EFFECT OF CHEMICAL SEED PIECE TREATMENT AND PLANTING DATE UPON EMERGENCE, YIELD AND QUALITY OF FOUR CULTIVARS OF IRISH POTATO (*Solanum tuberosum* L.)

by

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CHAPTER I

INTRODUCTION

In Kansas, as in many other states, local production of Irish potatoes, Solanum tuberosum (L.), is insufficient to provide adequate supplies for either local processing or fresh market sales throughout the year. These states, generally, rely on the purchase and shipment of potatoes from out-of-state production areas for the bulk of their needs while local supplies provide only a seasonal supplement. With an economy beset with such problems as inflation and energy crises, local markets as well as growers in the major producing areas of the country are experiencing difficulty controlling costs. Demand for potatoes has remained strong, however; and, according to the American Potato Handbook (1,2), in 1974 the use of processing potatoes in key processing states increased 14% over 1973. Additionally, per capita consumption of fresh potatoes was projected to remain firm due in part to rapidly rising prices of competing products such as macaroni, rice, and dry beans. With reported prices of $8 to $9.25 per cwt, F.O.B., for fresh market potatoes in some of the major potato producing areas and projected fourth quarter 1974 prices of $3 to $3.60 per cwt for processing potatoes, growers experienced one of the highest seasons on record for prices.

With the increased market value of potatoes, along with rapidly rising fuel and transportation costs for long distance shipping of large volume produce, local markets are confronted with increased prices for potatoes. These combined factors provide the local grower with a newfound competitive advantage over the major producing areas and should encourage potato production. With a long growing season, a sizable chipping industry, and established production areas in the state, the potential for such increases in Kansas is excellent.

In the Kansas and Arkansas River Valleys, potatoes for a mid-summer crop are usually planted by April 1 and harvested during July. With a potential growing season extending into October, the opportunity for a fall crop exists. However, due to air and soil temperatures which usually exceed 38C (100F) during July, fall production has been limited due to marginal stands. Under high temperature conditions, Cordner (16) has shown that a high rate of respiration within the tubers creates a lack of oxygen. He concluded that this condition is a physiological disorder that causes seed piece breakdown and results in reduced or weakened stands. According to Shadbolt et al. (76), total loss is also possible since complete breakdown of the seed piece may occur within 48 to 72 hours after planting.

Extensive research has been conducted on potato seed piece treatments; however, none has been done under Kansas conditions since Elmer's research (24) during the period 1935-1940 dealing with various mercury and copper compounds, formaldehyde, lime, gypsum, and sulfur. Additionally, limited research has been conducted relating chemical treatment to soil temperature, or determining cultivar interactions with chemical treatment and soil temperature. Therefore, this study was initiated to determine i) the effect of chemical seed piece treatment upon the yield and quality of several potato cultivars, and

ii) the effect of chemical treatment at various soil temperatures on the yield and growth response of potato cultivars. Based upon these objectives, evaluations of the following factors were made:

1. The effect of chemical seed piece treatment upon emergence, growth response and yield;

2. The effect of soil temperature on emergence, growth response and yield;

3. Cultivar responses to chemical seed piece treatments;

4. The effect of chemical seed piece treatment upon specific gravity of potato tubers;

5. The effect of chemical seed piece treatment upon common scab infection of potato tubers.

CHAPTER II

LITERATURE REVIEW

Effect of Seed Piece Treatment on Emergence, Growth Response and Yield

As summarized by Sanford (74), whole potato tubers have been disinfected before being cut for seed pieces in order to kill such superficial pathogens as *Actinomyces scabies* (Thaxter) Gussow, *Rhizoctonia solani* Kuhn, and certain *Fusarium* species. However, this treatment provides the cut surfaces of the seed pieces with no direct protection against common soil-borne pathogens such as *Erwinia carotovora* (Jones) Holland, *Fusarium coeruleum* (Lib.) Sacc., and *Pythium ultimum* Trow. These pathogens occur in cultivated soils and are responsible for seed piece rots that occur in storage prior to planting or develop rapidly in the soil under certain temperature and moisture conditions.

While *E. carotovora* and *F. coeruleum* appear to be more important sources of rotting in freshly cut potato seed pieces, Jones (37) states that *P. ultimum* caused extensive rotting of seed pieces in certain heavy soils in British Columbia. He recommended 48 hours storage in a humid atmosphere as adequate treatment to allow a callus to form on the cut surface and reduce infection.

As early as 1919, Shapovalov and Edison (77) reported that lowered temperatures and high humidity in storage or adequate moisture levels in the soil were essential to promote callus formation on the cut surfaces. They found that infection by decay producing organisms could occur so rapidly that callus formation was checked completely causing complete decay or development of a weak shoot.

According to Priestly and Woofenden (69), the formation of suberin begins to form on the cut surface of a potato tuber immediately. In the presence of adequate oxygen and a moist atmosphere, this layer can form within 24 to 48 hours. Within a few days, wound periderm (cork) is formed below the suberin deposit as a result of cell division in the cork phellogen. At low temperatures, the formation of suberin and wound periderm developed more slowly. Additionally, they found that certain cultivars healed more slowly than others.

Weiss et al. (85) concluded that, at 61F, suberization required 3 days to heal sufficiently to resist penetration by *F. coeruleum* effectively. They also indicated that fungal infection during this period could arrest the natural healing process.

Sanford (75) reported that any physical, chemical or biological factor that could speed up the formation of a continuous suberized layer would be beneficial to the exclusion of fungal parasites as well as the subsequent development of wound periderm layers. His research was directed toward finding an "ideal" chemical for treating freshly cut potato sets to effectively protect against parasitic fungi and bacteria while in storage or in the soil, and also encourage the natural healing process. He determined that healing of cut seed pieces is rapid and provides effective protection against infection at 78F; but at 61F or lower (a temperature common at planting time for an early crop), healing is too slow and requires the use of a chemical treatment. Spergon and calcium hydrate accelerated suberization and Spergon provided effective protection against *F. coeruleum*. Response to other chemicals was varied. He noted that the differential effect of chemicals was most evident during early suberization and became indefinite after 15 days.

Newton and Lines (65) agree with Jones (37) in identifying *P. ultimum* as a source of seed piece rot in heavy soils. Their research examined various materials commonly used as dusts for treating seed pieces. Results varied; but Fermate, and to a lesser degree Spergon and Arasan, prevented *Pythium* rot on early plantings of potatoes. They noted that Semesan Bel, while not effective against *Pythium* rot, appeared to stimulate growth.

Newton (64) later reported that Arasan and Fermate as well as Spergon were effective in preventing seed piece decay. He concluded that they interfere less with natural healing processes than fungicides containing copper or mercury, which were frequently phytotoxic and increased the number of seed pieces that rotted through attack by *Fusarium* spp.

Bonde (4,5,6) and Bonde and DeSouza (7) in a series of studies conducted in Maine showed that treating freshly cut seed potatoes with streptomycin or Agrimycin solution reduced bacterial seed piece decay and the incidence of blackleg disease caused by *Erwinia atroseptica*. They also reported improved emergence, yield, color, size, and vigor of plants. However, Bonde and Malcolmson (9) later demonstrated that streptomycin and Agrimycin treatments, while controlling decay caused by bacteria, increased infection from species of *Fusarium* and other fungi. This difference was attributed to suppression of bacteria which would normally inhibit fungal growth. Also, Waggoner (82) examined a wide range of fungicides in vitro and concluded that i) fungicides had no effect upon the bacterial activity of streptomycin; ii) streptomycin did not increase the growth of Fusarium but did increase the susceptibility of cut potato slices to the fungus; and iii) various fungicides, including captan and dichlone, were capable of reducing the growth of fungus in the presence or absence of streptomycin.

Fink et al. (27) evaluated several fungicides, streptomycin formulations, and combinations of the two in field trials. They noted a trend toward increased stands with chemical treatments with some instances of more rapid and vigorous vine growth than the untreated controls. In several cases, increased yields occurred with chemical treatments when stands had not been increased.

Palm and Young (67) noted incompatibility between certain fungicide-streptomycin combinations. At times, a mixture of two compounds was significantly less fungicidal than the fungicide used alone. However, none of the mixtures tested exhibited phytotoxicity to the cut seed pieces. Continued work by Bonde and Hyland (8) determined that, while Agrimycin solutions reduced the amount of bacterial seed piece decay, the rate and extent of wound periderm formation was affected. They concluded that the reduction in suberization and periderm formation was a factor in increased susceptibility of seed pieces to fungal invasion and decay. Combinations of Agrimycin and captan did not eliminate the effect on wound periderm formation and actually increased susceptibility to decay by Fusarium spp.

During the latter 1940's through the 1970's, researchers have experienced variation with seed piece treatments under varying environmental conditions. As demonstrated by Lane (41) seed piece treatments were ineffective in improving stands under favorable growing conditions. These conditions, he indicated, permitted the untreated seed to produce relatively vigorous plants even though attacked by decay organisms. Yet, he reported that under adverse conditions thiram and zineb reduced rot, improved stands, and increased yields significantly when compared to untreated seed pieces.

Gould and Randall (31) concluded that neither tuber disinfection nor seed piece treatment was a factor in stand or yield in field trials in western Washington. They felt that environmental factors encountered during the period from planting to emergence accounted for most differences exhibited in their research. Similar work was reported by Nickel (66) when evaluating several treatments under high soil temperatures in California. Results were varied but he noted a favorable trend toward treatments of Zerlate and Dithane Z-78. He also noted that a strong disinfectant, such as acidulated mercuric chloride, could be used for the spring crop without adverse effects but was too severe under soil temperature conditions for a fall planting.

Fink (28), Line and Eide (50), and Duncan and Gallegly (20) have reported that under favorable soil temperature and moisture conditions, chemical treatment of seed pieces appears to offer no advantage over untreated seed pieces if planting occurs immediately after cutting. Line and Eide as well as Duncan and Gallegly agree that chemical treatments may be beneficial if cut seed pieces are to be stored before planting.

Various methods and effects of inoculation of seed pieces with disease pathogens have been examined. Lutz (54) reported that most

Fusarium-caused dry rots started at injuries made during harvesting and storage. Various treatments applied to tubers as they were stored had no effect in reducing storage rots. Ayers and Robinson (3) concluded that control of dry rot in storage could be obtained by seed piece treatment at planting time. They felt that the fungicide destroyed seed-borne inoculum that would otherwise develop in the soil and infect the new tubers through wounds. Using captan dust and combination dips of captan-Agrimycin and zineb-Agrimycin, Line and Eide (51) indicated that the treatments were more effective against organisms naturally present on the tubers than those applied as inoculum. They concluded that decay producing organisms are present on most tubers making artificial inoculation unnecessary. Fisher (29) related the severity of seed piece decay to tuber temperature at cutting time and subsequent storage temperature. Tubers warmed to 65F prior to cutting showed less decay than tubers cut at 38F; but regardless of tuber temperature, 7.5% captan dust reduced decay.

In studies with fungicide-Agristrep combinations, Robinson *et al.* (72) reported that Semesan Bel-Agristrep was more effective than captan-Agristrep in controlling blackleg, dry rot and *Verticillium* wilt in potatoes. Occasional phytotoxicity was noted with Semesan Bel but there was no adverse effect upon stand.

In field trials and laboratory tests, Fink (28) found that fungicide-streptomycin combinations offered no advantage over fungicides used alone in improving stands. He noted that some mixtures resulted in significantly lower stands than fungicides used alone although when dieldrin was added to the mixture, the tendency for reduced stands was reversed. He concluded that while no correlation existed between the results of field and laboratory testing of seed piece treatments, fungicide-streptomycin mixtures might result in lower stands and yields than no treatment at all.

Wade (81) noted severe seed piece breakdown in field tests with streptomycin dip and dust treatments; however, addition of captan to the treatment reduced breakdown. In storage tests of treated seed pieces the most consistent performance occurred with captan, thiram and maneb. Polyram and captan provided similar results in preventing decay due to *Fusarium* spp. while Mercury dips, Semesan Bel and Morsodren were effective in reducing *Rhizoctonia* infection.

Murphy (62) indicated that Fusarex treatment of seed potatoes delayed emergence but final stands and yields were not affected.

Easton *et al*. (22) reported that yield was not affected by seed piece treatment or date of planting although captan, captan-dimethyl sulfoxide mixtures, and Polyram treatments significantly reduced seed piece decay in one of two plantings.

Cole *et al*. (15) conducted a series of field trials on soil and seed piece treatments on Kennebec and Katahdin varieties in Pennsylvania. They observed no significant differences between varieties and treatments except for a detrimental effect from benomyl and thiabendazole. They noted a difference in cultivar response to benomyl although the overall rating for benomyl was lower than any other seed piece treatment. However, in a comparison between Maine and North Carolina locations, Leach and Nielsen (47) reported that thiabendazole and benomyl effectively controlled *Fusarium* contamination of seed pieces. They noted no adverse effects and concluded that all fungicide treatments increased yields at both locations.

Mizicko et al. (59) determined that dihydroquercetin (DHQ) and combinations of DHQ-captan produced no significant difference in plant emergence, plant vigor or yield in a series of field trials.

Effect of Temperature on Response to Seed Piece Treatment

Following Shapovalov and Edison's (77) early work on wound cork formation in relation to seed piece decay, Vincent and Pawson (80) studied the effect of soil temperatures at planting upon seed pieces. They found a greater incidence of seed piece decay at high soil temperature than at lower temperatures. However, this effect was influenced by the condition of the cut seed piece. Freshly cut as well as suberized seed pieces from shriveled tubers gave equal response at low soil temperatures while freshly cut seed pieces gave unsatisfactory germination at high temperatures. They concluded that, with shriveled sets, suberization was an aid in preventing decay in late plantings after the soil had become warm. With firm unsprouted tubers, they found freshly cut and suberized sets to be equal if suberization of the cut sets had been conducted in a humid atmosphere. They noted that poor stands in early plantings may be due, not to low soil temperature, but in part to wet soil from which air is excluded.

Kraus and Woodbury (39) concluded that germination and stands at different soil temperatures were directly related to the temperature and humidity during cutting and suberization. They found that seed pieces exposed to temperatures above 70F and low humidity during or immediately after cutting decayed more and resulted in poorer stands and yields than those held at temperatures between 50 and 60F and high relative humidity (above 60%). In their research, chemical treatments applied as solutions had no beneficial effect.

The respiration of tubers at high temperatures was studied by Ward (83). He found that tubers treated with ethylene chlorhydrin respired at a high rate at temperatures of 90 to 95F. This rate was sustained over a period of about 12 days until the tubers were completely broken down. Under Oklahoma planting conditions for a fall crop, Cordner (16) noted the effect of ethylene chlorhydrin upon tubers at high soil temperatures. However, at cool soil temperatures in the spring, he noted that the ethylene chlorhydrin treatment hastened sprouting and improved plant stands. He suggested that seed piece breakdown at high soil temperature originates as a physiological disorder and not as a pathological decay. High respiration rates, along with oxygen deficiency in the tuber tissue, caused a situation similar to blackheart. He suggested that soil conditions at planting time were of great importance and recommended taking advantage of conditions such as rainy weather, irrigation and straw mulch which moderated high soil temperatures.

Various researchers have examined the relationship of soil moisture and irrigation to yield and quality of potatoes. Clark (14) and Cykler (17) concluded that the number of tubers set per plant was independent of moisture content of the soil but tuber weight and consequently total yield were directly related to the amount and frequency of irrigation during the period of tuber development. Edmundson (23) reported significant yield increases with irrigation. Since potatoes are a shallow rooted crop, he found frequent applications of 2 to 4 inches preferable to less frequent applications of 4 to 5 inches.

The conclusions of Struchtemeyer (79) and de Lis et al. (19) established a critical relationship between the life cycle, water requirements and yield of the potato. Their conclusions are supported by several authors. Bradley and Pratt (10,11) reported that high moisture levels resulted in better top growth, earlier tuber set, and greater weight of tubers; while Fulton and Findlay (30) reported increased yield with irrigation if adequate nutrients were available. Prince and Blood (70) reported an increase in yield of U.S. No. 1 size tubers with irrigation but noted reduced yield at high application rates. Additionally, Robins and Domingo (71) found reduced total yield and U.S. No. 1 yield under moisture stress. They noted an increased incidence of spindle tuber when the stress occurred early- to mid-season.

A significant aspect not dealt with in the above research is the relationship between soil moisture and temperature. In Alabama, Ware (84) noted that irrigation in the fall may be of greater value than irrigation in the spring since rainfall is usually low and temperatures are higher. In California Lorenz (53) reported that in April the average soil temperature at a 6 inch depth was higher than the air temperature; however, in June the air temperatures were above the soil temperature. He established diurnal soil temperature fluctuations of 20, 15, and 8F at the 3, 6, and 9 inch soil depths respectively. He reported that foliar shaded soil was 8 to 10F cooler than bare soil and that irrigated soil was 4F cooler than non-irrigated soil. Kushman et al. (40) found that in southern Alabama soil temperatures averaged 3F warmer in dry plots than in wet plots.

Yamaguchi et al. (86) determined that optimum soil temperature for tuber formation was between 60 and 75F. Potatoes grown in soil temperatures below 60F and above 75F gave lower yield, specific gravity, and starch content. Optimum air temperatures for tuber formation were reported by Kehr *et al.* (38) to be about 60 to 65F. At temperatures of 68 to 85F, tuber development was markedly reduced and above 85F tubers were poorly developed. They reported optimum temperature for photosynthesis was about 68F and at temperatures above the optimum a greater proportion of photosynthate was used in respiration and there was less accumulation. They concluded that mean air temperatures greater than 70F reduced yields and indicated that cultivars differed in tolerance to high temperatures.

Epstein (25) concluded that tuber yield was greatest at 70F, specific gravity greatest at 60F, and the number of tubers greatest at 48F in a study including soil temperatures of 48, 60, 72, and 84F. He felt that by keeping field soil cool during tuber initiation more tubers could be produced. At 84F he found a greater incidence of irregularly shaped tubers.

Motes and Greig (60) in a series of field studies reported that high air temperature, combined with low precipitation, increased irrigation requirements. Under these conditions, they concluded that irrigation both increased yields and lowered soil temperatures. They suggested that both specific gravity and yield were inversely related to temperature.

Effect of Seed Piece Treatment on Specific Gravity

In the past, research has primarily related specific gravity to environmental factors. Smith and Nash (78) pointed out that mature tubers were higher in specific gravity and that lower temperatures during the latter part of the growing season produced tubers of higher specific gravity. However, LeClerg (48) noted that soil and climatic conditions did not materially influence the relationship between specific gravity and dry matter content of potato tubers. He reported that significant interaction existed between varieties and environmental conditions over a period of years in a study of dry matter content (49).

Jacob et al. (34) indicated that irrigation would possibly increase tuber specific gravity. Working in Maine, Murphy and Govens (63) reported that conditions including a long growing season, with long days for plant growth followed by short days for tuber development, and temperatures less than 70F increased specific gravity. Dunton (21) recorded increased specific gravity only during one out of 10 years of irrigation research on potatoes. He noted that high potassium fertilization reduced specific gravity and concluded that season of the year seemed to be the most important factor influencing specific gravity.

Murphy et al. (61) determined that the influence of foliar fungicides on specific gravity was caused by increased maturity of plants through protection from defoliation diseases. Manzer et al. (55) did not eliminate the possibility that foliar fungicides might promote higher yields or specific gravity through a nutritive or regulatory effect; however, they found these factors to be strongly influenced by the extent of defoliation. Under conditions unfavorable for development of late blight, they found no significant difference between treated and untreated plants with respect to yield or specific gravity. They noted phytotoxic effects from some experimental fungicides were reflected in lower yields and specific gravity.

Effect of Seed Piece Treatment on Common Scab

Irregular results with seed piece treatment research were reported by McKinney *et al*. (57). They concluded that soil temperature played an important part in the development of scab infection and that other soil factors probably influenced the interaction.

Fellows (26) related potato scab development to tuber growth. He determined that the apical end of the tuber was the region of greatest growth activity. Stomata were present in the newly formed epidermis of the tuber as it expanded. As the tuber matured, the stomata were transformed into lenticels and the epidermis developed several cork layers followed by suberization. He determined that if scab was to occur, infection had to take place through stomata or young unsuberized lenticels. In mature tubers or in tubers that had stopped active growth, suberization and development of cork layers prevented infection.

Sanford (73) questioned the necessity of treating seed potatoes for control of scab. Since *Actinomyces scabies*, the causal organism for scab, was found on virgin soil in Canada, he felt that the amount of inoculum added on contaminated seed might not be important in the increase of natural soil infestation.

Scab resistance in potato cultivars, as reported by Johnson and Schaal (35), is related to the concentration of chlorogenic acid present in the potato epidermis. They found that chlorogenic acid creates an unfavorable medium for the scab organism by lowering the pH of the cell and increases the production of suberized tissue on freshly cut tubers.

Hoyman (33) stated that soil conditions, weather, and cultivar susceptibility were the most important factors in determining the incidence of scab infection. He noted the scope of research with fungicides and antibiotics but reported that seed piece treatment would not control scab. However, Houghland and Cash (32) and Cetas (12) have reported some success with chemical control of scab on upland soil; and Davis et al. (18) reported significant reduction of scab on highly buffered calcareous soil with chemical treatments of Terraclor, Terraclor Super-X, sulfur and gypsum. However, they concluded that no treatment provided commercial control.

A great deal of research relates scab control to soil moisture conditions. Lapwood (42), McKee (56), and Lapwood and Lewis (45) determined that scab infection is directly related to the timing and length of low soil moisture conditions. Lapwood and Hering (43,44) reported wet soil prevented scab infection; but, to be most effective, it must occur during the first month of tuber development. They concluded that as long as the apex of the tuber is growing, infection can occur although late infection reduces the extent of blemishing.

CHAPTER III

MATERIALS AND METHODS

In 1974, a factorial experiment with four potato cultivars, five seed piece treatments, and three planting dates was conducted at the Horticulture Farm, Manhattan, Kansas. Certified seed stock of LaRouge, Norchip, Superior and Viking cultivars was purchased in February 1974 and stored at 34F (1.1C) until the seed pieces were cut. Treatments consisted of: i) an untreated control; ii) Benlate 50WP; iii) Bravo W-75; iv) Orthocide 50WP (captan); and v) Polyram 80WP. See Appendix I. All fungicide treatments were mixed with talc to achieve a concentration of 7.5% active ingredient (A.I.). Sufficient materials were mixed prior to the first planting to treat all subsequent plantings.

Tubers were cut into 2 ounce (57 g) seed pieces on March 29, May 6, and July 1. While wet from cutting, the seed pieces were mixed with the fungicide treatments in a polyethylene bag at a rate of 1 lb. dust/100 lbs. seed pieces (.45 kg/45.4 kg). When thoroughly covered with the dust, seed pieces for each replication were placed in open paper bags and stored at room temperatures of 60 to 75F (15.6 to 23.9C) and 30 to 40% relative humidity for a period of about 72 hours.

Three planting dates (April 1, May 10, July 3) were used employing a randomized complete block design with four replications per treatment for each date. Twenty-two seed pieces were planted 12 inches

(31 cm) apart in rows 3 feet (0.9 m) apart and covered to a depth of 4 to 6 inches (10 to 15 cm).

Prior to planting, each field was treated with chlordane at 4 lbs/acre (4.5 kg/ha). Normal cultivation practices were followed to control weeds and prepare the seed bed. The plots for the May 10 and July 3 plantings were treated with Eptam at 0.5 gallon/acre (4.6 l/ha) prior to the May 10 planting date. Following emergence of the plants in the April 1 and May 10 plantings, a combination of hand and tractor cultivation was used as required to control weeds. At weekly intervals from emergence until harvest, foliar sprays of insecticide-fungicide combinations (including Thiodan or Sevin and Bravo, Manzate or copper sulfate) were applied. The April 1 and May 10 plantings were furrow irrigated on June 4, 20, July 2; and June 20, July 2, respectively, until irrigation was lost due to equipment failure. The April 1 planting received sidedressings of urea (45% N) on May 6 (110 lb/acre; 124 kg/ha) and May 24 (140 lb/acre; 157 kg/ha). The May 10 planting received one sidedressing of 18-46-0 fertilizer on May 24 (396 lb/acre; 443 kg/ha). Due to the loss of irrigation on July 3 and the resulting poor stand, the July 3 planting received no cultivation, fertilization, insect or disease control.

Visual observations were made at 30 and 60 days after each planting date to determine early emergence and stand count, respectively, and to evaluate plant uniformity and vigor. The April 1 and May 10 plantings were harvested on August 2 and August 21, respectively. All tubers were collected and graded by U.S. Grades and Standards for potatoes. Total yield, weight of U.S. No. 1 grade tubers, and the weight of a 25 tuber sample of U.S. No. 1 grade tubers was determined.

Six U.S. No. 1 grade tubers were washed and air dried to determine specific gravity using the weight-in-air/weight-in-water method. After the above data were collected, the U.S. No. 1 grade tubers for each variety were combined by treatment and random 10 tuber samples were evaluated for the presence of scab.

Soil temperature was monitored at the field from April 1 until August 31 with thermograph probes placed at 2 and 4 inches (5.1 and 10.2 cm) below the soil surface (Figures 1, 2, and Appendix II). The area was kept weed free so that soil temperatures without foliar shading were recorded. Air temperature and precipitation data (Figure 1) were collected by the Physics Department, Kansas State University.

All data were subjected to an analysis of variance. Duncan's Multiple Range Test (.05) was performed on the visual ratings, stand counts and scab evaluation data. Due to missing data on yield and specific gravity, significance was determined by computation of LSD (.05) from the mean and standard error.

EXPLANATION OF PLATE I.

Figure 1. Precipitation, mean air temperature and mean soil temperature at a 2-inch (5.1 cm) depth, Summer 1974, Manhattan, Kansas.

Figure 2. Mean soil temperatures at 2-inch (5.1 cm) and 4-inch (10.2 cm) depths, Summer 1974, Manhattan, Kansas.

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Figure 1. Precipitation, mean air temperature and soil temperature at a 2-inch (5.1 cm) depth, Summer, 1974, Manhattan, Kansas.

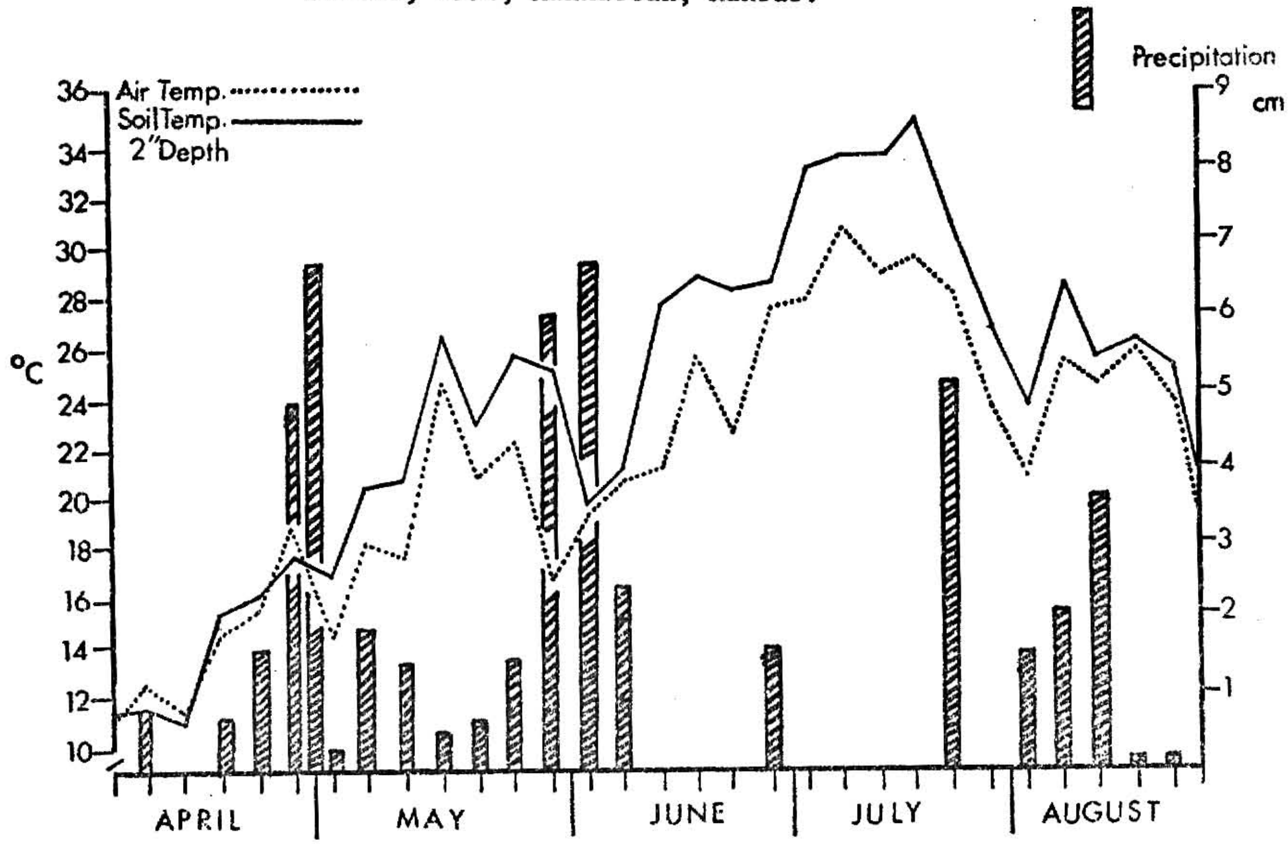
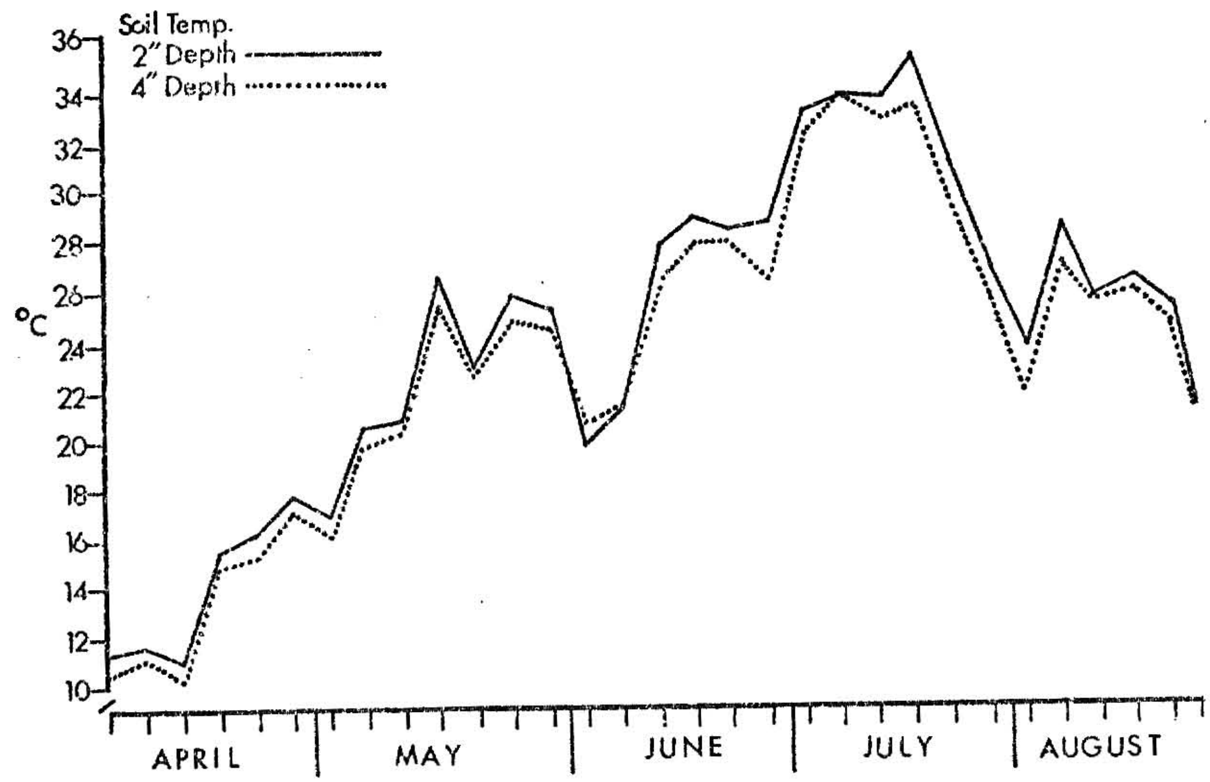


Figure 2. Mean soil temperatures at 2-inch (5.1 cm) and 4-inch (10.2 cm) depths, Summer, 1974, Manhattan, Kansas.



CHAPTER IV

EXPERIMENTAL RESULTS

Characteristics of potato cultivars studied in this experiment, as affected by seed piece treatment and planting date, were: early emergence, stand count, total yield, weight of U.S. No. 1 grade tubers, weight of 25 tubers, plant uniformity and vigor. Other factors recorded include the effect of chemical seed piece treatment upon i) specific gravity and ii) common scab infection. Tables 1, 2, and 3 are arranged to allow statistical comparisons between treatments and planting dates regardless of cultivars whereas the remaining tables compare treatments among cultivars for each planting date.

Effect of Seed Piece Treatment on Emergence, Growth Response and Yield

April 1 planting date. Composite data on early emergence, stand count and yield are shown in Table 1. An important result which showed up in a comparison of treatments was that Benlate dust (7.5% A.I.) produced a significantly higher early emergence of plants. None of the treatments resulted in a significant increase in eventual stand count or influenced plant vigor or uniformity (Table 2). Total yield from both Benlate and captan treatments was significantly better than the untreated control, although only Benlate significantly increased the yield of U.S. No. 1 grade tubers. Bravo and Polyram treatments tended to reduce early emergence although neither significantly affected

Table 1. Effect of several fungicide seed piece treatments on emergence, stand count and yield of Irish potatoes planted at three planting dates, Summer 1974, Manhattan, Kansas.

Planting date	Early emergence[1]	Stand count[2] (% stand)	Yield in cwt/acre (quintals/ha)[3] Total	U.S. No. 1
April Planting				
Control	4.1 b[4]	21.2 (96) a[4]	283 (317) c[5]	217 (243) b[5]
Benlate	6.6 a	21.4 (97) a	354 (396) a	278 (311) a
Bravo	2.9 bc	21.3 (97) a	306 (343) bc	229 (256) b
Captan	4.4 b	21.4 (97) a	324 (363) ab	230 (257) b
Polyram	2.5 c	21.3 (97) a	287 (321) c	200 (224) b
May Planting				
Control	19.5 a	21.1 (96) a	180 (202) a	99 (111) a
Benlate	12.1 b	13.9 (63) b	112 (126) b	47 (53) b
Bravo	18.4 a	20.4 (93) a	190 (213) a	111 (124) a
Captan	18.9 a	20.3 (92) a	187 (209) a	108 (121) a
Polyram	19.6 a	20.8 (94) a	179 (201) a	104 (116) a
June Planting				
Control	0[6]	4.8 (22) c	---[6]	---[6]
Benlate	0	2.6 (12) c	---	---
Bravo	0	11.1 (51) a	---	---
Captan	0	9.4 (43) ab	---	---
Polyram	0	7.6 (35) b	---	---

[1]Plant emergence 30 days after planting expressed as mean of four 22-hill replications.
[2]Stand count 60 days after planting expressed as mean of four 22-hill replications.
[3]Yield data derived from means of four replications.
[4]Means within the same column not followed by the same letter are significantly different (DMRT 0.05).
[5]Means within the same column not followed by the same letter are significantly different (LSD 0.05).
[6]No early emergence or yield due to drought and loss of irrigation facilities.

Table 2. Effect of seed piece treatments on plant uniformity and vigor ratings of Irish potatoes planted at three dates, Summer 1974, Manhattan, Kansas.

Treatment	Plant uniformity[1]			Plant vigor[2]		
	Planting date					
	April	May	July[3]	April	May	July[3]
Control	3.75 a[4]	3.56 a	2.12 c	2.19 a	2.06 a	1.75 bc
Benlate	4.25 a	2.31 b	1.06 d	2.31 a	1.56 b	1.44 c
Bravo	4.00 a	3.75 a	2.94 ab	2.38 a	2.00 a	2.25 a
Captan	4.13 a	3.69 a	3.12 a	2.25 a	2.13 a	2.37 a
Polyram	4.06 a	3.63 a	2.25 bc	2.13 a	2.06 a	2.00 ab

[1]Composite rating for the 30 and 60 day visual evaluations for plant uniformity based upon scale of: 5 = 90% or more of emerged plants are equal in size; 4 = 75% or more are equal in size; 3 = 50% or more are equal in size; 2 = 25% or more are equal in size; 1 = less than 25% of emerged plants are equal in size.

[2]Composite rating for the 30 and 60 day visual evaluations for plant vigor based upon scale of: 3 = largest, most vigorous plants in the plot; 1 = smallest, least vigorous plants in the plot.

[3]Ratings based upon 60 day visual evaluation only.

[4]Means within the same column not followed by the same letter are significantly different (DMRT 0.05).

Table 3. Effect of seed piece treatments on weight of 25 tubers and specific gravity of Irish potatoes planted at three dates, Summer 1974, Manhattan, Kansas.

Treatment	Weight of 25 tubers[1]				Specific gravity[2]	
	April		May		April	May
	lbs.	kg	lbs.	kg		
Control	10.9 ab	12.2	8.8 a	9.9	1.060 a	1.052 a
Benlate	11.8 a	13.2	7.2 b	8.1	1.062 a	1.052 a
Bravo	10.5 b	11.8	8.1 ab	9.1	1.062 a	1.053 a
Captan	11.2 ab	12.5	8.9 a	9.9	1.061 a	1.052 a
Polyram	10.6 b	11.9	8.2 a	9.2	1.062 a	1.053 a

[1]Mean weight of all replications.
[2]Calculated by weight-in-air/weight-in-water method.
[3]Means within the same column not followed by the same letter are significantly different (LSD 0.05).

stand count, plant vigor or uniformity. Total yield from both treatments was comparable to the untreated control.

May 10 planting date. Benlate significantly reduced early emergence, stand and yield when compared with all other treatments (Table 1). The remaining fungicide treatments were comparable to the untreated control. The most striking difference showed up in the stand count. Benlate had a 63% final stand as compared to 96% for the untreated control. The reduced stands not only depressed yield but also were significantly reflected in plant vigor and uniformity (Table 2). Within the four remaining treatments, none of the chemical treatments produced statistically significant differences, although data for the chemical treatments tended to have slightly higher values than the untreated control.

July 3 planting date. Due to the adverse temperature and moisture conditions during and after planting, sprouting and emergence of all seed pieces were reduced regardless of treatment. With the observed drop in temperatures experienced in August (Figure 1) along with limited rainfall in July and August, plant emergence was not noted until 60 days after planting (Table 1). The reduced stands consisted of small, weak plants, and did not have the potential to produce a meaningful yield. Despite this condition, significant protection from decay and seed piece breakdown was provided by all chemical treatments except Benlate during an extended dry dormant period in hot soil. Bravo and captan treatments provided the best protection producing stand counts of 51% and 43%, respectively, although Polyram treatment was also significantly better than the untreated control. Benlate, as in the May planting, exhibited a detrimental effect upon emergence and produced a lower stand count than any other treatment.

Cultivar Responses to Chemical Seed Piece Treatments

Early emergence and stand count. In the April 1 planting, none of the seed piece treatments had a significant effect upon stand count (Table 4). Benlate treatment tended to produce higher early emergence on LaRouge, Norchip and Superior cultivars; however, it was significantly higher than the untreated control only on LaRouge. Response to Bravo, captan, and Polyram treatments was essentially equal to the untreated control. On Norchip cultivar, Benlate and captan produced a higher rate of emergence although there were no significant differences between captan, Polyram, Bravo and the untreated control. The largest single response to a chemical treatment occurred with Superior cultivar. Benlate treatment produced a rate of emergence significantly greater than any other chemical treatment. Captan and the untreated control produced equal rates of emergence while Bravo and Polyram treatments inhibited early emergence on Superior cultivar. This inhibition was not reflected in the 60 day stand count although Polyram treatment tends to reflect slightly lower emergence, stand and yields than any other treatment on Superior. The rate of emergence of Viking, regardless of treatment, appears to be lower in comparison with all other cultivars. Only in the case of Viking cultivar was response to any chemical seed piece treatment not significant at the 30 or 60 day observations. Benlate treatment produced no beneficial effects upon Viking with emergence equal to the untreated control. The response to Bravo, captan and Polyram treatments tends to be slightly greater than

Table 4. Effect of seed piece treatments on emergence, stand count and yield of four Irish potato cultivars planted on April 1, 1974, Manhattan, Kansas.

Treatment	Early emergence[1]	Stand count[2] (% stand)	Yield in cwt/acre (quintals/ha)[3] Total	Yield in cwt/acre (quintals/ha)[3] U.S. No. 1	% of total yield[4]
LaRouge Cultivar					
Control	2.5 fghi[5]	22.0 (100) a[5]	306 (342) cdef[6]	250 (280) bcde[6]	82
Benlate	6.0 bcde	22.0 (100) a	428 (479) a	348 (389) a	81
Bravo	4.0 defgh	21.3 (97) a	330 (369) bcde	255 (286) bcde	77
Captan	2.5 fghi	21.0 (95) a	342 (382) bcd	267 (299) bcd	78
Polyram	3.0 efghi	22.0 (100) a	343 (384) bcd	248 (278) bcde	72
Norchip Cultivar					
Control	5.0 cdef	21.0 (95) a	340 (381) bcd	241 (270) bcde	71
Benlate	8.3 bc	21.3 (97) a	383 (429) ab	266 (298) bcd	69
Bravo	4.5 defg	20.8 (94) a	344 (385) bcd	245 (275) bcde	71
Captan	6.8 bcd	22.0 (100) a	389 (435) ab	299 (335) ab	77
Polyram	4.0 defg	21.5 (98) a	375 (421) abc	264 (296) bcde	70
Superior Cultivar					
Control	8.8 ab	20.5 (93) a	219 (245) gh	170 (190) fg	78
Benlate	12.0 a	20.8 (94) a	321 (359) bcde	262 (293) bcde	82
Bravo	2.0 ghi	22.0 (100) a	242 (271) fg	189 (212) efg	78
Captan	7.3 bcd	20.8 (94) a	216 (242) gh	166 (186) g	77
Polyram	1.8 ghi	20.0 (91) a	162 (181) h	86 (97) h	53
Viking Cultivar					
Control	0.3 i	21.3 (97) a	269 (301) efg	211 (236) cdefg	78
Benlate	0.3 i	21.8 (99) a	291 (326) def	242 (271) bcdef	83
Bravo	1.0 hi	21.8 (99) a	307 (344) cdef	223 (250) cdefg	73
Captan	1.3 hi	21.8 (99) a	349 (391) bcd	282 (316) abc	81
Polyram	0.8 hi	21.8 (99) a	268 (300) efg	201 (225) defg	75

[1]Plant emergence 30 days after planting expressed as mean of four 22-hill replications.
[2]Stand count 60 days after planting expressed as mean of four 22-hill replications.
[3]Results are mean yields of four replications from plots harvested on August 2, 1974.
[4]U.S. No. 1 yield divided by total yield.
[5]Means within the same column not followed by the same letter are significantly different (DMRT 0.05).
[6]Means within the same column not followed by the same letter are significantly different (LSD 0.05).

the untreated control after both the 30 and 60 day stand counts, but this was not significant.

Early emergence and stand count data for the May 10 planting are shown in Table 5. The untreated control produced a rate of emergence and stand count that was equal to or exceeded all chemical treatments. Benlate treatment tended to reduce early emergence and exhibited a significantly detrimental effect upon stand count on Norchip and Superior, and was particularly pronounced on Viking cultivar with only a 45% final stand as compared to the untreated control with a 94% final stand. The trend is also reflected in LaRouge, although this difference is not significant.

In the July 3 planting (Table 6), with the exception of Benlate, chemical treatments produced larger stands than the untreated controls on all four cultivars. Most important was the protection provided by Bravo, captan and Polyram treatments on LaRouge, and Bravo treatment on Norchip cultivar. In these specific cases, stand counts ranging from 60 to 75% were achieved despite the extreme temperature and soil moisture conditions to which the seed pieces were subjected. Also, captan treatment on Superior along with captan and Bravo treatments on Viking produced stands significantly greater than the untreated controls. Benlate treatment continued to exhibit a detrimental effect upon the stand counts of all cultivars. The higher rates of emergence from Bravo, captan and Polyram treatments at this planting date parallel the higher plant uniformity and vigor ratings for these treatments (Table 2).

Yield. The effect of treatments on yield from the April 1 planting is shown in Table 4. With the exception of Polyram treatment

Table 5. Effect of seed piece treatments on emergence, stand count and yield of four Irish potato cultivars planted on May 10, 1974, Manhattan, Kansas.

Treatment	Early emergence[1]	Stand count[2] (% stand)	Yield in cwt/acre (quintals/ha)[3] Total	U.S. No. 1	% of total yield[4]
LaRouge Cultivar					
Control	20.0 abc[5]	20.3 (92) ab[5]	206 (231) defg[6]	135 (152) abc[6]	65
Benlate	17.0 cd	17.0 (77) bc	149 (167) g	64 (71) cde	43
Bravo	16.8 cd	18.5 (84) abc	213 (239) cdefg	139 (155) ab	65
Captan	19.5 abcd	19.8 (90) ab	227 (254) bcdef	157 (176) a	69
Polyram	18.8 abcd	19.8 (90) ab	246 (276) abcd	167 (187) a	68
Norchip Cultivar					
Control	20.8 ab	21.8 (99) a	280 (314) ab	120 (135) abc	43
Benlate	13.0 e	12.8 (58) de	185 (207) defg	82 (92) bcde	44
Bravo	19.8 abcd	21.8 (99) a	295 (330) a	132 (148) abc	45
Captan	18.3 bcd	20.5 (93) ab	272 (305) abc	121 (136) abc	44
Polyram	20.0 abc	21.0 (95) a	232 (260) abcde	108 (121) abcd	47
Superior Cultivar					
Control	21.0 a	21.8 (99) a	58 (65) h	24 (26) e	41
Benlate	16.3 de	15.8 (72) cd	66 (74) h	28 (32) e	43
Bravo	19.8 abcd	20.3 (92) ab	52 (58) h	23 (26) e	44
Captan	18.8 abcd	19.5 (89) ab	84 (95) h	39 (43) de	47
Polyram	19.8 abcd	20.3 (92) ab	57 (64) h	16 (18) e	29
Viking Cultivar					
Control	16.3 de	20.8 (94) a	174 (195) efg	114 (128) abc	65
Benlate	3.0 f	10.0 (45) e	49 (55) h	16 (18) e	32
Bravo	17.3 bcd	21.3 (97) a	202 (226) defg	150 (167) ab	74
Captan	19.3 abcd	21.3 (97) a	166 (186) fg	117 (131) abc	71
Polyram	19.3 abcd	22.0 (100) a	182 (204) defg	124 (139) abc	68

[1]Plant emergence 30 days after planting expressed as mean of four 22-hill replications.
[2]Stand count 60 days after planting expressed as mean of four 22-hill replications.
[3]Results are mean yields of four replications from plots harvested on August 21, 1974.
[4]U.S. No. 1 yield divided by total yield.
[5]Means within the same column not followed by the same letter are significantly different (DMRT 0.05).
[6]Means within the same column not followed by the same letter are significantly different (LSD 0.05).

Table 6. Effect of seed piece treatments on emergence and stand count of four Irish potato cultivars planted on July 3, 1974, Manhattan, Kansas.

Treatment	Early emergence[1]	Stand count[2] (% stand)
LaRouge Cultivar		
Control	0	6.3 (28) bcd[3]
Benlate	0	2.3 (10) fg
Bravo	0	15.3 (69) a
Captan	0	15.5 (70) a
Polyram	0	13.3 (60) a
Norchip Cultivar		
Control	0	7.5 (34) bc
Benlate	0	4.3 (19) cdefg
Bravo	0	16.5 (75) a
Captan	0	7.3 (33) bc
Polyram	0	8.3 (38) b
Superior Cultivar		
Control	0	2.5 (11) efg
Benlate	0	3.0 (14) defg
Bravo	0	5.3 (24) bcdef
Captan	0	7.0 (32) bc
Polyram	0	3.3 (15) defg
Viking Cultivar		
Control	0	2.8 (13) defg
Benlate	0	1.0 (5) g
Bravo	0	7.5 (34) bc
Captan	0	7.8 (35) b
Polyram	0	5.8 (26) bcde

[1]Plant emergence 30 days after planting expressed as mean of four 22-hill replications.

[2]Stand count 60 days after planting expressed as mean of four 22-hill replications.

[3]Means within the same column not followed by the same letter are significantly different (DMRT 0.05).

on Superior cultivar, total yield from all chemical treatments equaled or exceeded total yield from untreated seed pieces. There is a trend showing highest yields associated with earlier emergence rates as well as a parallel between higher total yields and higher yields of U.S. No. 1 tubers. In comparisons among treatments, yields were significantly increased with Benlate treatments on LaRouge and Superior cultivars while captan treatment on Viking cultivar was greater than the untreated control. On Norchip cultivar, all treatments were associated with essentially equal yields. Polyram treatment produced a lower percentage of U.S. No. 1 grade tuber on both LaRouge and Superior cultivars. Within the April 1 planting, no clear-cut significance existed between cultivars and treatments on the weight of 25 tubers (Table 7). However, in all cases, there is a trend for at least one or more chemical treatments to be associated with higher tuber weights than the untreated control. This trend was most pronounced for Benlate treatment with weights of 25 tubers from all four cultivars greater than the untreated controls. This was followed by captan treatment on Norchip and Viking cultivars. On Norchip cultivar, the weights from all chemical treatments exceeded the untreated control.

Due to the lack of irrigation water during the last eight weeks of growth, yields from the May 10 planting (Table 5) were noticeably lower than yields from the April 1 planting. The trend toward lower early emergence and stand counts associated with Benlate treatment also was exhibited in yield on all cultivars except Superior. Though the differences were not statistically significant, there is the possibility that Polyram and Bravo treatments were more effective under the conditions following the May 10 planting than they were following the April 1 planting. This possibility is exhibited by slightly higher yields for either one or both treatments on LaRouge, Norchip and Viking cultivars. With the exception of Polyram treatment on Superior cultivar and Benlate on LaRouge and Viking, the percentage of tubers grading out U.S. No. 1 tends to be higher for chemical treatments than for untreated controls. The effect of treatments upon the weight of 25 tubers from the May 10 planting (Table 7) was inconclusive. This factor was probably influenced more by lack of moisture than from any effect of seed piece treatment. In addition to reduced yields, the percentage of tubers grading out as U.S. No. 1 was also lower.

Effect of Soil Temperature on Response to Seed Piece Treatments

The mean soil temperatures at a 2-inch depth (5.1 cm) for the first 30 day period and the second 30 day period after planting are presented in Table 8.

At cool soil temperatures during the first 30 day period following the April 1 planting, Benlate treatment tended to produce a higher rate of early emergence on LaRouge, Norchip and Superior varieties (Table 4). Response from Bravo and Polyram treatments was equal to all other treatments on LaRouge, Norchip and Viking cultivars; however, on Superior both treatments significantly reduced the rate of emergence. While no treatment influenced final stand count, plant vigor or uniformity, the higher rates of early emergence generally tend to be associated with higher total yields.

In warmer soil temperatures during the 30 days following the May 10 planting, early emergence of the untreated controls are equal to Bravo, captan and Polyram treatments on all four cultivars. Benlate

Table 7. Effect of seed piece treatments on weight of 25 tubers of four potato cultivars planted at two dates, Summer 1974, Manhattan, Kansas.

Treatment	Planting date			
	April		May	
	lbs.	kg	lbs.	kg
LaRouge Cultivar				
Control	12.1 ab[1]	13.6	9.4 abcde	10.5
Benlate	12.2 a	13.6	7.7 defgh	8.6
Bravo	11.4 abc	12.7	8.3 abcdef	9.3
Captan	11.2 abc	12.5	9.6 abcd	10.7
Polyram	11.3 abc	12.6	9.2 abcde	10.2
Norchip Cultivar				
Control	9.9 c	11.1	7.9 cdefg	8.9
Benlate	10.7 abc	11.9	7.9 cdefg	8.8
Bravo	10.0 c	11.2	7.5 efgh	8.4
Captan	10.8 abc	12.0	8.4 abcdef	9.4
Polyram	10.1 bc	11.2	8.2 bcdef	9.2
Superior Cultivar				
Control	11.1 abc	12.4	8.0 cdefg	8.9
Benlate	11.9 abc	13.3	7.5 efgh	8.4
Bravo	10.6 abc	11.8	7.0 fgh	7.8
Captan	10.9 ab	12.2	7.5 efgh	8.4
Polyram	10.2 bc	11.4	6.1 gh	6.9
Viking Cultivar				
Control	10.6 abc	11.8	9.9 abc	11.1
Benlate	12.6 a	14.1	5.8 h	6.5
Bravo	10.3 bc	11.5	10.0 ab	11.2
Captan	11.9 abc	13.4	10.3 a	11.5
Polyram	11.0 abc	12.3	9.5 abcde	10.6

[1]Means within the same column not followed by the same letter are significantly different (LSD 0.05).

Table 8. Mean soil temperatures[1] following planting of potato seed piece treatments, Summer 1974, Manhattan, Kansas.

Planting date	Soil temperature C (F) 0-30 days after planting[2]	31-60 days after planting[3]
April 1	13.8 (57)	22.6 (73)
May 10	23.5 (74)	27.1 (81)
July 3	32.5 (91)	25.9 (79)

[1]Measured at a depth of 2 inches (5 cm) on an unshaded bare soil surface.

[2]Mean temperature of six 5-day periods following planting date (see Appendix II).

[3]Mean temperature of six 5-day periods beginning 30 days after planting date.

significantly reduced the emergence of Norchip, Superior and Viking cultivars in comparison with the untreated control. The detrimental effect displayed by Benlate after 30 days significantly reduced stand count of Norchip, Superior and Viking after 60 days even though all other treatments were equal with respect to emergence, stand count, plant vigor and uniformity.

After 30 days in the hot dry soil following the July 3 planting (Table 6), no emergence had occurred for any treatment or cultivar. With decreased soil temperature and limited rainfall during August, the remaining viable seed pieces were able to sprout and emerge. The response to Benlate treatment in hot soil tended to produce reduced stands similar to the response following the May 10 planting. Bravo, captan and Polyram treatments tended to produce higher stand counts than the untreated control. In comparison with the untreated control, significant differences were noted with Bravo, captan and Polyram treatments on LaRouge; captan treatment on Superior; Bravo and captan treatment on Viking; although the highest single response occurred with Bravo treatment on Norchip.

Effect of Seed Piece Treatment on Specific Gravity

As shown in Table 9, no treatment provided a clear advantage over any other treatment. On Norchip and Viking cultivars, tubers from the Bravo treatment tended to have higher specific gravities than the other treatments. These differences were statistically significant for Viking but not for Norchip. Additionally, total yield from Bravo treatment on Norchip and Viking is higher than any other treatment in the

Table 9. Effect of seed piece treatments on specific gravity[1] of four potato cultivars planted at two dates, Summer 1974, Manhattan, Kansas.

Treatment	Planting date: April	Planting date: May
LaRouge Cultivar		
Control	1.055 de[2]	1.049 cdefg
Benlate	1.058 abcde	1.053 abcde
Bravo	1.058 abcde	1.046 defg
Captan	1.059 abcd	1.052 bcdef
Polyram	1.058 abcde	1.051 bcdefg
Norchip Cultivar		
Control	1.064 abcd	1.056 abc
Benlate	1.066 ab	1.055 abcd
Bravo	1.067 ab	1.063 a
Captan	1.065 abc	1.059 abc
Polyram	1.066 ab	1.060 ab
Superior Cultivar		
Control	1.066 ab	1.059 abc
Benlate	1.068 a	1.056 abc
Bravo	1.065 abc	1.059 abc
Captan	1.068 a	1.054 abc
Polyram	1.065 abc	1.058 abc
Viking Cultivar		
Control	1.055 de	1.042 fg
Benlate	1.056 cde	1.043 efg
Bravo	1.058 abcde	1.046 defg
Captan	1.053 e	1.041 g
Polyram	1.057 bcde	1.043 efg

[1]Calculated by weight-in-air/weight-in-water method.
[2]Means within the same column not followed by the same letter are significantly different (LSD 0.05).

May 10 planting (Table 5); however, this relationship does not exist for the April 1 planting (Table 4).

Effect of Seed Piece Treatment on Common Scab

No treatment provided an advantage over other treatments in reducing the occurrence of common scab on U.S. No. 1 tubers (Table 10).

Table 10. Effect of seed piece treatments on control[1] of common scab infection of four potato cultivars planted at two dates, Summer 1974, Manhattan, Kansas.

Treatment	Planting date	
	April	May
LaRouge Cultivar		
Control	2.6 abcd[2]	3.2 bcd[2]
Benlate	2.5 abc	2.7 ab
Bravo	2.4 ab	2.7 ab
Captan	2.1 a	2.9 abc
Polyram	2.7 bcde	2.8 ab
Norchip Cultivar		
Control	3.1 def	3.2 bcd
Benlate	2.8 bcde	3.1 bcd
Bravo	3.0 cdef	2.9 abc
Captan	3.4 f	3.2 bcd
Polyram	2.6 abcd	3.4 d
Superior Cultivar		
Control	2.7 bcde	3.2 bcd
Benlate	2.6 abcd	3.0 bcd
Bravo	2.4 ab	2.7 ab
Captan	2.7 bcde	2.4 a
Polyram	2.7 bcde	2.7 ab
Viking Cultivar		
Control	3.5 fg	4.1 fg
Benlate	3.6 g	3.2 bcd
Bravo	3.5 fg	4.0 efg
Captan	3.5 fg	3.6 ef
Polyram	3.2 ef	4.2 g

Comparison performed by Dr. W. Willis, Extension Plant Pathologist, Kansas State University, Manhattan, Kansas.

[1]Visual evaluation using rating scale: 0 = No scab; 1 = Few shallow lesions; 2 = Several deeper lesions; 3 = Deep cracked lesions covering more than 25% of tuber surface; 4 = Deep cracked lesions covering more than 50% of tuber surface.

[2]Means within the same column not followed by the same letter are significantly different (DMRT 0.05).

CHAPTER V

DISCUSSION

Effect of Seed Piece Treatment and Soil Temperature on Emergence, Stand and Yield

The results of this research indicate that early emergence at either low or high soil temperatures (April 1 and July 3 plantings, respectively), stand count at high soil temperatures (July 3 planting), total yield, U.S. No. 1 tubers, and weight of 25 tubers were influenced by chemical treatments for all cultivars. Under favorable soil temperature and moisture conditions at planting time (May 10 planting), chemical treatments provided no significant advantage over untreated seed pieces.

On July 3, 1974, irrigation at the Horticulture Farm was lost due to equipment failure. During the month, air and soil temperatures reached their peak (Figures 1 and 2). Air temperature reached a daily high of 106F (41C) and only five days during the month had a daily high air temperature below 95F (35C). Soil temperatures at the 2-inch depth reached a maximum high of 113F (45C). Total rainfall was 2.6 inches (6.6 cm), most of which fell in the latter part of the month. Consequently, all three plantings were subjected to severe moisture stress and high temperatures during critical times in their growing cycles. Jones and Johnson (36) reported that droughts occurring early in the season were not as detrimental to yield as those occurring later.

Yield, specific gravity and the degree of scab infection were undoubtedly affected by the lack of water during the last 5 and 8 weeks of the growing cycles for the April 1 and May 10 plantings, respectively. The July 3 planting produced no yield data and provided only limited information relating to stand count.

The April 1, May 10 and July 3 plantings reflect the interaction of seed piece treatment, cultivar, and soil temperatures (13.8C, 23.5C and 32.5C, respectively, Table 8). Under cool, moist soil conditions for the April 1 planting, all chemical treatments tended to produce higher total yields than the untreated control, although only Benlate and captan showed significant differences (Table 1). Even though final stand counts are equal for all treatments, the highest total yields appear related to higher rates of early emergence. As observed by Elmer (24) complete early decay of seed pieces was the most harmful to stands but partial decay was also injurious because of resulting lack of vigor. He felt that when the seed piece remained firm, greater growth response would result since its food materials could be used by the plant, not only until emergence, but until all stored food could be utilized. Sanford (74), Newton and Lines (65), Newton (64), and Fink et al. (27) have reported increased sprout vigor from the use of various seed piece treatments, while Leach and Nielsen (47) also reported increases in yields with several fungicide treatments.

Cetas (13), Leach and Nielsen (47) and Leach et al.(46) have shown that benomyl dust is particularly effective in controlling Fusarium seed piece decay. Under the conditions of this experiment, Benlate dust (7.5% A.I.) created an apparent phytotoxic reaction which exhibited itself as a softening and blackening of the cut tuber surface. Despite this reaction, Benlate produced a beneficial response in practically all recorded factors from the April 1 planting. Apparently stimulated by a significantly higher rate of early emergence (Tables 1 and 4) and a slightly higher plant uniformity evaluation (Table 2), Benlate treated seed pieces produced the highest total yield, a significantly higher yield of U.S. No. 1 grade tubers and higher average tuber weight as reflected in the weight of 25 U.S. No. 1 tubers (Table 3). Generally, captan has shown satisfactory results when used as a seed piece treatment (8,13,20,22,28,29,47,50,51,59,67,72,81). It tended to give a slightly higher performance overall in comparison to the untreated control (Table 1) and showed a significant response in total yield from the April 1 planting. Both Bravo and Polyram depressed early emergence in comparison with the untreated control; however, there was no difference in stand count. As observed by Sanford (75) and Livingston (52), the differential effects of most chemicals are most evident during early suberization of the cut surface. Sanford (75) reported that this differential becomes indefinite after about 15 days and Murphy (62) noted that delayed emergence from Fusarex treatments on seed pieces had no effect upon final stands or yields. These observations appear valid for both of these treatments; however, the Polyram treatment produced the lowest percentage of U.S. No. 1 tubers (Table 4).

From a cultivar standpoint (Table 4), significance between treatments was more marked. The most obvious results concern the distinctly beneficial effect from Benlate treatment on yield of LaRouge and Superior cultivars. With Benlate treatment, Superior produced a total yield and U.S. No. 1 yield that were significantly greater than other treatments on this cultivar. Yield was greater than or equal to the untreated controls of the other three cultivars. Also noteworthy is the detrimental effect which Bravo and Polyram had upon early emergence of Superior cultivar. However, while Bravo did not affect final stand count, total yield, or U.S. No. 1 grade tubers, Polyram continued to reflect a detrimental effect upon all these factors.

Mean soil temperature at the May 10 planting increased 15-20F (8.3-11.1C) over the April 1 planting (Table 8). With warmer soil and adequate moisture remaining at planting depth, emergence and stand counts among treatments showed little difference. With the exception of Benlate treatment, the untreated control was equal to the chemical treatments on all cultivars. Numerous researchers (20,27,31,41,50,80) reported that under favorable conditions which enable rapid emergence, chemical treatments appear to offer no advantage over properly suberized untreated seed pieces for establishing good stands and yields. Gould and Randall (31) concluded that the environmental factors encountered during the period from planting to emergence accounted for most differences in their research. Based upon the results in Table 1 for the May 10 planting, there was no significant difference between stand and yield from untreated seed pieces as compared to Bravo, captan, and Polyram treatments. Benlate treatment, on the other hand, exhibited a decidedly detrimental effect upon stand and yield. Considering the differences between the April 1 and May 10 plantings for Benlate treatment, the increase in mean soil temperature from 57 to 74F (13.8 to 23.5C) apparently accelerated the phytotoxic effects of this treatment thereby causing a significant stand and yield reduction, lower tuber weight, and decreased plant uniformity and vigor.

From a cultivar standpoint, there were no differences in emergence and stand count among the untreated control, Bravo, captan, and Polyram treatments from the May 10 planting (Table 5). There were significant differences in the cultivar responses to Benlate treatment. In comparisons among cultivars, Benlate treatment caused the least amount of stand reduction on LaRouge and Superior. These are the same cultivars on which Benlate treatment produced higher rates of early emergence in the April 1 planting (Table 4). It is also important to note that Superior cultivar produced the lowest total yield with Polyram treatment in the April 1 planting as well as the lowest weight of 25 tubers and the lowest percentage of U.S. No. 1 grade tubers in both the April 1 and May 10 plantings.

Had irrigation been available throughout the growing season, it is believed that yields would have been higher for both the April 1 and May 10 plantings. The overall results from the May 10 planting are significantly lower than the April 1 planting and demonstrate the severity of the moisture stress, combined with high temperatures, encountered while these plants were in the tuberization stage. Struchtemeyer (79) and de Lis et al. (19) examined water requirements and growth cycle relative to yield; and various authors (14,17,30,70) have reported increased yields with irrigation. Additionally, Robin and Domingo (71) have shown significant reductions in yield and U.S. No. 1 grade tubers caused by moisture stress.

Another significant relationship to be noted at this point is the interaction between soil temperature and soil moisture and the probable effect it had upon the results of these two plantings. During the period June 10 to July 10, mean soil temperature reached 81F (27.2C). Yamaguchi et al. (86) determined, however, that optimum soil temperature for tuber formation is between 60 and 75F; and above 75F yield, specific gravity, and starch content are lower. Epstein (25) concluded that tuber yield was greatest at a soil temperature of 70F. Kehr et al. (38) reported that yields are reduced above 68F air temperature since respiration increased and less photosynthate accumulated. They also indicated that cultivars differ in their tolerance to high temperatures. In California, Lorenz (53) noted that air temperatures exceeded soil temperatures at certain times of the year, while at other times soil temperatures exceeded air temperature. Both he and Kushman et al. (40) reported that irrigated soil is approximately 3 to 4F cooler than non-irrigated soil. And, under Kansas conditions, Motes and Greig (60) concluded that irrigation not only increased yields and lowered soil temperature, but also that irrigation requirements were directly related to air temperature. They suggested that yield and specific gravity are inversely related to temperature.

The above factors also had a direct influence upon development of stands in the July 3 planting. With mean soil temperature above 90F (32C) during the first 30 days after planting, the seed pieces were subjected to extreme conditions. When Ward (83) studied the respiration of tubers under high temperatures, he found that at temperatures of 90 to 95F tubers treated with ethylene chlorhydrin sustained a very high rate of respiration until the tubers completely broke down. Cordner (16) suggested that seed piece breakdown at high soil temperatures was a physiological disorder and not a pathological decay. He reported detrimental effects from ethylene chlorhydrin at high soil temperatures also, but noted that under cool soil temperatures this treatment hastened sprouting and improved stands. Nickel (66) concluded that a strong treatment such as acidulated mercuric chloride could be used without adverse effects for a spring crop but such treatment was too severe under soil conditions for a fall planting. This relationship between soil temperature and effect of treatment upon sprouting, stands and yield was observed on Benlate treatments in this research. Although Cole et al. (15) reported reduced stands and yields with benomyl treatment in Pennsylvania and concluded that benomyl was too strong to be considered as a potato seed piece treatment, this conclusion cannot be supported under Kansas conditions for an early spring planting. However, as soil temperatures increased, Benlate showed an increasingly detrimental effect upon stands and yields. In the July 3 planting (Table 6) Benlate treatments resulted in significantly lower stand counts, plant vigor and uniformity. Overall, Bravo, captan, and Polyram treatments provided significantly greater protection from decay and breakdown than the untreated control (Table 1). There is a particularly marked effect between cultivars and treatments at high soil temperatures (Table 6) with the most significant being Bravo treatment on Norchip cultivar. LaRouge cultivar also responded satisfactorily to Bravo, captan, and Polyram treatments.

Effect of Seed Piece Treatment on Specific Gravity

Most work indicates that specific gravity is influenced primarily by environmental factors. Smith and Nash (78) have shown that specific gravity is related to tuber maturity and that lower temperatures during the latter part of the growing season produced tubers of higher specific gravity. The effect of irrigation upon specific gravity is either conflicting or inconclusive (21,30,34,60,70). Temperature, or season of the year, seems to have a more direct effect upon specific gravity than does irrigation (21,60,63).

Foliar fungicides reportedly have a beneficial effect upon specific gravity. As concluded by Manzer et al. (55), the possibility of a nutritive or regulatory effect from foliar fungicides cannot be excluded; but, according to Murphy et al. (61) the principal effect is related to greater maturity of the potato vines through protection from defoliation diseases.

Benomyl has been shown to have systemic activity both through foliar uptake (58) as well as root uptake (68). Though it does not yet have Environmental Protection Agency (EPA) clearance for use as a seed piece treatment on potatoes, it was included in this experiment to determine whether its systemic activity would influence specific gravity. However, as shown in Tables 3 and 9, no treatment produced a significant effect upon specific gravity.

Effect of Seed Piece Treatment on Common Scab

Early work by McKinney et al. (57) reported irregular results with seed piece treatments as a control for common scab. They concluded that soil temperature was an important factor in scab infection and that it probably interacted with various other soil factors. Hoyman (33) agrees with this conclusion and added that in addition to soil conditions, weather and cultivar susceptibility were the most important factors in determining the incidence of scab infection. He noted that seed piece treatment would not control common scab. While limited success has been reported with chemical control of scab (12,18, 32), most research (42,43,45,56) indicates that soil moisture plays a direct role in reducing or enhancing conditions which govern the extent of scab infection. Under the conditions of this experiment, no treatment appeared to influence the degree of scab infection (Table 10).

CHAPTER VI

SUMMARY AND CONCLUSIONS

Under favorable soil temperature and moisture conditions, the chemical seed piece treatments evaluated offer no advantage over untreated seed pieces with respect to early emergence, stand, or yield. Under less favorable conditions (either cool or hot) several chemical treatments have a significant effect upon these factors. There were found to be, however, no "ideal" chemical treatments that will provide satisfactory results under all conditions. For example, the chemical treatments which under cool wet conditions provided a beneficial response may, under hot dry conditions, produce an opposite response.

Specific cultivar responses to chemical treatments are an important factor that few researchers have reported and represents an area of research that should be explored further.

Based upon the conditions and results of this research, the following conclusions can be drawn:

1. Under the cool moist soil conditions normally present for an early spring planting in Kansas, treatments had no effect upon seed piece decay but strongly influenced early emergence, total yield and U.S. No. 1 yield. Overall, Benlate provided the earliest emergence, plant uniformity and yield despite a phytotoxic reaction with the cut surfaces of the seed pieces. However, considering the interaction of treatment, soil temperature and cultivars, no single chemical treatment

was the best for all four cultivars. Important cultivar responses were observed with Benlate treatment on LaRouge, Norchip and Superior; captan treatment on Norchip and Viking; and Polyram treatment on Norchip. A decidedly detrimental effect was observed with Polyram treatment on Superior.

2. Under the warm moist conditions present for the late spring planting untreated seed pieces produced stands and yields generally comparable to the Bravo, captan, and Polyram treatments. While one or more chemical treatments produced total yields greater than the untreated controls, only in the case of Polyram treatment on LaRouge was the difference significant. With increased soil temperature, Benlate treatment had a detrimental effect upon emergence and stands of all four cultivars and significantly lowered yields of LaRouge, Norchip, and Viking cultivars.

3. Under hot dry soil conditions for the mid-summer planting, several chemical treatments provided protection from seed piece breakdown and decay. There was also a strong cultivar response. In comparison with the untreated controls, significant beneficial responses were achieved on stands with Bravo treatment on LaRouge, Norchip and Viking cultivars; captan treatment on LaRouge, Superior and Viking; and Polyram on LaRouge. Only in the case of LaRouge and Norchip cultivars, however, were the results meaningful with respect to the actual stands achieved.

4. As shown by earlier work and supported by this research, specific gravity is closely related to temperature. Seed piece treatment produced no significant differences in specific gravity. However, Bravo treatment on Norchip and Viking cultivars showed a trend toward

slightly higher specific gravity values in comparisons among treatments.

5. The incidence of increased scab infection has been shown to be directly related to low soil moisture. Since this research encountered drought conditions throughout July and part of August, scab evaluations for all cultivars are high. The slightly lower ratings for LaRouge and Superior cultivars are probably indicative of a natural resistance and the effects of treatment are inconclusive.

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APPENDIX I. Company Name, Chemical Name, Formulation and Manufacturer of Fungicide Seed Piece Treatments Used in This Study

Benlate . . . . . . Benomyl (methyl 1-(butylcarbamoyl)-2-benzimidazole-carbamate); 50% wettable powder. E. I. duPont de Nemours & Co., Inc.

Bravo . . . . Chlorothalonil (tetrachloroisophthalonitrile); 75% wettable powder. Diamond Shamrock Chemical Co.

Orthocide . . . . . Captan (N-[(trichloromethyl)thio]-7-cyclohexene-1,2-dicarboximide); 50% wettable powder. Chevron Chemical Co.

Polyram . . . . . . Mixture of 5.2 parts by weight of ammoniates of [ethylenebis (dithiocarbamate)] zinc and 1 part by weight of ethylenebis [dithiocarbamic acid], bimolecular and trimolecular cyclic anhydrosulfides and disulfides; 80% wettable powder. FMC Corp.

APPENDIX II. Mean Air and Soil Temperature and Precipitation for the Period April 1 to August 31, 1974, Manhattan, Kansas

Five Day Period Beginning		Temperature °C Air	Soil (2" depth)	Soil (4" depth)	Precipitation (cm)
April	1	10.9	11.3	10.5	0.81
	6	12.7	11.7	11.2	0
	11	11.5	11.1	10.4	0.56
	16	14.4	15.3	14.4	1.55
	21	15.5	16.1	15.3	4.80
	26	18.8	17.6	17.4	6.60
May	1	14.5	16.9	16.7	0.03
	6	18.1	20.2	19.7	1.80
	11	17.4	20.4	19.8	1.27
	16	24.4	26.6	25.3	0.46
	21	21.0	23.0	22.8	0.63
	26	22.6	25.7	25.4	1.32
	31	16.7	25.4	24.6	0
June	5	19.2	19.5	19.8	12.57
	10	20.4	22.6	22.6	2.26
	15	22.6	27.8	26.8	0
	20	25.9	29.1	28.6	0
	25	22.6	28.7	28.6	0
	30	27.9	29.0	27.2	1.47
July	5	28.0	32.9	32.2	0
	10	30.6	33.6	33.7	0
	15	29.6	33.6	32.8	0
	20	29.5	35.2	33.7	0
	25	28.1	31.0	30.4	5.11
	30	23.5	26.6	26.0	0
August	4	20.6	23.7	22.1	1.42
	9	25.4	28.5	26.9	2.01
	14	24.3	25.3	25.2	3.61
	19	26.0	26.2	25.7	0.15
	24	23.9	25.1	24.8	0.18
	29	19.2	21.3	21.3	0

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EFFECT OF CHEMICAL SEED PIECE TREATMENT AND PLANTING DATE UPON EMERGENCE, YIELD AND QUALITY OF FOUR CULTIVARS OF IRISH POTATO (*Solanum tuberosum* L.)

by

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B.A. Kansas State University, 1964

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Department of Horticulture and Forestry

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Manhattan, Kansas

1975

ABSTRACT

Production of Irish potatoes in Kansas is limited due to the short period in the spring when soil temperature and moisture conditions are favorable for establishment of satisfactory stands. During 1974 a factorial experiment was conducted to examine the response of LaRouge, Norchip, Superior and Viking cultivars to fungicide seed piece treatments and varying soil temperatures encountered at different planting dates. Using fungicide treatments of Benlate, Bravo, captan, and Polyram (7.5% dusts) and an untreated control, potato seed pieces, stored for 72 hours following cutting and treating, were planted in Sarpy fine sandy loam soil on April 1, May 10, and July 3. Mean soil temperatures during the 30-day period following the planting dates were 57, 74, and 91F, respectively.

Under the conditions of this experiment, no treatment influenced final stands of the April 1 planting. Benlate exhibited phototoxicity with all cultivars but produced a significantly earlier rate of emergence, and overall, exhibited a trend toward higher yields, tuber weights and plant uniformity. Bravo, captan and Polyram treatments were, generally, equal to the untreated control although captan produced a total yield comparable to Benlate. Following the May 10 planting, Benlate treatment exhibited a significantly detrimental effect upon growth and yield. Bravo, captan, and Polyram were equal to the untreated control. Due to drought, high temperatures and the loss of irrigation the July 3 planting was seriously affected. After 60 days, weakened stands were established but no yield data were taken. Bravo, captan, and Polyram provided protection from decay and seed

piece breakdown that was significantly greater than the untreated control and Benlate treatment.

Based upon this research, it is believed that a strong interaction exists not only between seed piece treatments and soil temperature but also among these factors and potato cultivars. Of the materials evaluated, no one fungicide produced the best overall response with all four cultivars. In the April 1 planting, treatments had no effect upon seed piece decay and stands. Benlate and captan produced the highest total yields. Overall, Benlate provided the earliest emergence, plant uniformity, and yield of U. S. No. 1 grade tubers with the most significant cultivar responses exhibited on LaRouge and Superior. Polyram treatment on Superior produced the lowest total yield of any treatment and a significantly lower yield of U. S. No. 1 grade tubers. In the May 10 planting, the untreated controls produced yields equal to or exceeding Bravo, captan, and Polyram while none of these treatments affected seed piece decay and stands. Benlate resulted in significantly lower emergence, stands and yields with the strongest detrimental response exhibited on Norchip, Superior and Viking cultivars. In the July 3 planting, several chemical treatments provided protection from seed piece decay and breakdown. Bravo, captan, and Polyram treatments produced stands that were significantly greater than the untreated control while Benlate produced the lowest stands. Due to weather conditions no yield data were taken.

Under the conditions of this research, no seed piece treatment had a significant effect upon either specific gravity or control of common scab infection.