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Effect of Early Growth Cultivation on Beans and Sweet Corn

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EFFECT OF EARLY GROWTH CULTIVATION

ON BEANS AND SWEET CORN

by

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Effect of Early Growth Cultivation

on Beans and Sweet Corn

by

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Utah State University, 1972

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Investigations involving four cultivation treatments were conducted at the Utah State University Greenville Experimental Farm to determine the effect of these treatments on yields of beans and sweet corn. The effects of the different treatments on soil water content, soil temperature, and weed control in beans and corn were investigated. The effect of cultivation on the degree of root rot infection and the effect of different planting dates were also investigated in the bean study.

The pre-emergence treatment (ridged just before the plants emerge) produced a 48 percent greater bean yield and a 40 percent greater corn yield than the control treatment (no cultivation). The planting-ridge treatment (ridged at planting time) produced 21 percent greater bean yield than the control treatment. The post-emergence treatment (cultivated after the plants emerged) yielded 10 percent more beans and 20 percent more corn than the control treatment. The second and third planting dates produced 16 and 42 percent, respectively, greater bean yields than the first planting date. The pre-emergence treatment had a higher soil water content and soil temperature than the other methods in both the beans and corn. The pre-emergence treatment had 50 percent less root rot infection than the control treatment. The planting-ridge treatment had 30 percent less root infection than the control and the post-emergence root infection was 17 percent less than the control. The root rot infection in the second and third plantings was 15 and 32 percent, respectively, less than the first planting. The order of best weed control was: pre-emergence, planting-ridge, and post-emergence. The pre-emergence treatment produced the most favorable results in all aspects of the study.

(92 pages)

INTRODUCTION

The author has raised pinto beans *(Phaseolus vulgaris)* and sweet corn *(Zea mays saccharata)* for 11 years (1957-1968) at four different locations in Twin Falls County, Southwestern Idaho. During this time it was observed that some pre-emergence cultivation techniques resulted in more effective weed control and apparently greater yields. The best technique consisted of placing a 2- to 4-inch ridge of soil over the seed row just prior to emergence of the seedlings. The crop needed to be cultivated only once more just prior to the first irrigation, provided no heavy rain occurred.

Most of the research that has been done on the effect of cultivation (dust mulch) on water lost by evaporation indicate that little value results from cultivation unless there is frequent rainfall or frequent winds. The indications are that cultivation (mulching) tends to raise the soil temperature early in the crop year and lower it in the hot summer months.

With crops such as beans and corn, particularly in irrigated regions, it is not necessary to retain the soil water for a long time. It is important however to prevent moisture loss from the root zone of the young plants for a period of 5 to 6 weeks. The crop is then ready to "lay by" (no more cultivation is needed) and the soil is shaded by the crop and evaporation is retarded. Usually irrigation is started at this time.

More work needs to be done on studying the most favorable soil environment for plants in irrigated soils. The purpose of this study was to determine what influence cultivation methods had on creating a more favorable environment, thus, increasing bean and corn yields.

OBJECTIVES

1. To determine if pre-emergence cultivation has an influence on yield on beans and sweet corn.
2. To determine what influence pre-emergence cultivation has on soil temperature and soil moisture.
3. To determine what influence pre-emergence cultivation has on *Fusarium* root rot in beans.
4. To determine what influence pre-emergence cultivation has on weed control in beans and sweet corn.
5. To determine what influence planting date has on bean yield .

LITERATURE REVIEW

Effects of Soil Mulching

The practice of mulching the soil to minimize water loss by evaporation to influence soil temperature, and to minimize weed growth is very old. Much research has been done in this area.

In a review of mulching effects on soil properties, Jacks et al. (1955) conclude that the only advantages of a cultivation to produce a mulch (dust mulch) are weed control and a contingent decrease in evaporation from the mulched soil as compared with that from unmulched control. They also claim certain disadvantages--that there is an erosion hazard, and that roots are prevented from using very fertile surface soil. Because of these disadvantages, many specialists have looked for some other type of mulch such as straw, gravel, or plastic. Jacks et al. (1955) also reviewed experiments that showed that infiltration rates were almost twice as high for straw mulches as for cultivated mulches.

A project conducted by Hanks and Woodruff (1958) indicated a soil mulch was most effective in reducing evaporation from the soil when a wind is blowing. The experiment, conducted in a wind tunnel, shows that when the wind was increased from 0 to 25 mph evaporation from the soil mulch increased 2 to 6 times, whereas from straw and gravel mulch it increased 10 to 15 times. Evaporation from gravel and straw mulches were 1.3 times greater than from soil mulch at 0 mph and 6.3 times greater at 25 mph.

Hanks et al. (1961) investigated the influence of straw, black-painted gravel, aluminum-painted gravel, and plastic mulches on net radiation, soil temperature, and evaporation. Their studies showed soil temperatures to be highest under clear plastic, followed by the control, black-painted, aluminum-painted, and straw covered treatments. Net radiation was highest on the black mulch, followed by clear plastic, contro, straw, and aluminum. Evaporation was greatest on the control plot and about equal on all other treatments with a total difference of no more than 1 inch of water.

Relations of Tillage and Soil Properties to Bean Growth

A review of literature by Russell (1950) indicated that there were certain optimum ranges of moisture and soil temperature for maximum growth for a given plant species. A greater percent of germination and healthier plant occurred if these optimum ranges, particularly temperature, were held steady throughout the germination period. A study of environmental requirements for germination and emergence by Bowen and Coble (1967) showed that a stress of any kind during germination lengthened the emergence time, decreased the percent of germinations, and decreased hardiness of the emerged plant.

Beans are a warm season crop and sensitive to extremes, particularly temperature. Extremely high temperatures interfere with the setting and filling of pods. Low temperatures result in poor growth. Hardenburg (1927) contends that the weight of seed or amount of reserve food for the seedling is the principle determinant of the growth rate, and that temperature acts as a catalyst.

Reddick (1917) investigated the effect of three temperatures, 34 C, 22 C, and 15 C, on bean plant development. He found that after 12 days, plants grown at 34 C developed the first trifoliate leaf, those at 22 C had just spread the first pair of true leaves, and those grown at 15 C had not all emerged. After 45 days, the beans grown at 34 C were beginning to blossom while those grown at 22 C did not begin blossoming until 11 days later, and the plants grown at 15 C were either dead or in very poor condition and none had developed satisfactorily. LeBaron (1958) investigated the effect of moisture levels on maturing rate and yield. The results indicated that a high moisture level from planting to maturity resulted in highest yield and earliest maturity. A low moisture level from planting to bloom, with high level from bloom to maturity, resulted in good yield but very late maturity.

Hardenburg (1927) stated that extremely heavy mineral soils such as adobes and clay loams were not suitable for beans because they subject the area to extreme puddling. Soils of organic origin were not suitable either as they were likely to produce a late maturing crop, i.e., too much vine to seed ratio. Medium loams of moderate fertility were recommended. Soils underlain with a shallow hard-pan subsoil were not recommended because they do not permit new root development. Light soils were preferred as they will warm up quicker resulting in a higher percentage of germination and faster early growth.

Fusarium Root Rot of Beans

Fusarium root rot, sometimes called dry root rot, is one of the most common and damaging diseases affecting beans. The disease occurs in many parts of the world, however, it is most common in irrigated areas.

Effect of fungus on beans

According to Maloy and Burke (1970) root rot is caused by the fungus *Fusarium solani f.* sp. *phaseoli*. Only beans are affected and most varieties are susceptible. The disease usually appears the second or third time beans are grown in soils that have never raised beans or have not raised them for several years.

The disease first appears as reddish-brown streaks on the stem or taproot. As the disease progresses the discolored area spreads until the entire taproot and lower stem is severly decayed. Above ground symptoms usually do not appear until the roots are severely damaged. At this stage there may be a stunting of the plant, a yellowing and dropping of the leaves, and a failure to produce full pods, severely reducing yield.

Characteristics of the fungus

The *Fusarium* fungus attacks the bean plant over most of the growing season. It progresses most rapidly however, in soil whose temperature ranges from 60 F to 95 F. Such temperatures do not usually occur in the early stages of bean growth and Burkholder (1919) feels this may allow plants in many cases to become established before disease becomes too limiting.

Burkholder (1925) found the fungus has many morphological and physiological changes when grown in a pure culture. The fungus, which may live in decayed material for many years, can undergo these same changes. When beans are again grown and are infected the fungus returns to its original state. However, the virulence is greatly reduced until the fungus has infected two bean crops. Zaumeyer and Thomas (1957) state that the organism is not carried in the seed but may adhere to the seed coat. These findings provide strong arguments for crop rotation to control the fungus.

Methods of control

Burke (1968) conducted research to determine the effect of root impedance on root rot. One-half of the samples were placed in clay pots to confine the roots of the beans. The other half of the samples had the same shape and volume of the clay pots but were placed in non-infested soil. The roots confined by the clay pots were severely rotted but those that grew freely into non-infested soil were not infected. In several cases a root would escape the pots through the hole in the bottom into the non-infested soil and was not damaged.

Compacted soil is a natural root impediment. During 1969 and 1970, Burke (1971) found that breaking the soil with subsoiler chisels to a depth of 20 to 22 inches near the bean drill path controlled the disease in three bean varieties grown in sandy loam soils. Loosening the soil did not prevent root infection, but permitted greater rooting depths and volume and resulted in near maximum bean yields.

Burke (1964) found that *Fusarium* root rot caused reduction in yields in early plantings but was not important in later plantings.

Procedures for Bean Production

Land preparation

Hardenburg (1927) stated that beans were influenced by rotation and fertilization less than most other field crops. However, seed bed preparation was very important. Hardenburg recommended fall or early spring plowing since it allows time for decomposition of organic matter and earlier warming of seed beds. As beans have a poor capacity to reproduce roots, fields should be deep plowed or chiseled to break up the plow pan. LeBaron (1958) recommended two methods for handling pre-planting irrigations: (1) pre-irrigate to saturation, harrow when dry, cultivate 2 to 3 inches in depth, and then harrow again, or (2) ridge and irrigate, level off crest of ridge, then plant. The advantages of the second method over the first is that the tractor time is reduced and irrigating is used to firm soil rather than tillage. The advantage of the first method is that it assures more complete weed seed germination which allows greater early weed control.

Planting

LeBaron (1958) suggested the following planting procedure. Surface soils (6 inches in depth) should be at least 10 C or more for good germination. Beans planted later in the season tends to fare better. Seeds should be planted 2 to 3 inches apart in 22- to 24-inch rows and at a depth of 2 1/2 to 3 1/2 inches (at least into moisture).

If ridged at planting time, ridges should be harrowed off within 4 or 5 days to prevent injury to emerging seedlings. Ridging helps to maintain moisture around the seed and is also effective in weed control.

Cultivation

Allard and Smith (1954) claimed there are only two reasons for bean cultivation: (1) to control weeds, and (2) to construct furrows for irrigation. They have established that inter-row cultivation results in more loss of moisture than does undisturbed soil. Two cultivations were recommended. The first, 3 to 4 weeks after planting, and the second just prior to irrigation.

LeBaron (1958) contened that ridging of some soil around the base of the plants is necessary for three reasons: (1) it will help promote the growth of secondary roots that are vital when the primary root system becomes affected by root rot, (2) ridging smothers small weeds in the bean row, and (3) the ridges allow for more efficient cutting.

Irrigation

LeBaron (1958) stated that the first irrigation must be applied before the plants are under stress, (25 days after planting). Sprinkler systems are not advisable because of diseases associated with the plattening of the plants by the water.

Myers et al. (1957) conducted investigations to determine the best approach for applying water to beans. Four different methods were included in the experiment: (1) irrigation applied to every row, (2) irrigation applied to every other row, (3) irrigation applied to every other row but alternating rows each successive irrigation, and

(4) irrigation applied in every other row for the first irrigation and every row thereafter. Each of these methods was treated with three frequencies of irrigation as follows: (1) short-water was added when one-half of available moisture was depleted in the root zone; (2) medium water was applied when two-thirds of available moisture was depleted from the root zone; and (3) long frequency water was added only after marked visible stress occurred (when plants neared the wilting point). When it was determined that plants needed water for their given frequency, water was applied until the soil was wet across the row. Irrigating in every row each irrigation with the shortest frequency produced the greatest yields.

Relations of Tillage Methods and Soil Properties to Corn Growth

Martin and Leonard (1967) recommended fall plowing and pulverization of the top 4 inches to provide a soil free from large air spaces in which to plant the seed. This should be done just prior to planting in order to suppress weeds. They also state that the principle reason for cultivation is to control weeds. Many experiments have shown that corn receiving no cultivation yields as well as those under conventional cultivation methods, provided the crop is kept free of weeds by some means. When cultivation is deeper than 3 inches there is a risk of root pruning.

Research by Barber (1970) showed that root development was influenced by tillage practices. There seemed, however, little relation between corn root distribution, morphology, and grain yield. Results showed the lowest grain yield and smallest amount of root growth from the no tillage treatment, but no significant differences between the tilled treatments. This is an indication that tillage is necessary but the degree is only important for weed control.

Mulching tests of Jones et al. (1969) showed a significant increase in both stover and grain yields in treatments using grass as a mulch. Water content above the 30 centimeter (cm) level remained much higher in the mulch treatments. The corn yields and water content of the tilled treatments were greater than the untilled treatments. The difference between tilled and untilled was not as great as the difference between mulched and no mulch treatments.

Olson and Schoeberl (1970) showed no significant difference in yield due to different tillage practices. However, they did show a wide range of soil conditions due to tillage methods which could indicate there may be a combination of practices that would bring about an optimum range of conditions that would influence yields.

MATERIALS AND METHODS

Treatments for Bean Research

The experiment was conducted at the Utah State University Greenville Experimental Farm with a Millville silt loam soil in plots of eight rows, 22-inch row spacing by 150 feet long. There were three planting dates: June 4, June 14, and June 20, 1971. This was done in an effort to avoid cool and wet weather during seedling establishment. The first planting received heavy rain and cool temperatures about the time of emergence of the beans, whereas the second and third plantings received a warm and dry weather condition at the time of seedling establishment. There were three replications of the following treatments in each planting date:

1. Pre-emergence. A 2 1/2-inch ridge of soil was placed over the row just as the beans were beginning to emerge. The ridge was formed with cultivator shovels 3 inches deep and 8 inches from the row. This treatment was cultivated once more with knives and tails at the 1 1/2-inch depth just prior to the first irrigation.
2. Planting-ridge. A 1 1/2-inch ridge of soil was placed over the bean row with disk-hillers immediately after planting. This treatment was also cultivated when the beans were 3 to 4 inches high with shovels 3 inches deep and 4 inches from the row. It was cultivated with knives and tails as in treatment one.

3. Post-emergence. This treatment was left as planted, cultivated when beans were 3 to 4 inches high and cultivated again in 7 days. Shovels at a 3-inch depth and 4 inches from the row were used. This treatment was cultivated with knives and tails at a 1 1/2-inch depth just prior to the first irrigation and between the first and second irrigation.
4. Control. The soil in this treatment was left as planted and the weeds were controlled by hand. Irrigation furrows were made at planting time.

Procedure for Beans

The entire experiment was fall plowed (October, 1970). Seedbed preparation was performed with a disk and harrow just prior to planting. Pre-planting irrigation was not required as the soil was already near field capacity.

The original soil surface was the reference point for the depths of the instruments installed in the following procedures.

Moisture and temperature

Tensiometers were installed 8 inches deep in one replication of each treatment of each planting and used for scheduling irrigations. Water was applied in furrows between every row for 6 hours when tensiometers measured 0.6 bar or about 12 percent water content by weight. Each treatment of the first planting was irrigated separately when moisture was at 0.6 bar. All of the treatments in second and third plantings were irrigated at the same time when the average tensiometer readings of each planting was 0.6 bar. The first planting was handled this way to determine if any treatment would require fewer irrigations. The treatments of the second and third plantings were pooled for convenience. The post-emergence and control treatments required six irrigations while the pre-emergence and planting-ridge treatments required only five. The second and third plantings also required five irrigations.

Gravemetric water content measurements were taken from each replication every week at 2-, 4-, 6-, 8-, 10-, and 12-inch depths. Total water content of a 60-inch profile was taken with a neutron probe every 2 weeks. One access tube was installed in one replication of each treatment.

Soil temperature was measured with thermocouples installed at 2-, 4-, and 6-inch depths in one replication of each treatment. Measurements were taken each hour from 7:00 am to 8:00 pm on three different days.

Yield measurements

A 3-foot section from each replication was harvested after the first irrigation to determine plant dry weight yield. The plants were cut off at the soil surface, placed in paper bags, and dried in ovens at 50 C until a stable weight was reached.

A 10-foot length of each of the six inside rows of each replication was harvested to determine bean seed yield. The pods were picked from the plants,placed in bags,and allowed to dry in the air. When the pods were dry they were shelled and the beans weighed. The harvesting dates were as follows: first planting, September 1, 1971; second planting, September 8, 1971; and the third planting, September 11, 1971.

Root development and weed control

Five plants were randomly selected from each replication to determine the root damage caused by the *Fusarium* fungus. A qualitative infection intensity scale of 0 to 5 was established, 0 being no infection and 5 representing infection of the entire taproot, with the numbers between representing various degrees of infection. Four weeks after planting, four plants were selected at random from each replication to determine root development. The plants were removed and treatments compared for relative root length.

After the final cultivation before the first irrigation a weed count was made for each replication of treatments 1, 2, and 3 to determine the influence of each treatment on weed control. Afterward the weeds were pulled by hand to prevent their presence influencing bean yields.

Treatments for Corn

The experiment was conducted in plots of 8 rows, 22-inch row spacing by 80 feet long. The corn was planted June 14, 1971, 3 inches deep and in a plant-spacing of 14 inches. The 22-inch rows were used so as to use the same cultivator setting as the bean experiment. Seedbed preparation was the same as for the beans. There were three replications of the following treatments:

1. Pre-emergence. A 3-inch ridge of soil was thrown over the row just as the corn was beginning to emerge. Cultivator shovels 3 inches deep and 8 inches from the row were used. Cultivation with knives and tails at 1 1/2-inch depth was done at "lay by."

2. Post-emergence. The seedbed was left flat after planting and was cultivated when the corn was 4 to 6 inches high with shovels 3 inches deep and 4 inches from the row. The same procedure was performed 10 days later. This treatment was cultivated with knives and tails at "lay-by" as in treatment one.
3. Control. The seedbed was left as planted with furrows between the rows for irrigating. The weeds were controlled by hand.

Procedure for Corn

Moisture and temperature

Tensiometers were installed at a depth of 12 inches in one replication of each treatment and was used to schedule irrigations. Water was applied for 8 hours when the tensiometers measured 0.6 bar. The entire experiment was irrigated when the average of the three tensiometers measured 0.6 bar. Four irrigations were applied.

Soil water content was measured at 6-, 12-, and 18-inch depths gravimetrically from the corn row every week until irrigations were applied. Samples were then taken 1 day before and 2 days after the irrigations. Total water content of a 60-inch profile was taken with a nuetron probe, one site in each treatment.

Soil temperature was measured with thermocouples installed at 2-, 4-, and 6-inch depths in the corn row of one replication of each treatment to determine influence of cultivations on soil temperature. Measurements were taken each hour from 7:00 am to 8:00 pm on three different days.

Yield and weed control

A 3-foot section from each replication of all treatments was cut at the soil surface, dried at 50 C in ovens, and weighed to determine plant growth on July 26, 1971. The same measurement was again taken at harvest time (September 14, 1971), to determine total plant production. The ears from the inside six rows of each replication of all treatments were picked and weighed to determine the canning corn yield on September 15, 1971. The corn was weighed with the husks intact as is the corn of commercial corn processors.

A weed count of the pre-emergence and post-emergence treatments was made at "lay-by" to determine the weed control of each treatment. The weeds were then pulled by hand to eliminate their influencing the corn yield.

RESULTS AND DISCUSSION

The bean and sweet corn experiments were designed as separate investigations and will be discussed separately.

Results of Bean Research

The results shown in the following tables are average values for each treatment within planting dates. A pooled analysis of variance is also included. The raw data and individual analysis of variances are shown in the appendix. The three different planting dates were utilized to insure favorable weather for at least one of the bean experiments therefore each planting date was handled as a separate experiment. A pooled analysis of variance was used to determine what effect planting date and the interaction of treatments and planting date had on the various aspects of the study.

Yield

Table 1 contains the results of the bean seed production of the three plantings. The F ratio in the analysis of variance shows significant differences due to treatment. The F ratio of replication within date shows no difference due to replication. The pre-emergence treatment produced a 48 percent greater yield than the control treatment. The yield of the planting-ridge treatment was 21 percent greater than the control and the post-emergence was 10 percent greater than the control.

Table 1. Effect of treatment and planting date on bean seed yield in kilograms per hectare

Treatment	Date 1[a]	Date 2[b]	Date 3[c]	Average
Pre-emergence	3423	4023	5101	4184
Planting-ridge	2882	3410	3993	3428
Post-emergence	2717	2948	3651	3105
Control	2320	2768	3384	2824
Average	2835	3287	4032	

Pooled Analysis of Variance

Source	df	SS	MS	F
Total	35	542,375		
Date	2	251,680	125,840	352.2**
Rep/Date	6	1,701	284	0.79
Trt	3	266,466	88,822	248.6**
Trt x Date	6	16,095	2,682	7.5*
Error	18	6,432	357	

[a]Planted 6/4/71; harvested 9/1/71.

[b]Planted 6/14/71; harvested 9/8/71.

[c]Planted 6/20/71; harvested 9/11/71.

*Indicates significance at 0.05.

**Indicates significane at 0.01.

The analysis of variance indicates there was significant differences between planting dates. Significance is also shown due to the interaction of treatment and planting dates. The third planting date produced 42 percent greater yield than the first planting. The second planting increased 16 percent more than the first planting.

The results of dry plant yield are recorded in Table 2. The analysis of variance shows that there was significant differences between treatments. The pre-emergence treatment produced 45 percent more plant weight than did the control treatment. Plant weight production in the planting-ridge treatment was 22 percent greater than the control treatments. Plant weights in the post-emergence treatment was 8 percent more than in the control. These increases were very similar to the increased found in the seed yield results.

There was significant difference due to the interaction of treatments and planting date. The increases between planting dates were not as great as was the bean seed yield increases. The third planting yielded 11 percent more than the first and the second yielded 5 percent more than the first planting.

The plant growth (height in cm) are plotted against time (days after planting) in Figure 1. At 40 days after planting the pre-emergence treatment was 29 percent taller than the control treatment. The planting-ridge treatment was 16 percent taller than the control and the post-emergence treatment was 9 percent taller than the control.

The planting dates also showed differences in plant growth after 40 days. The plants in the third planting were 28 percent taller than those of the first planting and the plants of the second planting were

Table 2. Effect of treatment and planting date on bean dry plant yield in kilograms per hectare

Treatment	Date 1[a]	Date 2[b]	Date 3[c]	Average
Pre-emergence	2078	2162	2305	2182
Planting-ridge	1770	1817	1891	1826
Post-emergence	1507	1650	1701	1619
Control	1390	1491	1617	1499
Average	1686	1780	1878	

Pooled Analysis of Variance

Source	df	SS	MS	F
Total	35	6,979		
Date	2	580	290	69.1*
Rep/Date	6	11.6	1.9	0.45
Trt	3	6,265	2,088	497**
Trt x Date	6	46	7.7	1.8
Error	18	76	4.2	

[a]Planted 6/4/71; harvested 7/18/71.

[b]Planted t/14/71; harvested 7/24/71.

[c]Planted 6/20/71; harvested 7/26/71.

*Indicates significance at 0.05.

**Indicates significance at 0.01.

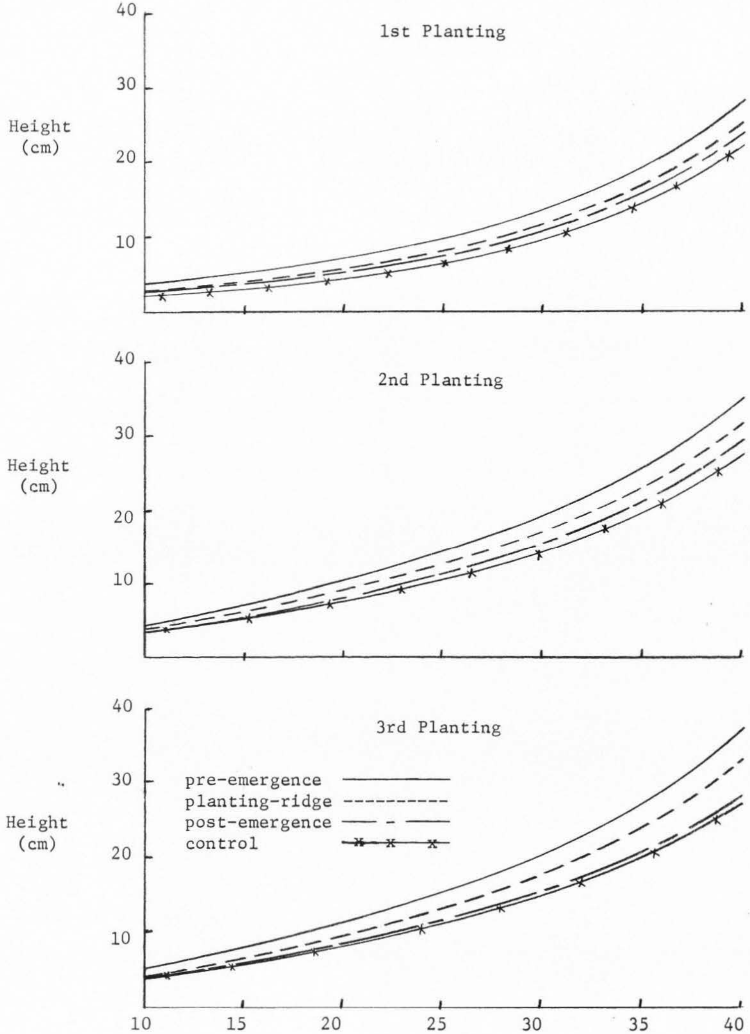

Figure 1. Effect of treatment and planting date on bean plant growth (height in cm) *vs* time (days since planted).

24 percent taller than those of the first planting. The plants in the third and second planting had reached about the same height after 35 days growth that the first planting did in 40 days.

The bean seed yield per plant was also taken of those plants used in the plant growth measurements. The results are listed in Table 3. The effect of the treatments was significant. The yield increase of the three treatments were:pre-emergence, 65 percent;planting-ridge, 39 percent; and post-emergence, 21 percent over the control.

The influence of planting dates was also significant. The third planting yields were 62 percent higher than the first planting. The second planting yields were 47 percent greater than the first. These results showed that the later planting dates provided conditions that enabled the plants to grow faster than the earlier plantings.

Soil water content

Figures 2 and 3 contain the results for gravemetric soil water content measurements for the first planting. The original soil surface was the reference point for sampling. The data show that the pre-emergence treatment maintained a higher water content from planting to the first irrigation particularly at the 2- and 4-inch depth. This does not mean that the pre-emergence treatment has a higher total water content from row to row but only that the water content was higher in the seed row area. The soil that was moved from the centers to the ridges over the seed row dries out as does the surface of the other treatments. However, in the pre-emergence and planting-ridge treatments the original soil surface was "insulated" by the ridge, thereby retaining the water in the original surface area for plant

Table 3. Bean seed yield (grams per plant) of the marked plants used for plant height measurements

Treatment	Date 1[a]	Date 2[b]	Date 3[c]	Average
Pre-emergence	15.7	21.5	24.1	20.4
Planting-ridge	12.8	18.8	20.1	17.2
Post-emergence	10.3	16.4	18.0	14.9
Control	8.7	13.3	14.9	12.3
Average	11.9	17.5	19.3	

Pooled Analysis of Variance

Source	df	SS	MS	F
Total	35	700.7		
Date	2	358.9	179.4	203.9**
Rep/Date	6	1.3	0.2	0.22
Trt	3	319.9	106.6	121.1**
Trt x Date	6	4.6	0.76	0.86
Error	18	16.0	0.88	

[a]Planted 6/4/71; harvested 9/1/71.

[b]Planted 6/14/71; harvested 9/8/71.

[c]Planted 6/20/71; harvested 9/11/71.

**Indicates significane at 0.01.

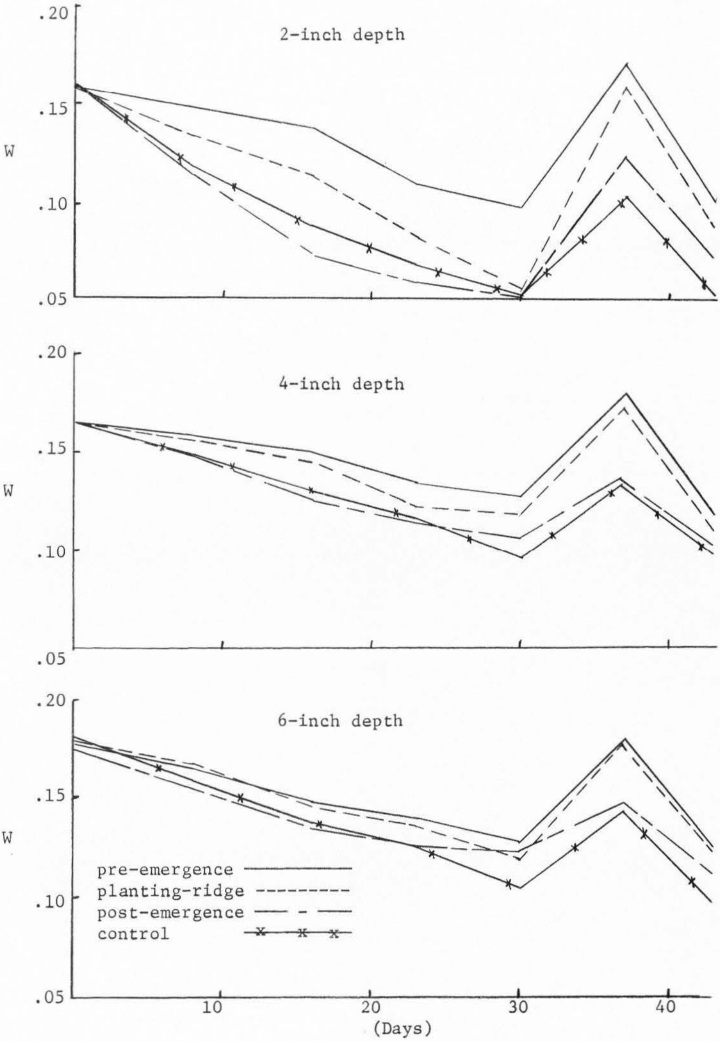

Figure 2. Soil water content by weight (W) *vs* time (days from planting) for 2-, 4-, and 6-inch depth in first planting (beans).

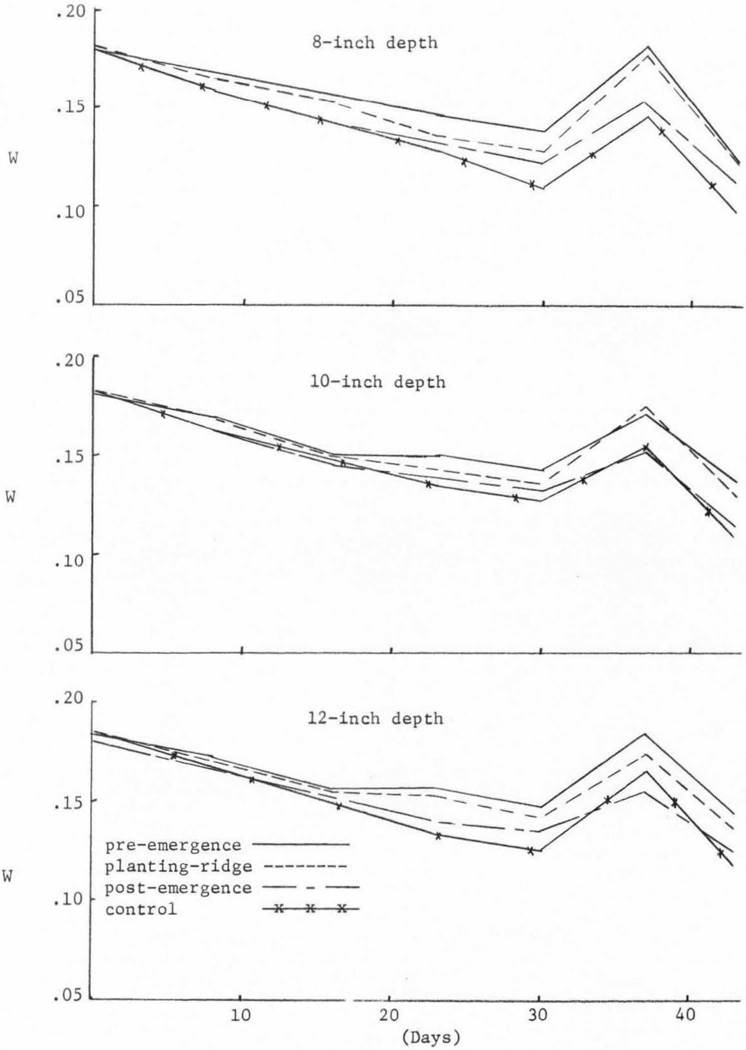

Figure 3. Soil water content by weight (W) *vs* time (days from planting) for 8-, 10-, and 12-inch depth in first planting (beans).

use. The planting-ridge treatment would probably have remained nearer the pre-emergence treatment if the soil had not been disturbed by cultivation. The limiting water content appeared to be about 0.10 by weight since the pre-emergence treatment did not get much below that point, even at the 2-inch depth. The plants seemed to use the water from the other depths rather than dry the 2-inch depth below 0.10. This would indicate that the difference in water content at the 2-inch depth between treatments was primarily due to evaporation loss. The evaporation losses in the seed area were different between treatments because of the difference in location of the seed to the new soil surface. The seed was originally 2 1/2 inches from the surface in all treatments. The 2 1/2-inch ridge of soil that was placed over the row before the surface soil had dried in the pre-emergence treatment placed the seed 5 inches from the present soil surface. The planting-ridge treatment acquired a 1 1/2-inch ridge, placing the seed 4 inches below the present surface. The soil in the planting-ridge treatment, however, was disturbed twice by cultivation that allowed more water to evaporate than in the pre-emergent treatment. The post-emergence treatment was ridged but the surface soil had already dried before the ridge was formed. This treatment also received more cultivation which allowed more water to evaporate. In the control treatment seed location, with regard to the soil surface, remained the same. The difference in the 2- and 4-inch depths, which could be subjected to evaporation account for the differences at the other depths.

The average water content at the 2-inch depth from planting to the first irrigation for each of the treatments was as follows: pre-emergence, .129; planting ridge, .110; post-emergence, .092; and control, .098. The average water content at the 4-inch depth for the same time period was: pre-emergence, .147; planting-ridge, .141; post-emergence, .131; and control, .132.

Figures 4, 5, 6, and 7 contain the results of the gravemetric water content measurements of the second and third plantings. The results were very similar to those of the first planting. The differences in the 2-inch depth were greater between treatments indicating more loss to evaporation due to the higher temperatures of the later plantings. The water content after irrigation reached about the same point for all treatments in the second and third plantings which indicated the soil was homogeneous. In the first planting, the post-emergence and the control treatments were irrigated 2 days before the other two which would account for the differences for the after irrigation measurement.

The average water content at the 2- and 4-inch depth for the treatments in the second planting from planting to the first irrigation were: pre-emergence, .120 and .133; planting-ridge, .098 and .126; post-emergence, .083 and .123; and control, .088 and .120. The average water content at the 2- and 4-inch depths for the third planting for the same time period were: pre-emergence, .121 and .32; planting-ridge, .099 and .123; post-emergence, .090 and .123; and control, .089 and .119.

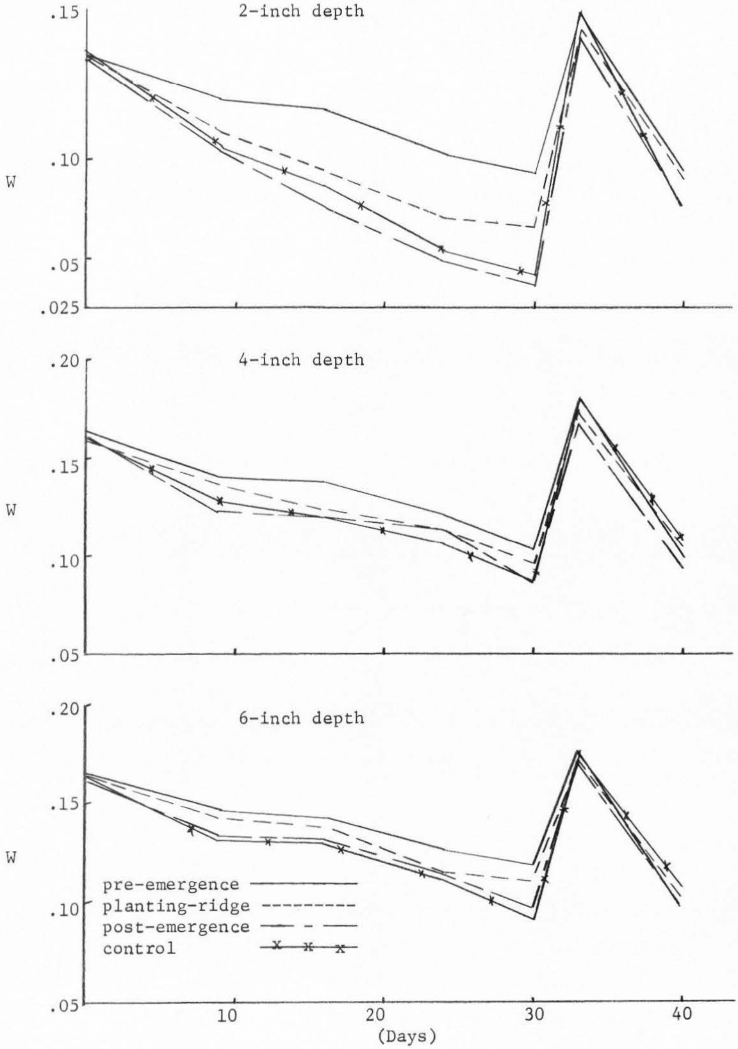

Figure 4. Soil water content by weight (W) *vs* time (days from planting) for 2-, 4-, and 6-inch depth in second planting (beans).

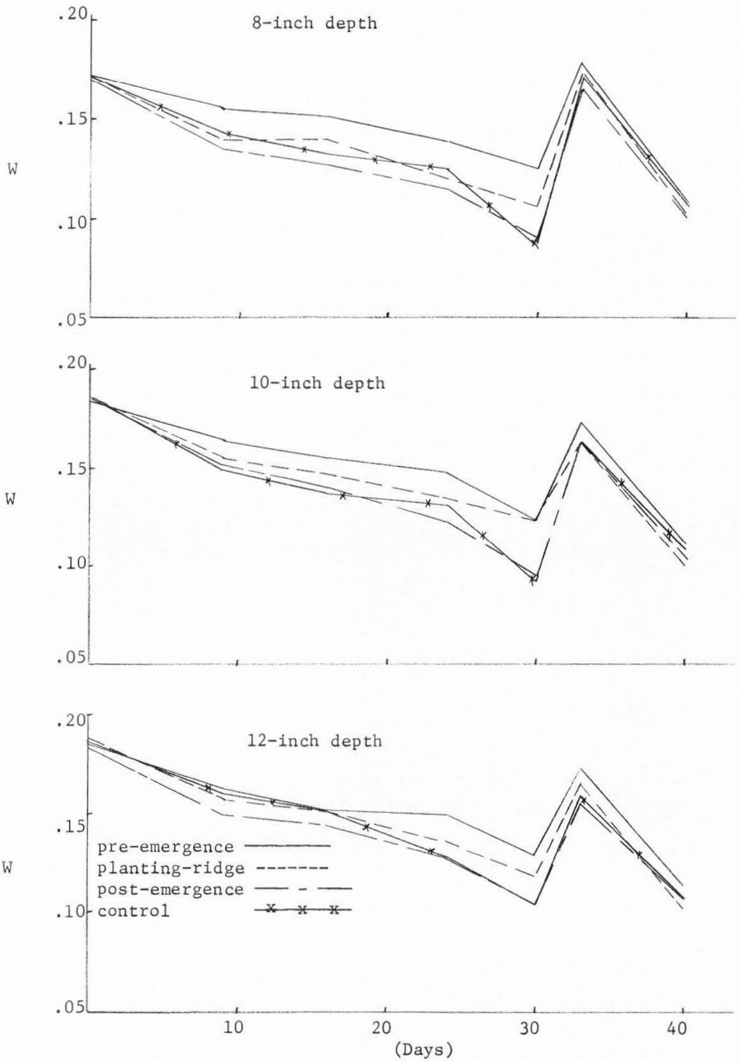

Figure 5. Soil water content by weight (W) *vs* time (days from planting) for 8-, 10-, and 12-inch depth in second planting (beans).

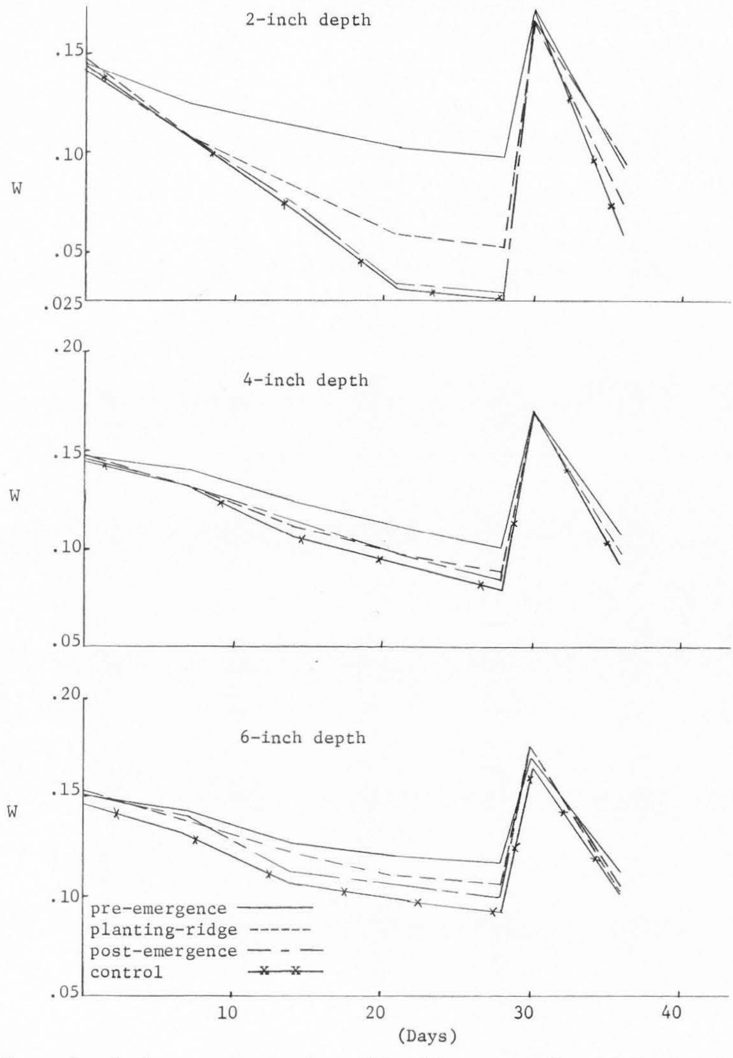

Figure 6. Soil water content by weight (W) *vs* time (days from planting) for 2-, 4-, and 6-inch depth in third planting (beans).

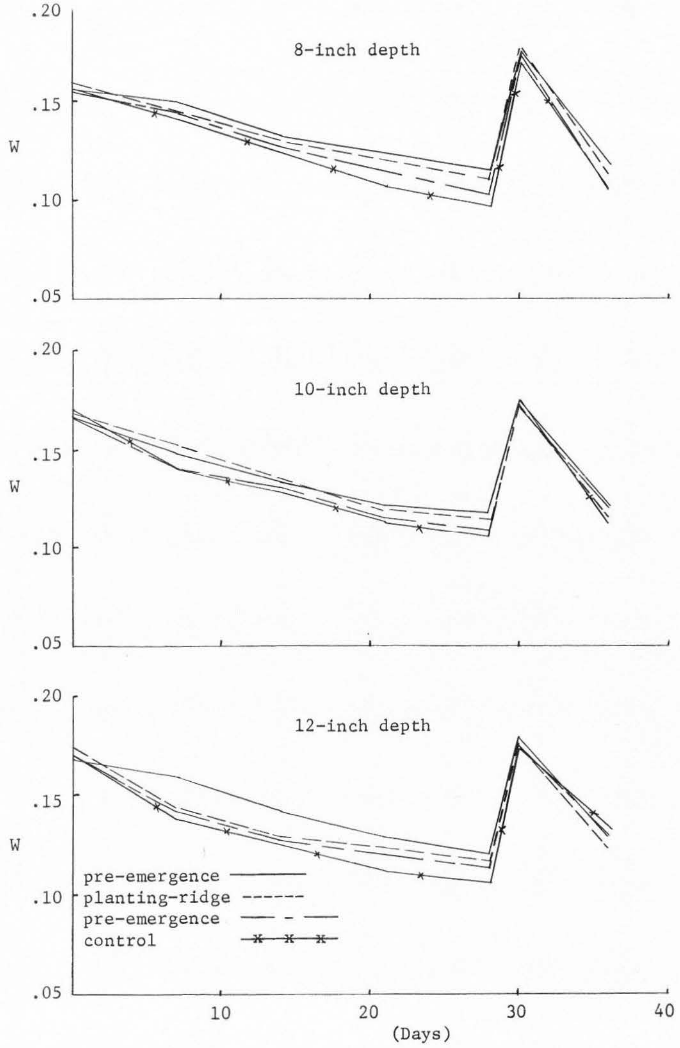

Figure 7. Soil water content by weight (W) *vs* time (days from planting) for 8-, 10-, and 12-inch depth in third planting (beans).

It should be noted here that the trends of the moisture content for the various treatments followed the same trends as the various yield results. The treatments with the highest yields also had the highest water content throughout the early growth period.

The soil water content of depths greater than 12 inches was measured with a neutron probe. The changes in water content was very near the same in all treatments within each planting date at corresponding depths.

Soil temperatures

The results of the soil temperature measurements for the first planting are shown in Figure 8. The pre-emergence treatment had the highest temperature throughout the day. The average soil temperatures for the treatments in the first planting throughout the day at 2-, 4-, and 6-inch depths were: pre-emergence, 29.9, 26.9, and 25.8 C; planting-ridge, 27.1, 25.8, and 24.6 C; post-emergence, 26.6, 25.3, and 24.2 C; and control, 28.1, 25.4, and 23.8 C. There does not however, seem to be a consistent relation between treatments at all depths.

Figures 9 and 10 show the results of the soil temperature measurements for the second and third plantings. The same general trends occurred here as in the first planting. The average soil temperatures for the treatments in the second planting throughout the day at 2-, 4-, and 6-inch depths were: pre-emergence, 33.3, 30.5, and 28.4 C; planting-ridge, 31.6, 29.2, and 27.7 C; post-emergence, 31.3, 28.8, and 27.0 C; and control, 32.3, 29.6, and 27.5 C. The same data for the third planting were: pre-emergence, 33.5, 29.3, and 28.1 C;

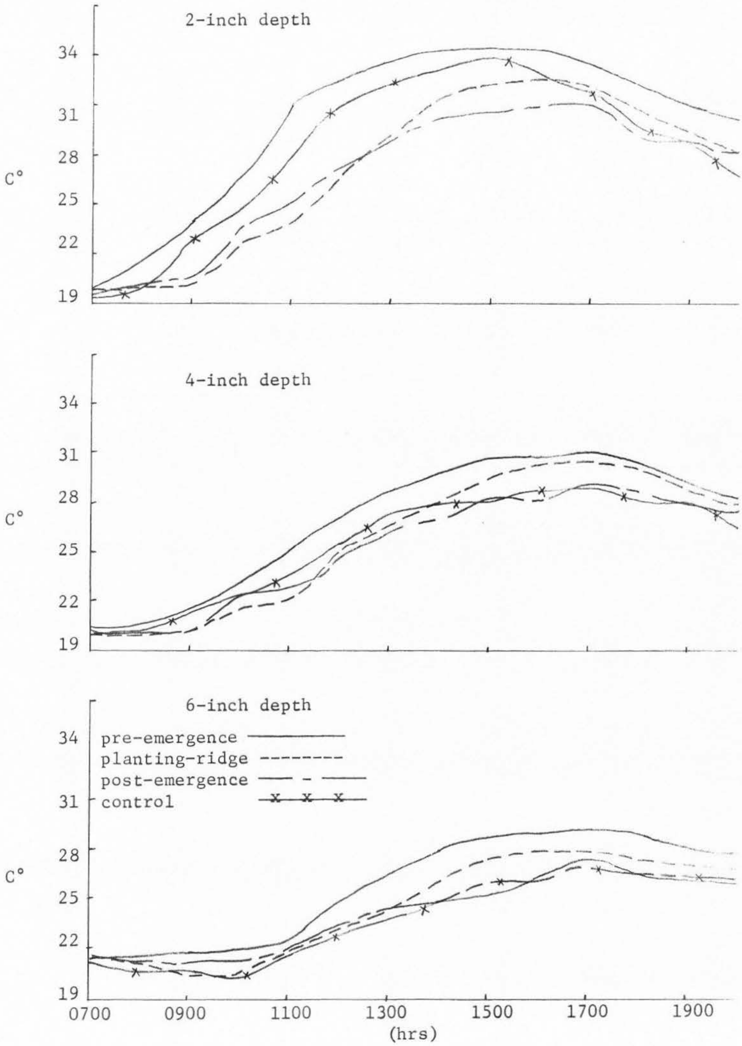

Figure 8. Soil temperature (C°) *vs* time (hrs) for 2-, 4-, and 6-inch depths in first planting of beans measured 6/30/72.

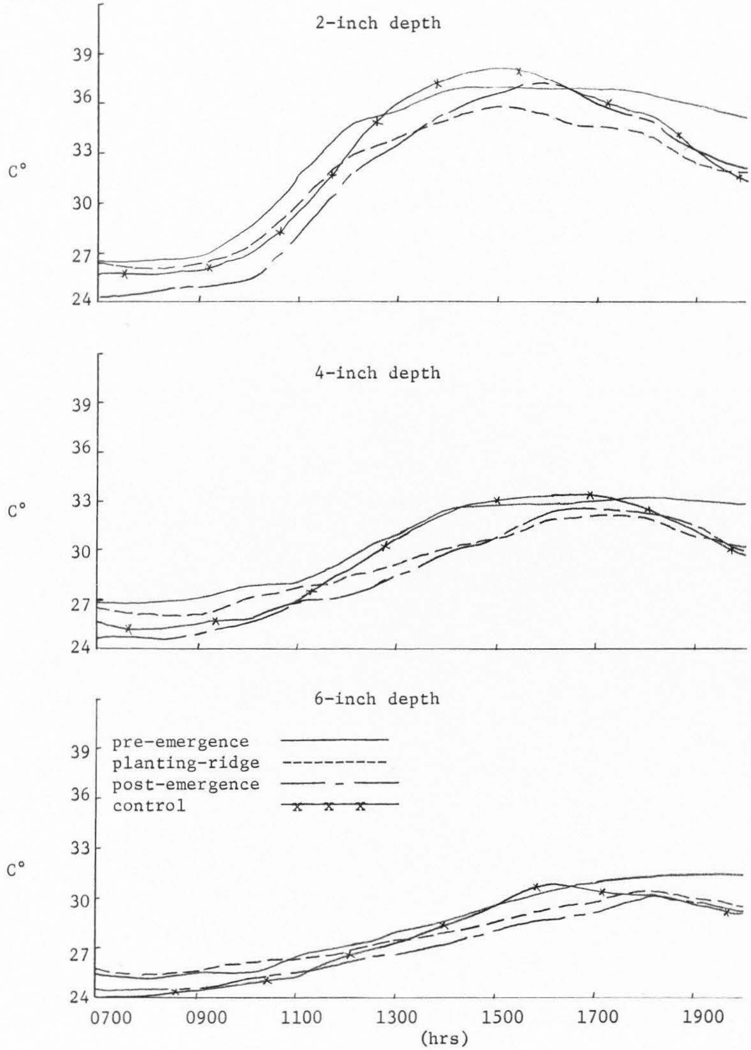

Figure 9. Soil temperature (C°) *vs* time (hrs) for 2-, 4-, and 6-inch depths in second planting of beans measured 7/14/71.

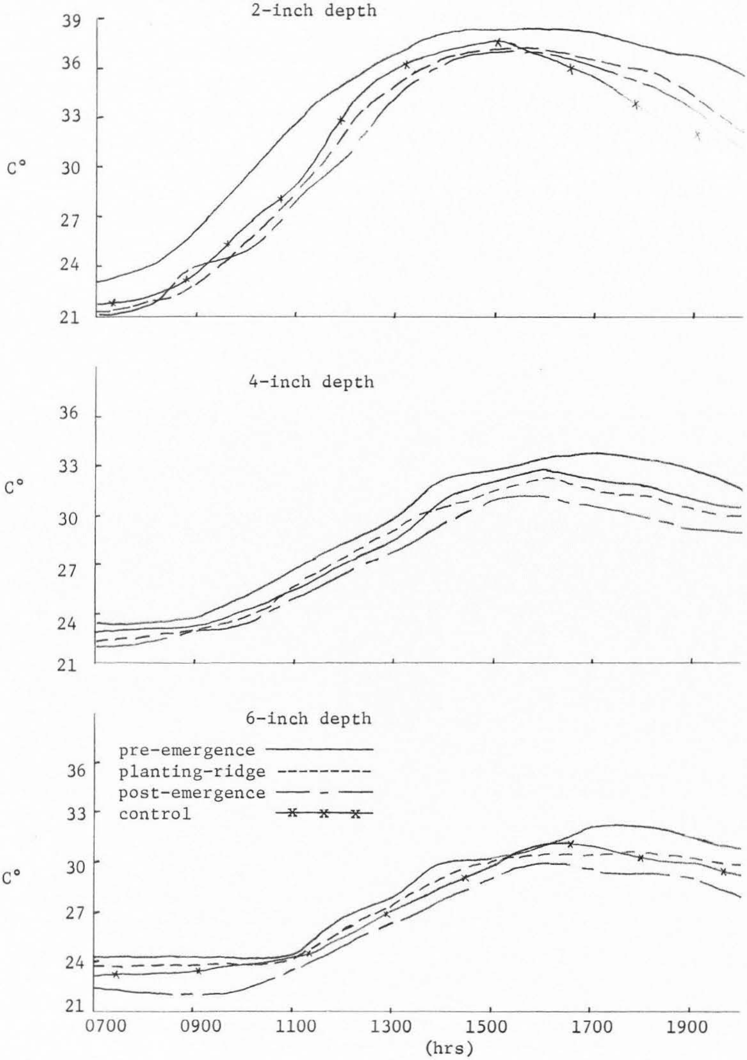

Figure 10. Soil temperature (C°) *vs* time (hrs) for 2-, 4-, and 6-inch depths third planting in beans measured 7/17/71.

planting-ridge, 31.4, 28.0, and 27.3 C; post-emergence, 30.8, 27.2, and 26.2 C; and control, 31.1, 28.2, and 27.1 C. The soil temperature of the pre-emergence treatment was generally highest followed by the control. The soil temperature of the planting-ridge treatment was generally greater than the pre-emergence treatment. Thus, the soil temperatures did not show a clear-cut relation to yield.

The data indicated that there may have been an effect due to the ridge of soil that was confounded by an effect due to time since cultivation. The pre-emergence and control treatments were cultivated at about the same time. The pre-emergence had the ridge of soil and the highest temperatures. The planting-ridge and the post-emergence treatments were disturbed at the same time with the planting-ridge treatment having the highest ridge and highest temperature.

With the exception of the pre-emergence treatment (which had highest temperature and greatest yield), the results of the temperature measurements failed to support the theory that increased soil temperatures will increase yield of beans. However, the results did show a temperature change due to the treatments.

There was undoubtedly a planting date influence on the general temperature effects. The average soil temperature during the growing season would be related to the yield differences.

Root disease development and weed control

The results from *Fusarium* root rot indexes are contained in Table 4. The influence of the treatments on root rot was significant. The pre-emergence treatment had 50 percent less infection than the

Table 4. Bean root rot infection. Scale 0-5 with 0 being no infection and 5 being total infection[a]

Treatment	Date 1	Date 2	Date 3	Average
Pre-emergence	2.4	1.9	1.0	1.8
Planting-ridge	3.0	2.4	1.9	2.4
Post-emergence	3.3	3.1	2.7	3.0
Control	4.0	3.6	3.3	3.6
Average	3.2	2.7	2.2	

Pooled Analysis of Variance

Source	df	SS	MS	F
Total	35	24		
Date	2	6	3	84.8**
Rep/Date	6	0.1	0.02	0.6
Trt	3	17	5.7	172.7**
Trt x Date	6	0.7	0.12	3.6*
Error	18	0.6	0.033	

[a]Measured 8/7/71.

*Indicates significance at 0.05.

**Indicates significance at 0.01.

control. The planting-ridge treatment had 30 percent less than the control and the post-emergence was 17 percent less than control.

These results agree with those of Burke (Personal communication, 1971), that if the plant has the opportunity to develop roots above the tap root it will do so and the plant will do quite well in spite of the attack of the fungus. These results showed a direct relationship between early soil ridging and secondary root formation.

The influence of the planting date on root rot infection was also significant as was the interaction between treatment and date (to a lesser degree). The infection in the third planting was 32 percent less than the first planting date. The second planting had 15 percent less root rot infection than the first planting. Burke (1964) also found that *Fusarium* root rot was more damaging in early plantings than later ones.

Figure 11 is a photograph taken July 6, 1971, showing the root development of one plant from each treatment of the third planting. The length of the roots were as follows: pre-emergence treatment, 10 cm; planting-ridge, 8.5 cm; post-emergence, 6.7 cm; and control, 5.5 cm. These same approximate results were obvious from casual inspection of the plots.

Figure 12 is a photograph taken July 26, 1971, also of the plants from the third planting. The same relationship between treatments is apparent as was shown in Figure 10 for 20 days earlier. These photographs indicate that the early conditions in the plants life are very critical and influence its entire growth.

Figure 11. Photograph taken July 6, 1971 showing bean root development.

Figure 12. Photograph taken July 26, 1971 showing bean root development.

Table 5 contains the results of the weed count of the treatments. The control treatment was not listed as this treatment was weeded periodically by hand. The pre-emergence treatment had 60 percent fewer weeds than the post-emergence treatment. The planting-ridge treatment had 33 percent fewer weeds than the post-emergence treatment. The advantage of the pre-emergence treatment was that this treatment allowed control of the weeds that were close to the surface that emerged ahead of the beans. The emerging weeds were smothered by

Table 5. Bean weed control--weeds/replication

Treatment	Date 1	Date 2	Date 3	Average
Pre-emergence	35	13	4	17
Planting-ridge	46	25	13	28
Post-emergence	68	35	24	42
Average	50	24	14	

Pooled Analysis of Variance

Source	df	SS	MS	F
Total	26	9405		
Date	2	2801	1401	54.7*
Rep/Date	6	14	2.3	0.09
Trt	2	6073	3037	119**
Trt x Date	4	210	52	2.05
Error	12	307	26	

*Indicates significance at 0.05.

**Indicates signficance at 0.01.

the soil ridge thrown over the row. This soil was loose and dried rapidly and the weed seeds in the new surface did not germinate until after irrigation at which time the weeds were shaded by the plants. The planting-ridge treatment was not as effective for weed control because the soil was moist when the ridge was formed and the weeds and beans grew at the same time. The post-emergence treatment involved similar growth for the beans and the weeds until cultivation. The weeds in the bean row were partially covered by the soil moved in by cultivation to "hill" but not cover the beans.

The later plantings also had less weeds. This was probably due to the edge the beans were given in the "race" with the weeds by the warmer climate of the later plantings. Also many weed seeds may have emerged earlier in the year before planting.

Discussion of Bean Results

Effect of treatments

The primary purpose of this investigation was to determine the effect of a pre-emergence cultivation on bean growth. The results showed it was the best technique used. Therefore, this discussion will be primarily concerned with effect of this treatment.

The advantages of the pre-emergence treatment are as follows:

1. Favors the seedling establishment of beans over weeds.
2. Maintains high water content in the seed zone.
3. Increases soil temperature in the early growth stage root zone.
4. Provides for a larger root volume without pruning roots and reduces root rot.
5. Produces the greatest yields.

Controlling weeds are one of the major problems of commercial, irrigated bean producers. With the emphasis on non-chemical weed control currently popular with ecologists, efficient methods of mechanical control are still necessary. The pre-emergent method smothers the weeds early and leaves a loose dry mulch with which to use for the last cultivation without having to disturb any soil other than the dry surface of the ridge. Even in the first planting, which received a heavy rainfall after the ridge was applied, this had the advantage. The large ridge in this treatment allowed a shallow cultivation to break up the crust that had formed and remove the small weeds that had germinated. Cultivation on the other treatments had to be post-poned until the beans were larger at which time many of the weeds were too large to cover. Also the beans in the pre-emergence treatment did not suffer seedling loss due to the crust as did the beans of the other treatments.

The pre-emergence treatment reduced the evaporation losses in the bean row area by bringing soil from centers over the bean row. This effectively increased the distance from the bean seed to the soil surface and reduced water loss from the soil at the seed depth. The bean roots only reach 4 to 6 inches from the row before the first irrigation so the moisture between rows was not needed.

The pre-emergence treatment was the only treatment to have a large enough effect on soil temperature to influence yield. The large undisturbed soil ridge seems to provide for a more direct angle of radiation. The undisturbed soil evidently provided better conductance of heat from the surface to the lower depths. The increased moisture in the zone also acted as a buffer resisting rapid fluctuations in temperature.

For the pre-emergence treatment the soil ridge was formed with the cultivator shovels operating considerable distances from the row (8 inches). This allowed the soil near the bean roots to remain undisturbed providing a good area for secondary root development without fear of pruning any of the roots with later cultivations as the later cultivation never went beneath the mulch. The decreased root pruning and increased root area formed by the ridge enabled the plant to better withstand the attack by the *Fusarium* fungus.

The yield results of this research showed conclusive evidence that the pre-emergence treatment was the best technique used. It is the opinion of this worker that the most significant influences of the pre-emergence treatment on yield were reduction of water loss near the seed, reduced root rot, and increased root development.

Effect of planting dates

The results of this investigation showed the influence of the later planting significantly increased the bean yields. In an irrigated area, such as this, temperature and day length are the two factors that can be improved by later plantings. Higher temperature and longer days allows the plant to receive more total energy in the later plantings than the early plantings. The more rapid plant growth of the later plantings also reduced fungus injury. Planting must be done early enough to allow the beans time to mature however.

Results of Corn Research

Yield

Table 6 shows the results for ear corn yields. There was significant differences in yield due to effect of the treatments. The post-emergence treatment yielded 20 percent more ear corn than the control treatment. The pre-emergence treatment yielded 40 percent more ear corn than the control treatment and 17 percent more than the post-emergence treatment.

Table 6. Effect of treatments on ear corn yield (lbs/80-foot row). Harvested 9/15/71

Treatment	Rep 1	Rep 2	Rep 3	Average	kg/ha
Pre-emergence	53.7	55.4	51.3	53.5	18,175
Post-emergence	45.0	45.6	46.7	45.8	15,559
Control	38.9	34.9	41.5	38.4	13,045
Average	45.9	45.3	46.5	45.9	15,593

Analysis of Variance

Source	df	SS	MS	F
Total	8	371.2		
Rep	2	2.2	1.1	.15
Trt	2	339.1	169.5	22.6*
Error	4	29.9	7.5	

CV = 7.5/45.9 = 0.06

The results of the dry weight yields taken between the first and second irrigation are contained in Table 7. The post-emergence treatment produced 26 percent more dry matter than the control treatment. The pre-emergence treatment produced 47 percent more dry matter than the control treatment and 17 percent more than the post-emergence treatment. The results contained in Table 8 indicated that the treatment influence effected the early growth of the crop.

Table 7. Effect of treatments on dry weight yield in grams/3 feet. Harvested 7/26/71

Treatment	Rep 1	Rep 2	Rep 3	Average	kg/ha
Pre-emergence	558	490	487	511.7	10,198
Post-emergence	451	425	438	438.0	8,729
Control	298	351	395	348.0	6,935
Average	435.7	422.0	440.0		

Analysis of Variance

Source	df	SS	MS	F
Total	8	48,594.2		
Rep	2	529.5	264.7	0.14
Trt	2	40,313.5	20,156.7	10.4
Error	4	7,751.2	1,937.8	

Table 8. Effect of treatments on the total plant yield in kilograms/3 feet. Harvested 9/14/71

Treatment	Rep 1	Rep 2	Rep 3	Average	kg/ha
Pre-emergence	1.68	1.70	1.63	1.67	33,288
Post-emergence	1.40	1.38	1.43	1.40	27,906
Control	1.18	1.11	1.16	1.15	22,923
Average	1.42	1.40	1.41	1.41	28,039

Analysis of Variance

Source	df	SS	MS	F
Total	8	0.41		
Rep	2	0	0	0
Trt	2	0.39	0.20	40.0*
Error	4	0.02	0.005	

The total plant yield results in Table 8 shows the effect of the treatments on total plant yield was significant. The yield of the post-emergence treatment was 21 percent greater than the yield of the control treatment. The pre-emergence treatment yielded 45 percent more than the control treatment and 19 percent more than the post-emergence treatment. These results indicate that the influence of the treatments on the early growth of the corn carried on through to maturity. The dry weight yields appear to be high. The samples were dried in the ovens at 50 C for 48 hours without the stalks being shredded. This may not have allowed the samples to dry completely. However, the values are near those determined by Sandberg (1971).

Soil water content

Figure 13 shows the water content at 6-, 12-, and 18-inch depths for each of the three treatments. The original seedbed surface was the reference point for the depth of sampling for all the treatments. The pre-emergence treatment maintained the highest water content from planting to the first irrigation at all three depths. The difference between the treatments decreased, however, with depth. The post-emergence treatment water content was higher than the control at the 6- and 12-inch depth but only slightly higher at 18 inches. The post-emergence treatment had a lower water content at the first measurement at 18 inches than the control treatment and this difference was maintained throughout the measured period. Very little water was used at this depth until 20 days after planting which was an indication of root depth for that period. The average water content of all the treatments from planting until the first irrigation for 6-, 12-, and 18-inch depths,respectively, were pre-emergence, .128, .144, and .188; post-emergence .113, .135, and .177; control .107, .127, and .181.

The pre-emergence treatment maintained a higher water content than the other treatments because the soil that was moved from the center to the ridge over the seed row dried out as did the surface of the other two treatments and insulated the soil below against further evaporation. This additional water was held within the root zone of the young corn plants and provided for a better early growth in the pre-emergence treatment. The water content measured by the neutron probe at depths greater than 18 showed very little change from planting until the first irrigation.

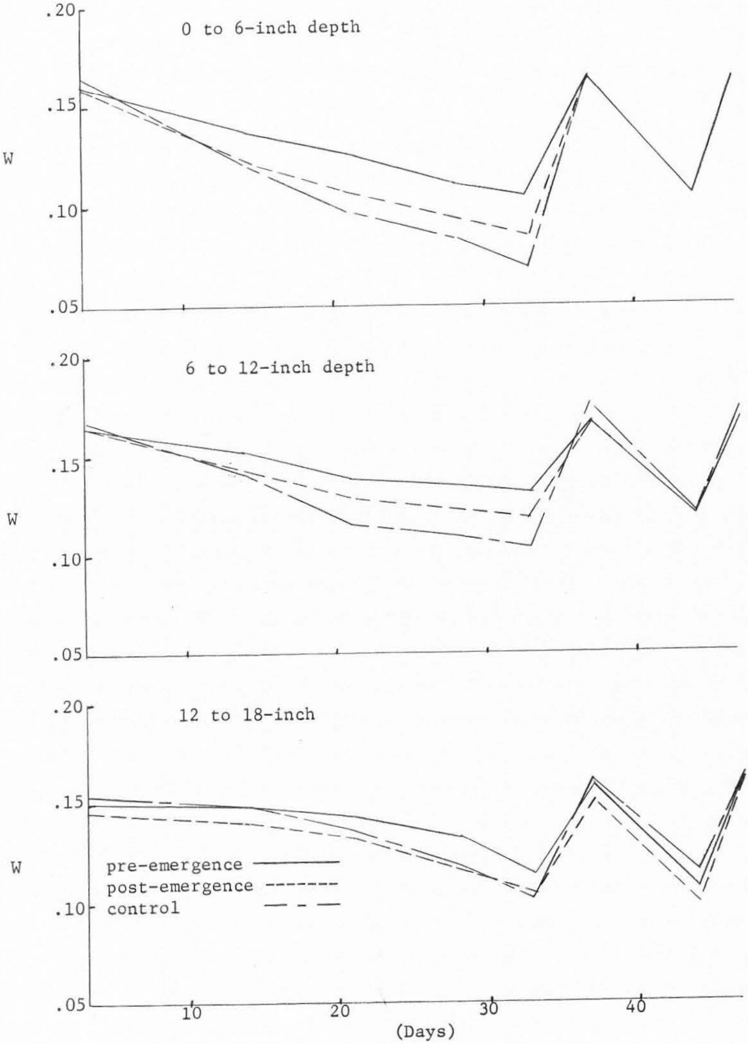

Figure 13. Soil water content by weight (W) *vs* time (days from planting) for 6-, 12-, and 18-inch depths (corn).

Soil temperature

Figure 14 shows a plot of soil temperature each hour from 0700 to 2000 at 2-, 4-, and 6-inch depths. Here again the seedbed surface was the reference point for the depths of measurements. The pre-emergence treatment maintained higher temperatures throughout the day than the other two treatments at all depths. The control treatment maintained higher temperatures at the 2-inch depth than the post-emergence treatment. At the 4- and 6-inch depths the post-emergence treatment and the control treatment temperatures fluctuated above and below each other. Here, as in the bean investigation, there was an effect due to the soil ridge but the effect was also confounded by the time since the soil was disturbed. The average temperature for the day at the 2-, 4-, and 6-inch depths were: pre-emergence, 29.6, 26.9, and 25.8 C; post-emergence, 26.2, 25.5, and 24.3 C; and control, 27.8, 25.3, and 23.8 C.

Weed control

Table 9 contains a weed count at "lay-by" of the three replications of the pre-emergence and post-emergence treatments. The control treatment was kept free of weeds throughout the period and was not counted. The main interest in this investigation was to keep weeds from being a factor in crop yield so the weeds were pulled by hand after counting. The pre-emergence treatment had 71 percent fewer weeds than the post-emergence treatment. The weeds germinating ahead of the corn was smothered by the soil ridge in the pre-emergence treatment whereas with the post-emergence treatment some of the weeds were too large to cover by the time the corn was tall enough to cultivate.

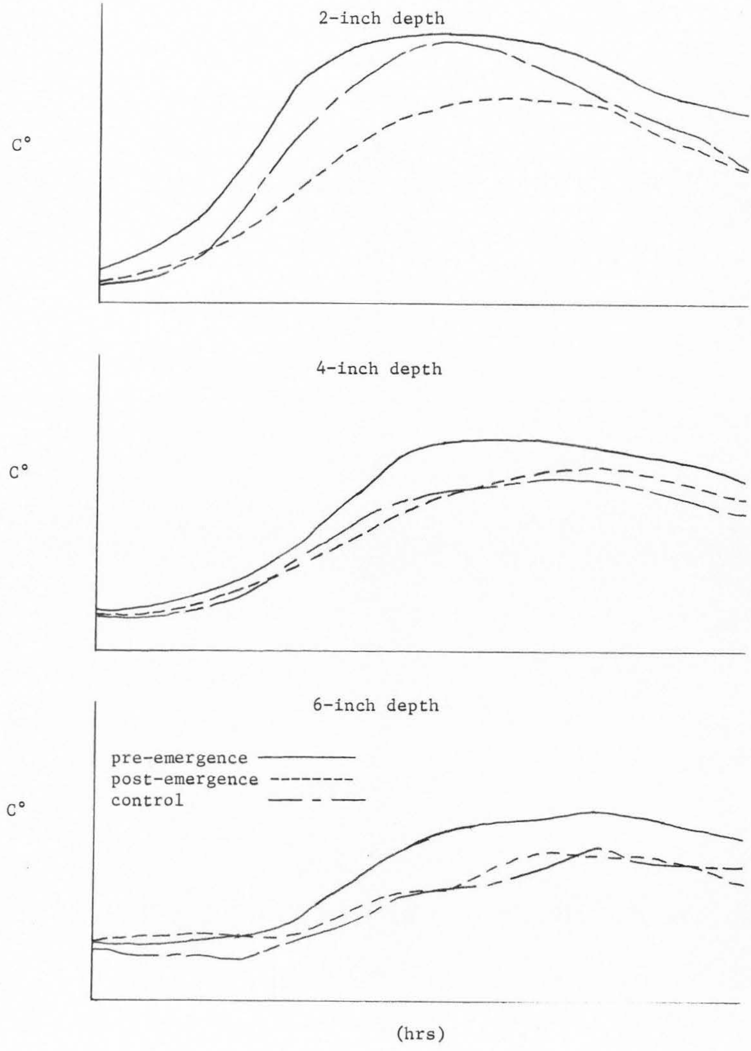

Figure 14. Soil temperature (C°) *vs* time (hrs) for 2-, 4-, and 6-inch depths in corn measured 7/19/71.

Table 9. Effect of treatments on weed control number of weeds/ replication at "lay-by"

Treatment	Rep 1	Rep 2	Rep 3	Average
Pre-emergence	13	25	19	19.0
Post-emergence	70	61	64	65.0
Average	41.5	43.0	41.5	

Analysis of Variance

Source	df	SS	MS	F
Total	5	3288.0		
Rep	2	3.0	1.5	0.03
Trt	1	3174.0	3174.0	57.19*
Error	2	111.0	55.5	

*Indicates significance at 0.05

Discussion of Corn Results

The results of this investigation showed that the pre-emergence technique of cultivation produced greater corn yield than the other methods. This technique maintains higher soil temperature and water content in the root zone for more favorable growing conditions at seedling establishment time. This method could be very valuable for raising corn particularly in a short season area as maturing time could be shortened by higher soil temperatures or with a longer season variety with greater yield potential.

CONCLUSIONS

The results of the bean and corn investigations showed that there was an effect of cultivation methods on bean and corn yields. The pre-emergence treatment produced a 48 percent greater bean yield and a 40 percent greater corn yield than the control treatment. The planting-ridge treatment produced 21 percent more beans than the control treatment. The bean and corn yields in the post-emergence treatment were 10 and 20 percent more, respectively, than the control treatment.

The difference in yield between treatments was due to differences in water content, root rot infection (in beans), rooting zone, and possibly temperature. The order of highest water content from 0- to 12-inch depths were: pre-emergence treatment, planting-ridge treatment, post-emergence treatment, and control treatment. The planting-ridge treatment was not used in the corn and with this exception the water content order for corn was the same as the beans. The order of highest soil temperature for beans (average of 2-, 4-, and 6-inch depths) were: pre-emergence 29.5 C, planting-ridge and control 28.1 C, and post-emergence 27.5 C. The average soil temperatures from 0 to 6 inches of each treatment for the corn were: pre-emergence 27.4 C, control 25.6 C, and post-emergence 25.3 C. The water content results correlate with the yield but the temperatures show no direct relationship with yield. The pre-emergence treatment had 50 percent less root rot infection than the control treatment. The planting-ridge treatment had 30 percent less infection than the control and the post-emergence treatment was 17 percent less than the control.

The difference in planting dates for beans also had a major influence on bean yield. The second planting produced 16 percent more beans than the first planting and the yield of the third planting was 42 percent greater than the control. The most important factor between planting dates was the differences in root rot infection. The root rot infection in the second and third plantings was 15 and 32 percent less, respectively, than the first planting.

These results of the beans and corn investigation showed that the pre-emergence method of cultivation produced greater yields in beans and corn by maintaining higher water content and soil temperatures in the root zone, and by allowing for greater root development and root rot resistance (in beans). This method also provided better weed control with less trips over the field.

RESEARCH NEEDS

The results from this study indicates that further study could be benefical to determine the following:

1. If different cultivation methods do have an influence on soil temperatures. This could possibly accomplished by recording soil temperatures continously from planting to harvest.
2. What influence planting date has on corn yield.
3. What influence cultivation methods have on root development in corn.

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APPENDIX

Appendix A
Basic Data Collected From Investigation

Important dates

June 4, 1971. Planted first planting beans and ridged planting-ridge treatment 1 1/2 inch.

June 7, 1971. Installed access tubes for neutron probe in the first planting.

June 10, 1971. Ridged pre-emergence treatment 2 1/2 inches of soil, heavy rain occurred that night.

June 14, 1971. Cultivated pre-emergence treatment to break soil crust caused by rain, planted second planting, ridged planting-ridge treatment, and planted corn.

June 15, 1971. Installed access tubes in second planting and corn.

June 18, 1971. Ridged pre-emergence treatment in corn.

June 20, 1971. Planted third planting, ridged planting-ridge treatment, installed access tubes, and ridged pre-emergence treatment in second planting.

June 23, 1971. Ridged pre-emergence treatment in third planting.

June 24, 1971. Cultivated planting-ridge and post-emergence treatments in the first planting.

June 29, 1971. Cultivated planting-ridge and post-emergence treatments in the second planting and installed tensiometers in the first planting.

June 30, 1971. Cultivated planting-ridge and post-emergence treatment in first planting.

July 2, 1971. Cultivated planting-ridge and pre-emergence treatment in third planting and installed tensiometers in the second planting.

July 3, 1971. Cultivated post-emergence treatment in corn and planting-ridge and post-emergence treatments in the second planting.

July 7, 1971. Cultivated planting-ridge and post-emergence treatments in the third planting.

July 9, 1971. Cultivated all treatments except the control in the first planting with knives and tails and installed tensiometers in third planting.

July 10, 1971. Irrigated post-emergence and control in first planting for 6 hours.

July 12, 1971. Irrigated pre-emergence and planting-ridge in first planting.

July 16, 1971. Cultivated with knives and tails all treatments except control in second and third plantings also the post-emergence in the first planting.

July 17, 1971. Irrigated second planting 6 hours and cultivated corn with knives and tails.

July 18, 1971. Irrigated third planting 6 hours, corn 8 hours, and took plant weight samples in first planting.

July 19, 1971. Cultivated planting-ridge in first planting.

July 20, 1971. Irrigated post-emergence and control in first planting 6 hours.

July 23, 1971. Irrigated pre-emergence and planting-ridge in first planting 6 hours.

July 24, 1971. Cultivated planting-ridge and post-emergence in second and third plantings. Harvested plant weight samples second planting.

July 26, 1971. Irrigated second planting 6 hours and harvested plant weight samples in third planting and corn.

July 27, 1971. Irrigated third planting 6 hours.

July 29, 1971. Irrigated post-emergence and control in first planting 6 hours and corn 8 hours.

August 1, 1971. Irrigated pre-emergence and planting-ridge treatments first planting 6 hours.

August 2, 1971. Irrigated second planting.

August 3, 1971. Irrigated third planting.

August 6, 1971. Irrigated post-emergence and control in first planting.

August 9, 1971. Irrigated pre-emergence and planting-ridge first planting.

August 10, 1971. Irrigated corn.

August 11, 1971. Irrigated second planting.

August 12, 1971. Irrigated third planting.

August 14, 1971. Irrigated post-emergence and control first planting.

August 16, 1971. Irrigated pre-emergence and planting-ridge first planting.

August 17, 1971. Irrigated second planting.

August 19, 1971. Irrigated third planting.

August 21, 1971. Irrigated corn.

August 23, 1971. Irrigated post-emergence and control first planting.

<u>September 1, 1971</u>. Harvested first planting.

<u>September 8, 1971</u>. Harvested second planting.

<u>September 11, 1971</u>. Harvested third planting.

<u>September 14, 1971</u>. Harvested plant weight in corn.

<u>September 15, 1971</u>. Harvested ear corn.

Table 10. Bean seed weights 10-foot section from each of the six inside rows from each replication of each treatment in grams

Pre-emergent treatment			Planting-ridge treatment			Post-emergence treatment			Control		
R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
					First Planting						
556.6	563.8	633.8	472.7	507.6	483.6	489.6	470.7	469.8	431.7	354.3	411.5
528.2	577.6	626.3	789.2	505.3	476.3	451.4	420.2	469.7	392.9	372.6	377.7
545.6	574.4	604.6	476.3	496.5	470.1	465.8	448.3	451.2	397.6	401.1	389.2
538.3	586.7	615.3	481.1	498.1	475.9	476.5	468.1	457.3	420.3	370.1	391.4
551.2	590.3	601.2	486.3	504.2	487.9	488.3	432.2	460.2	415.6	367.3	415.6
554.4	595.6	599.5	501.1	493.6	488.5	468.2	436.7	467.3	405.1	362.4	403.5
					Total						
3274.3	3488.4	3680.7	2906.7	3005.3	2882.3	2839.8	2676.2	2775.5	2463.2	2227.8	2388.9
					Average						
545.7	581.4	613.4	484.4	500.0	480.4	473.3	446.0	462.6	410.5	371.3	398.2
					Second Planting						
649.3	709.6	680.9	535.7	560.9	555.3	485.7	472.0	517.9	458.6	470.3	462.0
645.6	711.2	689.1	558.3	556.7	606.6	497.3	472.8	521.6	433.8	492.3	478.6
654.3	715.1	703.2	613.6	586.3	575.2	542.2	483.4	489.3	478.6	473.6	500.2
644.6	702.3	673.4	604.2	609.6	581.2	521.4	481.3	516.7	449.3	469.4	496.2
663.7	721.3	664.4	574.7	562.4	563.1	503.6	494.9	504.6	439.8	486.8	458.6
639.2	714.2	692.6	588.4	573.5	597.4	500.4	489.1	500.1	452.6	460.2	485.3
					Total						
3896.7	4273.7	4103.6	3474.9	3449.4	3478.8	3050.6	2893.5	3050.2	2712.2	2852.6	2880.9
					Average						
649.4	712.3	683.9	579.2	574.9	579.8	508.4	482.3	508.4	452.0	475.4	480.2

Table 10. Continued

Pre-emergent treatment			Planting-ridge treatment			Post-emergence treatment			Control		
R1	R2	R3	R1	R2	R3	R1	R2	R3	R1	R2	R3
					Third Planting						
830.9	827.2	825.2	680.3	668.3	663.1	600.1	646.8	607.3	525.6	573.3	578.6
845.6	887.3	901.3	659.6	672.5	691.3	625.6	629.4	627.6	548.3	588.9	591.3
893.0	855.6	856.7	687.4	659.1	711.4	608.4	603.4	639.4	570.6	579.6	603.6
878.5	866.3	897.6	661.3	686.8	701.8	604.5	615.7	616.9	556.3	596.3	609.7
861.2	849.1	874.3	678.5	663.7	678.9	613.7	633.3	622.7	529.6	583.4	584.3
875.3	868.6	871.4	669.7	678.1	670.1	621.6	612.9	609.8	539.2	590.6	574.5
					Total						
5184.5	5154.1	5226.5	4036.8	4028.5	4116.6	3673.9	3741.5	3723.7	3269.6	3512.1	3542.0
					Average						
864.1	859.0	871.1	672.8	671.4	686.1	612.3	623.6	620.6	544.9	585.3	590.3

Table 11. Bean seed yield (average of each replication) and analysis of variance

Treatment	Rep 1	Rep 2	Rep 3	Average gram	Average kg/ha
		Bean seed yield first planting			
Pre-emergence	545.7	581.4	613.4	580.2	3423.18
Planting-ridge	484.4	500.9	480.4	488.6	2882.7
Post-emergence	473.3	446.0	462.6	460.6	2717.5
Control	410.5	371.3	398.2	393.3	2320.5
Average					

Analysis of variance

Source	d.f.	SS	MS	F
Totals	11	57,685.7		
Rep	2	407.1	203.55	0.36
Trt	3	53,973.3	17,991.1	32.6 **
Error	6	3,305.3	550.9	

CV = $\sqrt{550.9}/481 = 0.04$

Treatment	Rep 1	Rep 2	Rep 3	Average gram	Average kg/ha
		Bean seed yield second planting			
Pre-emergence	649.4	712.3	683.9	681.9	4023.2
Planting-ridge	579.2	574.9	579.8	578.0	3410.2
Post-emergence	508.4	482.3	508.4	499.7	2948.2
Control	452.0	475.4	480.2	469.2	2768.3
Average	547.2	561.2	563.1	557.2	

Analysis of variance

Source	d.f.	SS	MS	F
Totals	11	83,978.0		
Rep	2	598.9	299.4	0.77
Trt	3	81,069.8	27,023.3	70.2 **
Error	6	2,309.3	384.9	

CV $\sqrt{384.9}/557.2 = 0.03$

Treatment	Rep 1	Rep 2	Rep 3	Average gram	Average kg/ha
		Bean seed yield third planting			
Pre-emergence	864.0	859.0	871.1	864.7	5101.7
Planting-ridge	672.8	671.4	686.1	676.8	3993.1
Post-emergence	612.3	623.6	620.6	618.8	3650.9
Control	544.9	585.3	590.3	573.5	3383.6
Average	673.5	684.8	692.0	683.4	

Table 11. Continued

Analysis of variance				
Source	d.f.	SS	MS	F
Total	11	149,031.3		
Rep	2	695.7	347.8	2.55
Trt	3	147,517.9	49,172.6	360.8 **
Error	6	817.7	136.3	
	CV $\sqrt{136.3}/683.4 = 0.01$			
	Pooled analysis of variance			
Total	35	542,374.9		
Date	2	251,679.9	125,839.9	352.2 **
Rep/Date	6	1,701.7	283.6	0.79
Trt	3	266,466.1	88,822.0	248.6 **
Trt x Date	6	16,094.9	2,682.5	7.5 *
Error	18	6,432.3	357.3	

[*] Indicates significance at 0.05 level

[**] Indicates significane at 0.01 level

Table 12. Plant weights for beans (3-foot section) from each replication in grams

Treatment	Rep 1	Rep 2	Rep 3	Average	Kg/ha
	Plant weights first planting				
Pre-emergence	103.2	107.7	107.0	106.0	2077.6
Planting-ridge	86.9	92.0	92.1	90.3	1769.9
Post-emergence	77.9	73.5	79.2	76.9	1507.2
Control	73.4	70.9	68.5	70.9	1389.6
Average	85.3	86.0	86.7	86.0	

Analysis of variance

Source	d.f.	SS	MS	F
Total	11	2,244.4		
Rep	2	3.6	1.8	0.22
Trt	3	2,192.2	730.7	90.2 **
Error	6	48.6	8.1	

$CV = \sqrt{8.1}/86.0 = 0.03$

Treatment	Rep 1	Rep 2	Rep 3	Average	Kg/ha
	Plant weights second planting				
Pre-emergence	110.6	108.7	111.6	110.3	2161.9
Planting-ridge	92.6	93.3	92.2	92.7	1816.9
Post-emergence	83.8	84.7	84.2	84.2	1650.3
Control	77.0	76.4	75.0	76.1	1491.6
Average	91.0	90.8	90.8	90.8	

Analysis of variance

Source	d.f.	SS	MS	F
Total	11	1,933.7		
Rep	2	0.2	0.1	0.08
Trt	3	1,926.2	642.1	535.1 **
Error	6	7.3	1.2	

$CV = \sqrt{1.2}/90.8 = 0.01$

Treatment	Rep 1	Rep 2	Rep 3	Average	Kg/ha
	Plant weights third planting				
Pre-emergence	116.4	116.5	119.9	117.6	2305.0
Planting-ridge	97.3	96.6	95.7	96.5	1891.4
Post-emergence	85.1	89.4	86.0	86.8	1701.3
Control	80.1	83.6	83.7	82.5	1617.0
Average	94.7	96.5	96.3	95.8	

Table 12. Continued

Analysis of variance				
Source	d.f.	SS	MS	F
Total	11	2,229.8		
Rep	2	7.8	3.9	1.18
Trt	3	2,201.9	734.0	222.4 **
Error	6	20.1	3.3	
		$CV = \sqrt{3.3}/95.8 = 0.02$		
	Pooled analysis of variance			
Total	35	6,979.5		
Date	2	580.2	290.1	69.1 *
Rep/Date	6	11.6	1.9	0.45
Trt	3	6,265.2	2,088.4	497.2 **
Trt x Date	6	46.5	7.75	1.84
Error	18	76.0	4.2	

*Indicates significance at 0.05

**Indicates significance at 0.01

Table 13. Bean root rot infection (scale 0-5, where 0 = no infection and 5 = total infection)

Treatment	Rep 1	Rep 2	Rep 3	Average
		First planting		
Pre-emergence	2.6	2.2	2.4	2.4
Planting-ridge	2.8	3.2	3.0	3.0
Post-emergence	3.2	3.4	3.4	3.3
Control	3.8	3.8	4.4	4.0
Average	3.1	3.2	3.3	3.2

Analysis of variance

Source	d.f.	SS	MS	F
Total	11	4.4		
Rep	2	0.1	0.05	1.0
Trt	3	4.0	1.33	26.6 **
Error	6	0.3	0.05	

$CV = \sqrt{.05}/3.2 = 0.07$

Treatment	Rep 1	Rep 2	Rep 3	Average
		Second planting		
Pre-emergence	2.0	2.0	1.8	1.9
Planting-ridge	2.2	2.4	2.6	2.4
Post-emergence	3.0	3.2	3.0	3.1
Control	3.8	3.4	3.6	3.6
Average	2.75	2.75	2.75	2.75

Analysis of variance

Source	d.f.	SS	MS	F
Total	11	5.1		
Rep	2	0	0	0
Trt	3	4.9	1.63	49.4
Error	6	0.2	0.033	

$CV = \sqrt{0.033}/2.75 = 0.07$

Treatment	Rep 1	Rep 2	Rep 3	Average
		Third planting		
Pre-emergence	1.0	0.8	1.2	1.0
Planting-ridge	1.8	2.0	1.8	1.9
Post-emergence	2.8	2.6	2.8	2.7
Control	3.2	3.4	3.2	3.3
Average	2.2	2.2	2.25	2.25

Table 13. Continued

Analysis of variance				
Source	d.f.	SS	MS	F
Total	11	9.0		
Rep	2	0	0	0
Trt	3	8.9	2.96	174.1 **
Error	6	0.1	0.017	

$$CV = \sqrt{0.017}/2.22 = 0.06$$

Pooled analysis of variance

Source	d.f.	SS	MS	F
Total	35	24.1		
Date	2	5.6	2.8	84.8 **
Rep/Date	6	0.1	0.02	0.6
Trt	3	17.1	5.7	172.7 **
Trt x Date	6	0.7	0.12	3.64*
Error	18	0.6	0.033	

*Indicates Significance at 0.05

**Indicates significance at 0.01

Table 14. Ear corn yield inside 6 rows of each replication in each treatment in lbs/80-ft row

Pre-emergence			Post-emergence			Control		
Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3	Rep 1	Rep 2	Rep 3
54.5	57.0	50.0	47.5	45.5	47.0	39.0	36.5	45.0
52.0	52.5	51.3	43.0	46.0	47.3	38.5	33.0	39.5
57.3	53.6	54.5	46.7	47.3	46.5	36.0	35.9	44.3
50.1	56.8	50.0	45.6	43.1	46.0	41.1	35.4	42.1
56.2	55.3	49.6	43.2	49.0	44.1	38.6	34.6	38.0
52.1	57.1	52.5	44.1	42.8	49.6	40.1	33.8	40.3
				Average				
53.7	55.4	51.3	45.0	45.6	46.7	38.9	34.9	41.5

VITA

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