

the fractured pan and help to stabilize the granulation that has taken place. The length of time that subsoil chiselling may be effective under our conditions is unknown as yet.

A word of caution is necessary with respect to reduced bearing pressure following subsoil chiselling. Heavy equipment may bog down if put on the area when the soil is wet immediately after such an operation.

## EFFECT OF 2, 4-D ON FOUR SWEET CORN HYBRIDS AT DIFFERENT STAGES OF GROWTH

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### REVIEW OF LITERATURE

Sweet corn has become one of the major vegetable crops grown in the Everglades area during the past few years. Research work elsewhere indicates that perhaps herbicidal applications of 2,4-D might be used to reduce hand weeding costs in this crop, particularly in periods of extremely wet weather and after lay-by, to kill rapidly growing sticker weeds, *Amaranthus spinosus*, which interfere with harvesting.

Both field and sweet corn varieties have been found by a number of investigators to differ in their tolerance to 2,4-D (1,2,6,8,9,12,16,19,24,25) and also in type of reaction to the same 2,4-D treatment. There has also been a considerable amount of study on the effect of 2,4-D on field and sweet corn treated at different stages of growth, whether used as an overall foliage spray, or applied directionally to the base of the plants (3,4,5,6,7,8,9,12,14,16,17,23,24,25,26,27). Many of these studies were made in combination with different amounts or formulations of 2,4-D.

Some growers in the area have applied 2,4-D to sweet corn in the past. In some cases unfavorable responses resulted, reflected in lower yields and poor quality of ears. Reports from these growers were conflicting in regard to susceptibility of varieties and stages of growth at which the plants were damaged when treated with 2,4-D. The main objectives of this study, therefore, were to find (1) the growth stage at which sweet corn is least susceptible to the effects of 2,4-D, and (2) whether there are differences in the tolerance of the four most commonly grown hybrids in the area—Gold Rush, Golden Security, Ioana and Calumet.

In general, injury to sweet corn by 2,4-D spraying seems to increase with age of the plant. The critical stage for spraying 2,4-D over the foliage of the corn plant appears to be the 6 to 24 inch stages; however, when directional application of the 2,4-D solution is made only to the base of the stalk of plants 15 to 18 inches or taller, very little or no damage has been done to the corn plants and yields have not been affected (4,9,14,18,26).

Results of extensive study with 2,4-D concerning the hazard of contamination to nearby sensitive vegetable crops indicated that only the sodium or amine salts of 2,4-D should be used in this area. Preliminary work using one pound of 2,4-D as directional spray did not cause noticeable damage to sweet corn plants, although most of the common broad leaf weeds could be killed with one-half pound of 2,4-D. In this study, therefore, 0.75 pounds of the amine salt of 2,4-D was applied to the corn plants at seven stages of growth.

Severe damage to corn plants, and in many cases lower yields, have resulted from the use of one pound or more of 2,4-D acid equivalent per acre (16,17,21,24). The safe amount of 2,4-D to be used in sweet corn appears to be from  $\frac{1}{4}$  to  $\frac{3}{4}$  pounds per acre (4,7,9,18,22).

From the various reports, therefore, it is apparent that varieties or lines of sweet corn might react differently to herbicidal application of 2,4-D spray. The degree of reaction is also related to stage of growth at which the corn plants are treated, the amount of 2,4-D acid used, and the method of application of the spray material.

### PROCEDURE

A mature Everglades peat soil with a pH of 5.8 was seeded on February 21, 1953 with Gold Rush, Golden Security, Ioana and Calumet varieties of sweet corn in a split plot design, in which varieties were the major treat-

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ments and stages of growth at which the 2,4-D spray was applied were the sub-treatments. Cultural practices were in accordance with Experiment Station recommendations. Amine salt of 2,4-D was applied at a concentration of 0.75 pounds of acid equivalent in 30 gallons of water per acre at a pressure of 25 pounds per square inch. Plots were single rows 30 feet long and there were six replications. Treatments 1 to 4 were overall sprays on the corn plants and weeds with the nozzle about ten inches above the top of the corn plants. Treatments 5 to 7 inclusive were

applied directionally to the base of the plants so that the 2,4-D spray would not touch the upper three-fourths of the corn plants. Treatment 8 was a hand-hoed check with no 2,4-D application.

Treatments 1,2,3,4 and 5 were applied 7, 12, 17, 22 and 33 days respectively from seeding. Treatment dates for 6 and 7 varied according to stage of maturity of each variety. The sixth treatment was applied to Gold Rush and Ioana 44 days from seeding, and to Golden Security and Calumet 46 days from seeding. The fifth treatment was applied at

Table I. Symptoms developed by four varieties of sweet corn due to 2,4-D treatment at 0.75 pounds per acre at different stages of growth.

<u>Varieties</u>	<u>Stage at Treatment</u>	<u>Condition of the plants</u>	
		March 18	April 11
Gold Rush	1 to 2 inches	Normal	Normal
	2 to 3 inches	Severe onion leaf-stunted slightly	Leaves slightly undulated
	4 to 5 inches	Stunted only and onion leaf in the making	Severe onion leaf.
	6 to 7 inches	Bent	Severe stunting and rolling of leaves
	Tasseling	----	Normal
Golden Security	Silking	----	Normal
	1 to 2 inches	Normal	Normal (taller than check)
	2 to 3 inches	Light rolling of leaves	Normal
	4 to 5 inches	Light rolling of leaves and few onion leaf	Stunted in growth and onion leaf
	6 to 7 inches	Severe bending, yellowish flattened top	Stunted in growth, severe onion leaf.
Ioana	15 to 18 inches	-----	Slightly stunted.
	Tasseling	-----	Normal
	1 to 2 inches	Normal	Normal (slightly taller than the check)
	2 to 3 inches	Normal	Normal (slightly taller than the check)
	4 to 5 inches	Very light rolling of the leaves	Slightly stunted in growth
Calumet	6 to 7 inches	Very light bending	Slightly stunted in growth, few onion leaves, leaf malformation almost disappearing
	15 to 18 inches	-----	Very slight check in growth
	Tasseling	-----	Normal
	1 to 2 inches	Normal	Normal
	2 to 3 inches	Normal	Normal
4 to 5 inches	Very light rolling of leaves	Slightly stunted in growth.	
Calumet	6 to 7 inches	Slightly-yellow	Slightly stunted in growth
	15 to 18 inches	-----	Normal
	tasseling	-----	Normal

the 15 to 18 inch stage. At this time, plants of the Gold Rush variety were in incipient tasseling, and thus more advanced in maturity. The sixth treatment was at incipient tasseling (15 percent) for all the varieties except Gold Rush, which was already in the silking stage. The seventh treatment was applied at incipient silking (15 percent) except for Gold Rush, which was already shedding pollen. Response of the corn plants to the 2,4-D action was measured by symptoms developed by the plants and by the quality and yields of resulting ears.

### RESULTS

The most important morphological symptoms present on the plants on March 18 and April 11 are summarized in Table I.

The degree of morphological reaction to the four foliar applications of 2,4-D was conspicuously different for each variety. In the majority of the cases the varieties responded in the following decreasing order of susceptibility: Gold Rush, Golden Security, Ioana, and Calumet, although there was very little difference in the degree of reaction of Gold Rush and Golden Security. Symptoms which appeared on the corn plants due to early 2,4-D treatment tended to disappear faster than symptoms which developed from treatments made later in the life of the plants.

Plants sprayed with 2,4-D seven days after seeding (one to two inch stage, treatment 1) and 12 days after seeding (two to three inch stage, treatment 2) showed a conspicuous light bending of the lower nodes of the stem. Recovery from this condition took about four days. Except for this bending of the stem of all varieties and the temporary appearance of the onion leaf formation or cigar like rolling of the leaves (Fig. 1) of Gold Rush as effect of treatment 12 days from seeding, 2,4-D did not produce any permanent undesirable reaction on the plants as reflected by yields. (See Table II.)

Application of 2,4-D to the corn plants 17 days from seeding (four to five inches tall, treatment 3) produced a severe onion leaf formation on all of the Gold Rush plants. About 15 percent of the Golden Security plants also appeared with onion leaves and the remaining 85 percent presented undulant leaf blades and inhibition of growth. Ioana

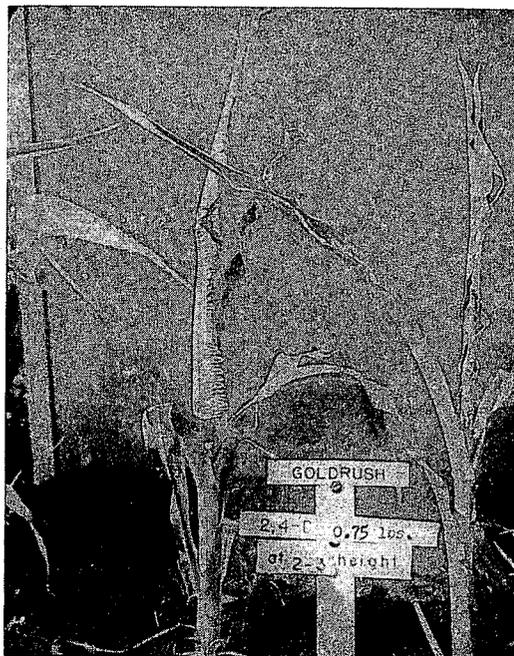


Fig. 1. Onion Leaf formation on Gold Rush variety produced by 2,4-D spraying when the plants were 2 to 3 inches tall. These plants recovered and produced a normal yield.

and Calumet plants showed light bending of the stem and a mild tendency to produce rolled leaves. Calumet and Ioana plants had recovered one month after treatment, but Golden Security and Gold Rush remained badly damaged. Application of 2,4-D to the plants 22 days from seeding (six to seven inch stage, treatment 4), produced severe damage to all four varieties. Four weeks after treatment, Gold Rush and Golden Security were severely stunted, with practically all the plants showing the onion leaf formation. Ioana and Calumet plants were stunted in growth and chlorotic.

The directional 2,4-D applications (treatments 5,6 and 7) did not produce any apparent ill effects on the sweet corn plants and did not affect yields. There was a significant reduction in yield due to the foliar applications of 2,4-D when the treatments were applied at the third and fourth stages of growth, whether the comparison is made within each variety or for the totals of the four varieties, with the exception of the third stage of growth of Calumet. (See Table II.) Comparing total yields of each variety, Ioana and

Table II. Total yields in pounds of marketable ears produced by four sweet corn varieties treated with 0.75 pounds of 2,4-D amine per acre at seven stages of growth.

Varieties	Treatments								Totals
	Height in inches or stage of growth				Tassel. Silk. Check				
	1 to 2	2 to 3	4 to 5	6 to 7	15 to 18	Tassel.	Silk.	Check	
Calumet	124.1	128.1	110.2	69.2*	115.9	123.0	129.0	112.2	911.7
Ioana	140.3	123.2	103.6*	58.6*	136.6	131.7	131.1	134.0	958.1
Golden Sec.	118.8	111.0	27.8*	19.2*	134.5	132.1	125.5	121.6	790.5
Gold Rush	<u>128.2</u>	<u>104.2</u>	<u>67.1*</u>	<u>66.4*</u>	<u>126.1<sup>(a)</sup></u>	<u>119.1<sup>(b)</sup></u>	<u>109.0<sup>(c)</sup></u>	<u>124.9</u>	<u>845.1</u>
Total	511.4	465.5	308.7*	213.4*	513.1	505.9	494.7	492.7	
L.S.D. 5%	(Variety totals)								80.55

\* Treatments significantly different from the check at 5% level.

(a) Incipient tasseling, (b) 25% silks, (c) pollen shedding.

Calumet have a significantly greater yield than Golden Security. Yields from plants of Golden Security, receiving 2,4-D at the four to seven inch stage (treatments 3 and 4) were more severely reduced than those of the other varieties. The interaction of varieties to dates of 2,4-D application (age of corn) was significant. This indicates that the reaction of each variety to a given age treatment is different. Quality of the marketable ears for all treatments was similar to the check.

It is evident that the degree of tolerance of each variety to 2,4-D action is different. The degree of reaction of the plants of each variety is in general correlated to the amount of decrease in yields; however, this was not always the case. Gold Rush developed severe symptoms after the second treatment with 2,4-D, but yields of these plants were not significantly reduced. On the other hand, the reaction of Calumet to the fourth 2,4-D application was mild; nevertheless its yields were reduced significantly.

#### DISCUSSION

When 2,4-D is sprayed on the foliage of young corn plants, a reaction with two definite patterns is found: one in which the corn plants are not permanently injured (up to three inches high and 12 days from seeding),

and the other in which severe damage of more or less permanent nature occurs to the corn plants and their yields (four to seven inches high and 12 to 22 days from seeding). Theoretically, 2,4-D damage to yield in corn is most likely to occur at any time after initiation of primordia of the reproductive organs to the time of fertilization; since up to this stage a more or less continuous process of differentiation takes place in the pistillate and staminate spikelets. Several experiments seem to prove this point (4,8,9,16,17,24,25,26,27). However, there is evidence also to the contrary (7,24,26), which may indicate that differentiation of reproductive organs does not take place in a continuous manner. An attempt was made, therefore, following this experiment to correlate the 2,4-D action with the morphological development of the tassel and ear primordia at treatment time in Ioana variety.

Microscopic examination of the growing points of Ioana plants of different sizes and ages indicated that tassel and ear primordia differentiation was just beginning to take place at the time of the third and fourth 2,4-D applications. In Figure 2, corn treated at the two to three inch stage, tassel initiation is not visible. In Figure 3, corresponding to the four to five inch stage, it is faintly visible as small dots indicating beginning of the tassel.

Fig. 2



Fig 3

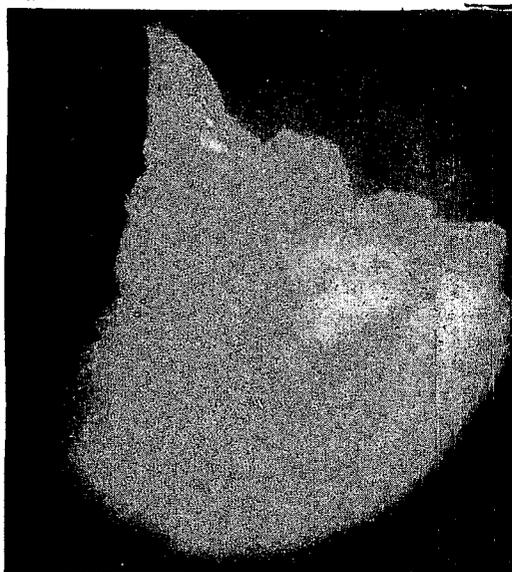
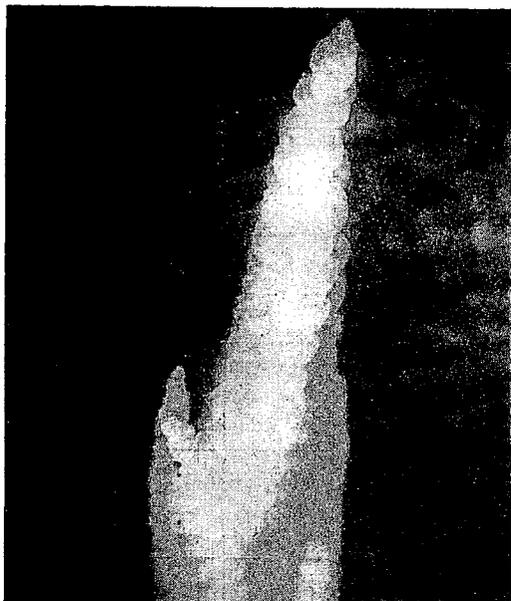


Fig. 4



Figs. 2, 3, and 4. Tassel primordia differentiation in sweet corn, variety Ioana. Fig. 2. Corresponds to the 2 to 3 inch stage. There is no visible initiation of tassel. Fig. 3. The 4 to 5 inch stage. The tassel is just beginning to differentiate as minute dots in the mass of tissue. Fig. 4. Corresponds to the 6 to 7 inch stage of morphological differentiation of the tassel, which is plainly visible.

stigma was receptive. This was the case. Immediately adjacent to the experimental field was a large acreage of sweet corn of the same age which provided a generous pollen supply. Since yields for both treatments 3 and 4 were significantly reduced, this seems to indicate that damage by 2,4-D spray was to both the tassel and ear primordia.

The response of plants to 2,4-D action increases with temperature up to a certain point (8,15,20). Temperatures were relatively low for the first two treatments (Figure 5) and higher for the third and fourth treatments which produced injury to the corn; however, it is difficult in this particular study to consider temperature as the only and main factor of injury. The third treatment, for instance, produced onion leaf formation in 15 percent of Golden Security plants. If temperature were the only conditioning factor, the onion leaf formation should have been present in all the plants. It seems that not all of the corn plants were in the growth stage of susceptibility; therefore, the real action of temperature is only one of several factors modifying growth

Figure 4 shows the small dots already in the process of growing and actually forming the future branches and spikes of the tassel. The assumption that damage to both ear and tassel primordia occurs seems to be true to a certain degree; for if the tassel primordia were the only tissues damaged by the 2,4-D spray, good yields could be expected provided a good supply of pollen existed at the time the

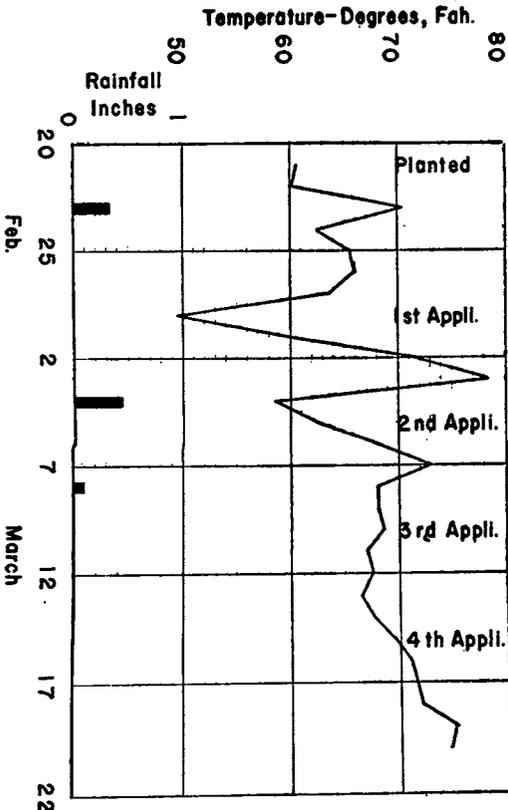


Fig. 5. Average temperature and amount of rainfall during the first four 2,4-D treatments.

(a complicated process) to which should be added the influence of interrelated multiple factors such as soil and climate. Thus, if 2,4-D is absorbed by the plant at the time of tissue differentiation, it is likely that this tissue will be affected more than any other part of the plant. If yields are the measure of 2,4-D response, any effect of the herbicide on the primordia differentiation of reproductive organs, gamete formation of tassel and ear, is certain to have an effect on yield of the plants.

It is possible that the directional applications of 2,4-D produced no foliar symptoms or effects on yields because the older nodes of the corn plants are better protected from wetting and penetration of the 2,4-D spray by the sheath of the leaves and ligule (11), or that the rate of absorption and translocation has been greatly reduced because the meristematic tissue of the lower internodes is the oldest growing part of the corn plant. The rate of

absorption of 2,4-D by susceptible plants appears to be much more rapid than in tolerant species (10). Furthermore, 2,4-D once absorbed is accumulated in the growing points of the plant, and, since there is a growing meristem in the lower part of the internode, it is possible, in the event of 2,4-D penetration, that this region blocks the translocation to other parts of the plant (10). Each of these factors appears to be important in preventing damage to corn plants when applying 2,4-D directionally; however, the physical and mechanical barriers to penetration of the herbicide into the plant would appear to be the greatest factor.

From the design of the experiment, it is not possible to compare the relative merits of foliage and directional application of 2,4-D, because the ages of the corn plants were different. However, it definitely appears for practical purposes that directional application of 2,4-D amine at 0.75 pounds per acre may be safely used for weed eradication with minimum injury to the four sweet corn varieties in the test when the plants are over 15 inches tall.

It has been postulated that, among the factors conditioning damage by 2,4-D, the rate of growth is more important than the age of the corn plant at treatment time (13). Another worker thinks that growing conditions rather than size of plant are more important (19). It seems that initiation and further development of tassel and ear primordia is one of the most important factors in influencing damage to sweet corn plants when using 2,4-D for weed control; however, conclusive proof of this point has not been established in the present study. Anatomical protection of the growing point (13) at the early age of the corn plant and physical barriers at later stages when directional application of 2,4-D was made also seem to be very important factors. Thus, it appears that 2,4-D should be used only in the early life of the sweet corn plant before tassel and ear differentiation begins; that is, up until the plants are two to three inches tall or about 12 days after planting, or after the 15 inch stage when directional applications of 2,4-D amine at 0.75 pounds per acre seem to be safe.

SUMMARY

A study was conducted in an attempt to determine the effect of herbicidal applications of

0.75 pounds of 2,4-D amine salt at different stages of growth of four varieties of sweet corn.

For practical reasons, the first four treatments of 2,4-D were made as overall foliage sprays. The last three applications were made directionally to the base of the plants so as to wet the weeds and only the lower  $\frac{1}{4}$  of the corn plants.

The four varieties in this study varied in their tolerance to 2,4-D as measured by yields in the following increasing order: Golden Security, Gold Rush, Ioana and Calumet. Symptoms developed by the plants varied in the following increasing order: Calumet, Ioana, Golden Security and Gold Rush. Application of 2,4-D spray to corn plants one to three inches tall did not produce any permanent injury to the plants or yields. When 2,4-D was sprayed on plants four to seven inches tall severe damage occurred to the corn plants and their yields. Directional application to plants 15 to 18 inches tall, at incipient tasseling and incipient silking, did not produce any permanent injury to the corn plants or their yields.

It is suggested that injury to corn plants and yield occurs when the 2,4-D application is made at the time of tassel and ear differentiation, which in this study appeared to start when the plants were slightly over three inches tall.

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