced from non-pelleted seed. Pelleting induced pickling cucumbers to vine more vigorously and to produce earlier fruit. Apparently the incorporated materials gave the plants a disease-free start and a stimulation from the phosphorus and plant stimulants that resulted in better rooting.

McGuffey (18) working with 15 kinds of vegetable seed found that, on an average, pelleting reduced germination 15 per cent. Pelleting significantly reduced the germination of all crops except carrot, cauliflower and turnip. The pelleting formula consisted of 35 per cent flyash and 65 per cent feldspar, with methyl cellulose used as a sticker to form the pellet. No fertilizer, fungicide or growth stimulant was incorporated.

EXPERIMENTAL PROCEDURE

Seed were pelleted by a process in which a layer of inert minerals, fungicides, fertilizers and growth stimulants were made to adhere to the seed by the use of methyl cellulose, a water soluble adhesive material. In this process the seed were placed in a pan which was adjusted to rotate at 45 revelutions per minute and an 8 per cent solution of methyl cellulose with a viscosity rating of 15 centipoises was sprayed onto the seed. Enough of this material was then applied to thoroughly moisten the seeds, then the various fertilizers, fungicides and growth stimulants were added to the pellet. The seed were then allowed to rotate 15 minutes or for a period of time sufficient for the materials to adhere to the seed before the next application of methyl cellulose was made. The process used in these tests was similar to that developed by Vogelsang (29).

The remainder of the process consisted merely of the building up of the pellet to the desired size by the alternating additions of methyl cellulose and the coating materials. The length of time required to pellet seeds depends on the original size of the seed and the size of the end product desired. In comparative tests it required 30 minutes to process one pound lots of sweet corn and two hours to process 10 ounce lots of lettuce, tomato and cabbage seeds.

In these tests a rolled copper pan rotated by an electric motor was found to be quite satisfactory. The pan at the point of attachment to the drive shaft was 8 inches in diameter, flared out to 16 inches at mid-depth and tapered down to 8 inches at the open end. This size pan was found to be very convenient in processing small, experimental lots of seed.

The pellets were dried by placing them in a wire mesh basket, and forcing hot air from a small electric heater through them. Because of the probable induction of dormancy in lettuce seed by this procedure a small electric fan was used for drying the lettuce seed.

Because preliminary tests indicated it to be the most satisfactory, a formula consisting of 70 per cent minco-clay and 30 per cent cellite was used as the coating on tomato, cabbage, and lettuce seeds whereas the sweet corn was coated with a mixture containing 65 per cent feldspar and 35 per cent fly ash. Table I shows the varieties, sources of seed, treatment and crops. The sources and descriptions of the materials are given in Table II.

In preliminary tests with lettuce seed of the Black Seeded Simpson variety pelleting resulted in poor germination. To counteract this effect, .4 per cent potassium nitrate (28) was incorporated in one lot of seed and a concentration of sulfuric acid sufficient to reduce the pH of the methyl cellulose sticker to 4.5 was incorporated in another lot of seed. Both of these materials have been used in breaking dormancy of certain crop seeds. (7).

The calcium salt of keto succinic acid was used in combination with the dried blood treatments in all cases on the basis of reports from Vogelsang (29) that this combination had proved beneficial.

Iron chlorophyll was used on the basis of information obtained from Vogelsang (29). Presumably this material would speed up chlorophyll production in the seedlings, since it is thought that iron is used by the plant in the photo-oxidation of "protochlorophyll" to chlorophyll.

TABLE--List of Chemicals, Crops, Varieties, Sources of Seed and Treatments Used in Seed Pelleting Experiments

Crop	Sweet Corn	Cabbage	Tomato	Lettuce
Variety 1/	Golden Cross Bantam Carmelcross	Golden Acre Danish Ball Head	John Baer Stokesdale	Great Lakes Black Seeded Simpson
		Treatment 2/		
A. Unpelleted	1½ Arasan	1% CuO	1% CuO	1% CuO
B. Pelleted	1½ Arasan	1% CuO	1% CuO	1% CuO
C. Pelleted	50 ppm Ca salt of keto succinic acid, 400 ppm dried blood	1% CuO 50 ppm Ca salt ot keto succinic acid 400 ppm dried blood	1% CuO, 50 ppm salt of keto succinic acid, 400 dried blood	1% CuO, pH of methyl cellulose reduced to 4.5
D. Pelleted	1½% Arasan, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood	1% CuO, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% super-phosphate	1% CuO, 4% Superphosphate	1% CuO, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood
E. Pelleted	1½% Arasan, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate	1% CuO 8% superphosphate	1% CuO 8% super-phosphate	1% CuO, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate

TABLE 1--(Continued)

Crop	Sweet Corn	Cabbage	Tomato	Lettuce
Variety 1/	Golden Cross Bantam Carmelcross	Golden Acre Danish Ball Head	John Baer Stokesdale	Great Lakes Black Seeded Simpson
		Treatment 2/		
F. Pelleted	1½% Arasan, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate, 400 ppm iron chlorophyll	1% CuO, 20% bone char	1% CuO, 50ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate	1% CuO, 50 CuO, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate, 400 ppm iron chlorophyll
G. Pelleted	————	1% CuO, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate, 400 ppm iron chlorophyll	1% CuO, 50 ppm Ca salt of keto succinic acid, 400 ppm dried blood, 4% superphosphate, 400 ppm iron chlorophyll	1 % CuO, .4% KNO3
No. of Lots	36	42	42	42

1/ Seed of each variety of the four crops were supplied by each of the following sources: Northrup-King & Co., Associated Seed Growers, Inc., and F. H. Woodruff & Sons, Inc.

2/ The amount of materials incorporated in the treatments are based on seed weight.

TABLE II--List and Description of Substances Used in Seed Pelleting Experiments

1. Calcium salt of keto succinic acid	Supplied by Dr. W. J. Hale Midland, Michigan
2. Dried blood	Hemoglobin from centrifuged, citrated blood. Supplied by Armour & Co., Chicago, Ill.
3. Bone char	A carbon compound containing 65 percent moisture and 35 percent solids of which 30 to 70 percent are fatty acids. Supplied by Michigan Sugar Beat Growers, Association, Saginaw, Michigan
4. Methyl cellulose	An adhesive material with a viscosity rating of 15 centipoises. Supplied by Dow Chemical Co., Midland, Michigan
5. Iron Chlorophyll	A chlorophyll extract containing small amounts of iron. Obtained from Valley Chemical Co., McAllen, Texas
6. Flyash	A carbon free compound collected from smoke stacks of coal burning furnaces.
7. Feldspar	One of the primary earth minerals
8. Cellite	Diatomaceous earth

Germination Tests: The seed were germinated in sandy loam soil in flats 15" x 21" x 4". The soil in the flats was firmed with a board, and 20 seed planted per row in rows spaced at two inch intervals. The seed was then covered with a measured amount of soil and an equal amount of water was then applied to all flats. Equal amounts of water were applied to the flats every second day until the tests were completed. All of the germination tests were conducted at Michigan State College in a greenhouse in which the temperature was maintained at approximately 70 degrees F.

The tests were replicated ten times so that a total of 200 seed from each treatment was tested for per cent germination during a 14-day period.

Investigations to Determine the Effect of Pelleting and the Incorporation Of Various Materials in the Pellet on Growth of the Seedlings: In order to determine if the incorporation of fertilizers and growth stimulants had any effect on seedling development, a series of experiments was set up in the greenhouse in 8-inch glazed pots.

The first of these experiments was conducted at Michigan State College. Cabbage seed from each of the seed treatments from the three sources and two varieties listed for cabbage in Table I were used. The experiment was laid out in the greenhouse in two blocks of different fertility levels. The soil with which the pots were filled was purposely a very infertile sandy type soil. In one block, which will hereafter be referred to as "high fertility", each of the 42 pots received .5 grams nitrogen, .5 grams phosphoric acid, and .5 grams potassium oxide, supplied from a combination of KNO_3, KH_2PO_4 and NH_4NO_3. The second block received no fertilizer and will hereafter be referred to as "low fertility". The experiment was designed in this manner to determine whether on a highly infertile soil the stimulation anticipated from the incorporation of fertilizers and growth stimulants in the pellet would be accentuated.

On October 1, 1949 twenty seeds of cabbage from each of the seven seed treatments were planted in the individual pots in each of the two fertility levels. After germination and emergence of the seedlings was completed, the plants were thinned to three plants per pot.

At the end of four weeks the plants were cut off at the surface of the soil and the fresh weight of the tops determined.

On June 1, 1950 experiments were conducted to determine the effect of the treatments on the fresh weight of tops and the nitrate-nitrogen, soluble phosphorus and potassium oxide content of sweet corn, tomato and lettuce. These tests were similar to the one conducted with cabbage except that they were carried out under half-shade in the Rio Grande Valley of Texas.

Tissue tests were made on fresh material collected from the pot experiments on cabbage, lettuce, tomato and sweet corn. The above-ground parts of three plants from each pot were macerated and the sap extracted from one gram samples with a weak acetic acid solution. Nitrate-nitrogen, soluble phosphorus, and potassium oxide determinations were run on the plant extracts according to the procedure of Carolus (10).

<u>Investigations to Determine the Effects of Pelleting and the Incorporation of Various Materials in the Pellet on Yield:</u>

<u>Sweet Corn:</u> Seed of two varities each from the three sources, and from the six treatments, outlined in Table I, were planted at 12-inch intervals in rows 25 feet long and three feet apart in the field May 15, 1949 to determine the effects of pelleting on yield. A split plot experiment was

designed so that sources of seed were replicated twice, varieties six and treatments twelve times in two blocks. The same experimental design was used on all crops for the yield tests.

Harvest dates were July 30 and August 10, respectively, for Carmelcross and Golden Cross Bantam. The total weight of marketable ears was recorded.

Cabbage: Seed of two varieties each from three sources and from the seven treatments, outlined in Table I, were planted at 12-inch intervals in rows 25 feet long and three feet apart in the field July 16, 1949.

The Golden Acre Variety was harvested September 20 and Danish Ball Head Variety in an immature state on October 15.

Tomato: Seed of two varieties each from these sources and from the seven treatments, outlined in Table I, were planted at 12-inch intervals in rows 25 feet long and three and one-half feet apart in the field April 5, 1950.

The first picking was made July 10 and successive pickings were made once each week for the three following weeks, giving a total of four pickings. Data on total weight of marketable fruit were collected.

Lettuce: Seed of two varieties each from the three sources and from the seven treatments, outlined in Table I, were planted at 6-inch intervals in rows 20 feet long and three feet apart.

Harvest dates were June 16 and July 30, respectively, for the Black Seeded Simpson and Great Lakes Varieties. Total weight of marketable product was recorded for each variety.

Statistical Methods: All data were subjected to an analysis of variance. The significance of the data was determined according to Snedecor's Statistical Methods (27).

EXPERIMENTAL RESULTS

A. Effect of Pelleting on Germination

The effects of the various factors and the first and second order interactions are shown in Table V. The third order interaction served as the error term. The error terms as shown in Table V are extremely small, however, only in the cabbage and sweet corn tests do we find any significant differences in the main factors.

In the cabbage germination tests germination was significantly greater at the 5 per cent level with seed from Northrup-King and Co., than with seed from either F. H. Woodruff and Sons or Associated Seed Growers, Inc. Replications were significantly different at the 1 per cent level in the cabbage tests.

In the sweet corn tests there was a significant difference at the 5 per cent level between sources of seed as shown in Table V. Germination was greater with sweet corn seed from Northrup-King and Co., than with seed from F. H. Woodruff and Sons, but there was no difference between the germination of seed from Associated Seed Growers, Inc. and seed from Northrup-King and Co., or between seeds from Associated Seed Growers, Inc, and F. H. Woodruff and Sons. The interactions R x T and S x R x T are significant at the 1 per cent level in the sweet corn tests as shown in Table V. The effects of variety, source of seed and treatment on germination of sweet corn and cabbage are shown in tables III and IV.

In these tests there were no significant effects from the pelleting treatments indicating that the incorporation of the various materials had no stimulating effect on germination. It is important to note, however, that pelleting in these tests did not reduce germination as was reported by McGuffey (18).

TABLE III--The Effect of Variety, Source of Seed and Treatment on Germination of Sweet Corn Seed 1/

Variety	Source	Treatment 2/						
		A	B	C	D	E	F	Average
Golden Cross Bantam	3/	165	164	168	170	169	166	168.3
	4/	166	170	168	167	169	171	168.8
	5/	169	171	171	172	166	170	169.8
Average		166.6	168.3	169.0	169.0	168.0	168.7	
Carmelcross	3/	167	170	175	165	169	167	169.5
	4/	171	166	172	168	169	171	168.8
	5/	169	172	170	171	169	168	169.8
Average		169.0	169.3	172.3	168.0	169.0	168.7	
General Average		167.8	168.8	170.7	168.8	168.5	168.7	

1/ Germination from 200 seed.
2/ See Table I for treatment materials
3/ Associated Seed Growers, Inc.
4/ F. H. Woodruff and Sons, Inc.
5/ Northrup-King & Co.

TABLE IV--The Effect of Variety, Source of Seed and Treatment on Germination of Cabbage Seed 1/

Variety	Source	Treatment 2/							6
		A	B	C	D	E	F	G	Average
Golden Acre	3/	162	165	155	152	153	157	151	156.4
	4/	170	161	158	160	164	158	162	161.9
	5/	169	160	164	164	166	164	164	164.4
Average		167.0	162.0	159.0	158.8	161.0	159.7	154.0	
Danish Ball Head	3/	172	162	162	159	161	163	162	163.0
	4/	165	161	158	152	157	158	158	158.4
	5/	175	170	168	168	164	165	162	167.4
Average		170.7	164.3	162.7	159.7	160.7	16[illegible].0	160.7	
General Average		168.9	163.2	160.9	159.2	160.9	160.9	159.9	

1/ Germination from 200 seed.
2/ See Table I for treatment materials.
3/ Associated Seed Growers, Inc.
4/ F. H. Woodruff and Sons
5/ Northrup-King Seed Company

TABLE V--Analysis of Variance Summary Table for Total Germination

Source of Variation	Df	Cabbage Mean Square	Lettuce Mean Square	Tomato Mean Square	Df	Sweet Corn Mean Square
Source (S)	2	16.50*	.46	.41	2	2.14*
Variety (V)	1	4.00	.08	.09	1	1.01
Replication (R)	9	14.11**	.84	1.95	9	.15
Treatment (T)	6	6.33	.31	1.00	5	.89
S x V	2	9.50	.06	.19	2	.60
S x R	18	5.28	.30	1.23	18	.31
S x T	12	.75	.45	1.07	10	.52
V x R	9	6.33	.39	.88	9	.59
V x T	6	.50	.53	.67	5	.25
R x T	54	3.98	2.08	3.14	45	1.33**
S x V x R	18	5.50	.65	.89	18	.14
S x V x T	12	1.00	.49	.64	10	.37
S x R x T	108	3.41	1. 50	1.93	90	1.93**
V x R x T	54	2.65	1.44	1.49	45	.56
V x R x S x T	108	4.30	1.33	2.68	90	.63
Total	419				359	

* Significant at the 5 percent point
** Significant at the 1 percent point

B. Effect of Pelleting on Seedling Development

Neither pelleting nor the incorporation of the various chemicals in the pellet had any effect on seedling development of the four crops. However, in the cabbage tests the average weights of plants grown from pelleted seed were considerably greater than those grown from non-pelleted seed. Though these differences are not statistically significant they are consistent enough to lead one to suspect that practical differences do exist. Under the high fertilizer treatments (table VI) for the variety Golden Acre the range in average weight of above-ground parts runs from 3.9 grams per plant from the non-pelleted treatment to 8.2 grams and 7.9 grams per plant from treatments E and F, respectively. These treatments consisted of pellets containing superphosphate.

These differences were not statistically significant probably because there was a rather wide variation within treatments.

There were no differences between treatments in the lettuce, tomato and sweet corn tests.

A summary of the analysis of variance is given in Table VII.

C. The Effect of Pelleting on the Nutrient Content in the Plant Extracts

Nitrate Nitrogen: Table X gives the analysis of variance summary for the nitrate nitrogen content of the plant extracts collected from plant material grown from pelleted and non-pelleted seed. It is apparent that the incorporation of the various materials in the pellet had no effect on the nitrate nitrogen content of the plant extracts from the four crops at the time of sampling. Samples were taken at the end of one month after the seed were planted, and any effect that the incorporation of the

TABLE VI--The Effect of Variety, Fertilizer and Treatment on Green Weight of Above-Ground Parts 1/

Variety	Fertilizer	Treatment 2/ A	B	C	D	E	F	G	Average
Cabbage									
Golden Acre	Low	1.8	1.5	2.0	1.7	2.1	1.7	1.9	1.8
	High	3.9	4.7	5.3	5.4	8.2	7.9	5.6	6.0
Danish Ball Head	Low	1.4	1.5	1.5	1.6	1.5	1.8	1.9	1.6
	High	3.1	3.5	4.6	3.6	3.6	3.7	4.1	3.8
Average		3.4	3.7	4.5	4.1	5.1	5.0	4.5	
Lettuce									
Great Lakes	Low	2.1	1.3	2.1	2.0	1.8	2.1	2.1	1.9
	High	5.3	4.7	5.4	5.2	5.1	6.7	6.3	5.5
Black Seeded Simpson	Low	1.6	1.5	1.6	1.6	1.4	1.5	1.8	1.6
	High	3.2	3.5	4.3	3.5	3.3	3.1	4.1	3.6
Average		3.1	2.8	3.4	3.1	2.9	3.4	3.6	
Tomato									
Stokesdale	Low	1.4	1.8	1.7	1.5	1.5	1.2	1.4	1.9
	High	4.0	3.6	3.7	3.7	3.7	3.7	3.8	3.7
John Baer	Low	1.6	1.6	1.4	1.5	1.5	1.9	1.9	1.6
	High	4.0	3.6	3.7	3.3	3.8	3.4	3.6	3.6
Average		2.8	2.7	2.6	2.5	2.6	2.6	2.7	
Sweet Corn									
Golden Cross Bantam	Low	2.0	2.0	1.7	1.7	2.0	1.8	---	1.9
	High	4.2	4.0	3.8	3.6	3.6	3.3	---	3.8
Carmelcross	Low	3.3	2.8	3.1	2.8	2.8	2.3	---	2.9
	High	5.4	5.1	5.2	5.3	5.3	5.4	---	5.3
Average		3.7	3.5	3.5	3.4	3.4	3.2	---	
General Average		3.0	2.9	3.2	3.0	3.2	3.2	3.2	

1/ Average wt. in grams per plant
2/ See Table I for treatment materials

TABLE VII--Analysis of Variance Summary Table for Green Weight of Above-Ground Parts of Cabbage, Lettuce, Tomato and Sweet Corn

Source of Variation	DF	Cabbage Mean Square	Lettuce Mean Square	Tomato Mean Square	DF	Sweet Corn Mean Square
Fertilizer (F)	1	199.03**	164.92**	94.51**	1	83.21**
Source (S)	2	3.45	5.53	.18	2	.19
Error a	2	.21	2.22	.06	2	.23
Variety (V)	1	28.70*	28.01	.01	1	28.62
Error b	5	4.09	4.90	.09	5	.49
Treatment (T)	6	2.69	.91	.09	5	.37
T x F	6	1.81	.33	.11	5	.03
T x S	12	1.64	.83	.14	10	.03
T x V	6	2.07	.70	.07	5	.08
Error c	42	1.94	.76	.15	35	.37
Total	83				71	

various materials may have had on nitrogen content may have been lost after this length of time. There were no significant differences between treatments with any of the crops included in these tests.

There was a significant difference at the 5 per cent level between varieties of cabbage and at the 1 per cent level between varieties of sweet corn. As might be anticipated, plants grown in the pots where fertilizer was added contained more nitrate nitrogen than those grown with the addition of no fertilizer (Table X). The differences were significant at the 1 per cent point with all four crops.

In Table VIII are listed the nitrate nitrogen contents of the various crops; the effect of variety, source of seed, high and low fertility on the nitrate nitrogen content of cabbage and lettuce is shown in Table IX. The concentrations are markedly higher for all crops at the higher levels of fertility. This was to be expected since nitrogen is highly soluble and is taken up rapidly by the plant when it is available. The plants grown in the low fertility series showed definite visual symptoms of nitrogen deficiency, and these deficiencies were confirmed by the tissue tests.

As shown in Table IX there were slight variations in nitrate nitrogen content between treatments, but these differences were not statistically significant (Table X).

Soluble Phosphorus: No statistically significant differences in soluble phosphorous content were detected between pelleting treatments with any of the four crops (Table XIII). The only differences in content of phosphorus were between rates of fertilizer in the cabbage, lettuce and tomato tests and between varieties of cabbage and lettuce.

The soluble phosphorus content of the different crops for the various treatments is shown in Tables XI and XII.

TABLE VIII--The Effect of Treatment and High and Low Fertility on the Nitrate-Nitrogen Content of Above-Ground Parts of Tomato, Lettuce, Cabbage and Sweet Corn

PPM Nitrate Nitrogen 1/

Treatment	Low Fertility					High Fertility					
	Tomato	Lettuce	Cabbage	S.Corn	Average	Tomato	Lettuce	Cabbage	S.Corn	Average	Gen. Average
A	84	382	96	128	173	135	591	155	174	264	218
B	83	387	96	126	173	136	595	156	172	264	218
C	85	383	96	128	173	136	598	166	175	268	221
D	80	280	96	127	171	135	593	161	174	265	218
E	83	382	92	128	171	134	589	166	172	265	218
F	85	388	95	129	174	137	593	158	173	265	220
G	84	389	92	—	188	135	600	159	—	223	206
Average	83	384	95	123	—	135	594	164	173	—	—

1/ Average of six determinations.

TABLE IX--The Effect of Variety, Source of Seed and High and Low Fertility on the Nitrate-Nitrogen Content of Above-Ground Parts of Cabbage and Lettuce

	PPM Nitrate-Nitrogen						
Source	Low Fertility	High Fertility	Average	Low Fertility	High Fertility	Average	General Average
			Cabbage Golden Acre - Danish Ball Head				
1/	96	163	129	86	144	115	122
2/	120	187	153	81	154	117	135
3/	102	174	138	84	139	112	125
Average	106	175	___	83	145	___	___
			Lettuce Great Lakes - Black Seeded Simpson				
1/	375	604	489	379	593	486	487
2/	391	595	493	381	592	486	490
3/	398	598	498	384	584	484	491
Average	388	599	___	381	589	___	___

1/ Associated Seed Growers, Inc.

2/ Northrup-King & Co.

3/ F. H. Woodruff & Sons, Inc.

TABLE X--Analysis of Variance Summary Table for PPM Total Nitrate Nitrogen in Above-Ground Parts of Cabbage, Lettuce, Tomato and Sweet Corn

Source of Variation	DF	Cabbage Mean Square	Lettuce Mean Square	Tomato Mean Square	DF	Sweet Corn Mean Square
Fertilizer (F)	1	89637**	922953**	56784**	1	37492**
Source (S)	2	1406	87	2	2	288
Error a	2	312	817	9	2	194
Variety (V)	1	13937**	1368**	119	1	48
Error b	5	3677	165	20	5	45
Treatment (T)	6	307	124	15	5	7
T x F	6	528	36	5	5	7
T x S	12	1133	74	16	10	33
T x V	6	602	704	22	5	68
Error c	42	3749	291	53	35	48
Total	83				71	

Table XI

Soluble Phosphorous Content of Plant Extracts

Treatment	Low Fertility					High Fertility					
	PPM Soluble Phosphorous*										
	Cabbage	Lettuce	Tomato	S.Corn	Avg.	Cabbage	Lettuce	Tomato	S.Corn	Avg.	General Average
A	145	31	180	103	115.4	187	46	285	109	157.3	136.3
B	142	35	185	102	116.4	189	49	285	108	158.1	137.3
C	140	33	183	105	115.8	186	48	284	108	156.7	136.3
D	143	33	184	105	116.6	183	47	283	107	155.5	136.0
E	144	34	184	104	117.0	185	48	287	108	157.6	137.3
F	140	35	185	105	116.7	182	47	287	107	156.2	136.4
G	142	35	183	___	120.3	183	47	285	___	172.0	146.1
Avg.	142.9	34.0	183.9	104.5	___	185.4	47.8	285.6	108.3	___	___

* Average of six determinations

TABLE XII--The Effect of Variety, Source of Seed and High and Low Fertility on the Soluble Phosphorus Content of Above-Ground Parts of Cabbage, Lettuce and Sweet Corn

	PPM Soluble Phosphorus						
Source	Low Fertility	High Fertility	Average	Low Fertility	High Fertility	Average	General Average
			Cabbage Golden Acre - Danish Ball Head				
1/	159	205	182	125	177	15	166
2/	172	195	183	129	162	145	164
3/	144	205	175	127	167	147	161
Average	158	202	—	127	168	—	—
			Lettuce Great Lakes - Black Seeded Simpson				
1/	40	56	48	32	40	36	42
2/	38	61	49	28	38	33	41
3/	35	54	44	28	36	32	38
Average	38	57	—	29	38	—	—

TABLE XII (Continued)

	PPM Soluble Phosphorus						
Source	Low Fertility	High Fertility	Average	Low Fertility	High Fertility	Average	General Average
			Sweet Corn Golden Cross Bantam - Carmelcross				
1/	98	105	101	107	99	103	102
2/	117	99	108	106	102	104	106
3/	102	111	106	94	130	112	109
Average	106	105	—	102	110	—	—
General Average	101	121	—	86	106	—	—

1/ Associated Seed Growers, Inc.

2/ Northrup-King and Co.

3/ F. H. Woodruff & Sons, Inc.

TABLE XIII--Analysis of Variance Summary Table for PPM Soluble Phosphorus in Above-Ground Parts of Cabbage, Lettuce, Tomato, and Sweet Corn

Source of Variation	DF	Cabbage Mean Square	Lettuce Mean Square	Tomato Mean Square	DF	Sweet Corn Mean Square
Fertilizer (F)	1	38059**	4046**	217**	1	253
Source (S)	2	234	116	10	2	298
Error a	2	1130	32	9	2	1744
Variety (V)	1	22019**	3827**	21	1	13
Error b	5	290	119	52	5	400
Treatment (T)	6	36	12	19	5	2
T x F	6	18	5	12	5	15
T x S	12	40	24	27	10	46
T x V	6	78	3	73	5	83
Error c	42	112	13	44	35	33
Total	83				71	

Potassium Oxide: The analysis of variance summary (Table XV) for the ppm of potassium oxide shows that it was not influenced by any of the pelleting treatments in any of the crops studied. The only factors showing statistically significant differences were rates of fertilizer in the cabbage and sweet corn tests and cabbage varieties.

Table XIV gives the potassium oxide content in ppm of the four crops for all treatments. It is interesting to speculate as to why there was no statistically significant variation between rates of fertilizers with a crop like tomato which has such a high potassium requirement. Apparently the tomato is either very thrifty and was able to obtain sufficient potassium from the more infertile soil or the soil contained adequate amounts of available potassium even though no fertilizer was added to it.

D. Effect of Pelleting on the Yields of Cabbage, Lettuce, Tomato and Sweet Corn

As seen in the analysis of variance summary (Table XVIII) there were statistically significant differences at the 5 per cent point between treatments in the cabbage and sweet corn yield tests.

In the cabbage tests the yield from treatment C was significantly greater at the 5 per cent point than yields from treatments D, E, F and G (Table XVII).

In the sweet corn tests treatment C yielded significantly less than any of the other treatments.

Table XVI shows the yields of cabbage, lettuce, tomato and sweet corn as affected by variety and source of seed.

TABLE XIV--The Effect of Treatment and High and Low Fertility on the Potassium Oxide Content of Above-Ground Parts of Cabbage, Lettuce, Tomato and Sweet Corn 1/

PPM Potassium Oxide

Treatment 2/	Low Fertility					High Fertility					
	Cabbage	Lettuce	Tomato	S.Corn	Average	Cabbage	Lettuce	Tomato	S. Corn	Average	Gen. Average
A	1788	585	5121	3014	2627	2360	590	5153	3575	2919	2773
B	1729	579	5095	3030	2608	2397	594	5064	3575	2907	2758
C	1747	584	5128	3033	2623	2351	593	5130	3589	2916	2769
D	1733	584	5135	3024	2619	2375	592	5141	3583	2923	2771
E	1747	582	5139	3050	2629	2369	592	5123	3584	2917	2773
F	1730	586	5136	3055	2627	2322	592	5080	3572	2891	2759
G	1730	588	5181	—	2500	2363	590	5113	—	2688	2594
Average	1744	584	5133	3034	—	2362	592	5115	3579	—	—

1/ Average of six determinations
2/ See Table I for treatment materials

TABLE XV--Analysis of Variance Summary Table for PPM Potassium Oxide in Above-Ground Parts of Cabbage, Lettuce, Tomato and Sweet Corn

Source of Variation	DF	Cabbage Mean Square	Lettuce Mean Square	Tomato Mean Square	DF	Sweet Corn Mean Square
Fertilizer (F)	1	8,035,242**	1304	236	1	5,293,715**
Source (S)	2	5931	597	16051	2	9,016
Error a	2	14,645	356	35016	2	14,445
Variety (V)	1	2,574,600**	15	332	1	35,867
Error b	5	173,333	87	21020	5	35,401
Treatment (T)	6	2,736	11	13,308	5	467
T x F	6	3,154	56	9,346	5	726
T x S	12	5,993	168	20,441	10	1,059
T x V	6	7,652	130	30,213	5	11,263*
Error c	42	14,202	225	31,007	35	4,018
Total	83				71	

TABLE XVI--The Yields of Cabbage, Lettuce, Tomato and Sweet Corn as Affected by Variety and Source of Seed 1/

Source	Yield	Yield	Average
	Cabbage		
	Golden Acre -	Danish Ball Head	
2/	39	21	30
3/	40	22	31
4/	35	20	28
Average	38	21	—
	Lettuce		
	Great Lakes -	Black Seeded Simpson	
2/	19	18	18
3/	14	15	15
4/	13	13	13
Average	15	15	—
	Tomato		
	Stokesdale -	John Baer	
2/	16	13	15
3/	15	13	14
4/	18	15	16
Average	16	13	—
	Sweet Corn		
	Golden Cross Bantam -	Carmelcross	
2/	16	14	15
3/	15	15	15
4/	12	11	11
Average	14	13	—
General Average	21	16	—

1/ Yield in Pounds from two row plots 25 feet long for sweet corn and cabbage and from two row plots 20 feet long for lettuce and tomato.
2/ Associated Seed Growers, Inc.
3/ F. H. Woodruff and Sons, Inc.
4/ Northrup-King and Co.

TABLE XVII--Total Yields of Cabbage and Sweet Corn as Affected by Treatment

Treatment	Yield in Pounds	
	Cabbage	Sweet Corn
A	367.3	176.9
B	361.2	177.0
C	405.4	136.3
D	345.4	180.8
E	337.3	171.3
F	353.7	174.6
G	347.4	———
LSD at .05	52.32	31.56

TABLE XVIII--Analysis of Variance Summary Table for Yields of Cabbage, Lettuce, Tomato and Sweet Corn

Source of Variation	DF	Cabbage Mean Square	Lettuce Mean Square	Tomato Mean Square	DF	Sweet Corn Mean Square
Replication(R)	1	23	451	38	1	2
Source (S)	2	81	198	48	2	103
Error a	2	306	159	25	2	42
Variety (V)	1	6315**	3	163	1	20
Error b	5	89	17	3	5	15
Treatment (T)	6	49*	20	4	5	23*
T x R	6	46	19	4	5	8
T x S	12	20	26	3	10	11
T x V	6	39	19	1	5	10
Error c	42	21	12	4	35	8
Total	83				71	

DISCUSSION

Pelleting and the incorporation of slightly soluble fertilizers and other growth stimulants in the pellet had no effect on germination. This is not in agreement with the results reported by McGuffey (18) who found that pelleting reduced germination by 15 per cent. However, the seed with which he worked was coated with a material composed of 65 per cent feldspar and 35 per cent fly ash which forms a very hard coat that does not deteriorate rapidly when immersed in water. In the tests reported herein the seeds were coated with a material consisting of 70 per cent minco clay and 30 per cent cellite. This coating material formed a very hard coat but one that deteriorated almost instantaneously when immersed in water. The difference in coating materials probably accounts for the differences in results. Probably with a fly ash-feldspar coating, germination was reduced because the pellet did not receive enough moisture to cause it to deteriorate and allow the germinating seedling to emerge.

Evidently the incorporation of growth stimulants and fertilizers had no effect on germination since non-pelleted seed germinated as well as the pelleted seed.

Germination of the cabbage seed was reduced from 84.5 per cent for the non-pelleted seed to from 81.5 per cent to 79.0 per cent for the pelleted seeds. Though the non-pelleted seeds germinated consistently better than the pelleted seeds the differences were of no practical or statistial significance.

The fact that pelleting in these tests had no detrimental effect on germination is of considerable significance. The benefit to be derived.

from pelleting, if germination is not impaired, lies in the possibility of precision planting of small seeded vegetable crops and has already been pointed out (9, 18). The results of this test indicate that cabbage, lettuce, tomato, and sweet corn seeds can be coated with a 70 per cent minco clay and 30 per cent cellite mixture without a subsequent reduction in germination.

The failure to obtain stimulation of germination by addition of fertilizers and growth stimulants probably lies in the fact that most seeds have an abundant supply of all the substances that are necessary for germination. It is conceivable that with seeds produced under conditions of inadequate nutrient supply some stimulation could be obtained by methods such as were used in these tests.

These data are not in agreement with those of McGuffey (18) in which germination of cucumber, melon, sweet corn, and tomato seeds was greatly benefitted by incorporation of various materials in the pelleted seed. The apparent conflict in these data may be due to the fact that different materials were incorporated in the seed. He makes no statement as to what materials were used other than "various fungicides, fertilizers, and plant stimulants were used." The concentrations of the materials may have been varied in such a manner as to account for the differences. It is also logical to assume that seed from different sources may react differently to pelleting and also to the different materials incorporated in the pellet. If this is found to be the case then considerable work will have to be done in order to determine what effect the different materials will have on different seeds and seeds from different sources.

The fact that seedling development as measured by fresh weight of tops of plants grown both from pelleted and non-pelleted seed showed no significant differences indicates that the various materials incorporated in the pellet had no effect on seedling development. The absence of stimulation in seedling development probably resulted from the fact that there was either already present in the soil an adequate supply of nutrients for normal development or the amount incorporated in the pellets was insufficient to increase the rate of seedling development. This possibility should be examined further since in these tests the quantity of materials used was not sufficient to be toxic. Possibly a much higher concentration of these materials could be used without having a detrimental effect on germination and result in a stimulating effect on growth.

It may also be suggested that possibly under other more adverse conditions some of the pelleting treatments used in these tests might have been of value in seed germination and subsequent seedling development.

Tissue tests run on the four crops to determine the nutrient content of the tops showed that the incorporation of the various materials in the pellet brought about no increase in the concentration of nitrate nitrogen, soluble phosphorus, or potassium. A possible explanation for this is that the time elapse between seeding and date of sampling was so great that the effect on nutrient content was lost. In order to detect any differences in nutrient content resulting from the incorporation of the various materials in the pellet it might be necessary to make the tissue tests within a few days after the seedlings have emerged.

Although, the yields from the pelleted seed were in some cases better than those from non-pelleted seed none of the differences were of any statistical significance. Treatment C in the cabbage yield tests was greater at the 5 per cent level than treatments D, E, F and G. This indicates that the addition of the Ca salt of keto succinic acid, dried blood, CuO combination was beneficial in increasing the yield of cabbage over some of the other treatments with pelleted seed. When superphosphate and iron chlorophyll were incorporated with keto succinic acid, dried blood and CuO then the yield was significantly reduced below that of treatment C. This leads to the assumption that these materials were antagonistic to the beneficial effects of the materials included in treatment C. This antagonisn was probably due to the effect that posphorus has on the absorption of nitrogen.

The low yield obtained from treatment C in the sweet corn tests could have been due to the absence of any fungicide in the pellet.

In some cases the pelleted seeds outyielded the non-pelleted seeds, but the differences in yield never reached a significant level.

In order to increase yield by pelleting the materials incorporated would have to be of sufficient quantity to stimulate development of the seedling and give it a good start. Apparently the necessary concentrations were not achieved under the conditions of these experiments, or the chemicals were not suitable.

The results of these tests are in agreement with those of Burgesser (8) in which no stimulation of seedling development was obtained by the incorporation of fertilizers and various growth stimulants in pelleted seed.

It is highly significant, however, that no injury from pelleting or the incorporation of various chemicals was detected in these tests. This is in contrast to results obtained by other workers (9, 18), and may be in part explained by the very small batches of seed used, differences in the inert coating materials used, and generally careful handling. It should be pointed out that germination tests were run under controlled greenhouse conditions which were generally ideal for seed germination. Under more adverse conditions a larger variation in germination might be expected, and also, stimulation of seedling development as a result of the incorporation of certain of the growth stimulants in the pellet might be obtained. Data supporting these hypotheses have been reported though they are somewhat inconclusive.

The fact that no injury to germination or seedling development was observed as a result of the incorporating of various fertilizers and growth stimulants indicates the need for conducting further experiments with the incorporation of higher concentration of the materials in the pellet.

CONCLUSIONS

The pelleting of seeds of two varieties each of sweet corn, cabbage, lettuce and tomato did not affect germination in most cases. Germination of pelleted cabbage seed was reduced below that of non-pelleted seed, but the difference was not statistically significant. The incorporation of the various fertilizers and growth stimulants was not effective in stimulating germination and seedling development or increasing nitrate nitrogen, soluble phosphorus and potassium oxide in the plants under the conditions of these experiments.

The fact that pelleting had no effect on germination is of significance. Pelleting should be of considerable value to vegetable growers in that it will allow for precision planting of small seeded crops thereby reducing the amount of seed used and it will eliminate expensive hadd thinning. On the basis of this work it would appear to be an economically sound practice from the standpoint of precision planting.

On the basis of these experiments the following conclusions can be made regarding the effects of pelleting and the incorporation of various chemicals in pelleted seed on plant growth:

1. Pelleting had no detrimental effect on germination, but germination was not stimulated by the incorporation of the various chemicals in the pelleted seed.

2. Incorporation of chemicals had neither a beneficial nor an adverse effect on seedling development indicating that higher concentrations of the materials might possibly be used to advantage.

3. Incorporation of chemicals did not increase the content of nitrate nitrogen, soluble phosphorus, or potassium oxide.

4. Neither pelleting nor the incorporation of the chemicals had any effect on earliness.

5. Yield was not affected by pelleting or the incorporation of the various materials at the rates employed in these tests. Some of the treatments with pelleted seed were better than others, but none were better than the non-pelleted treatments.

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