DEVELOPMENT AND DESIGN OF A PRECISION COTTON PLANTER

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THESIS AND ABSTRACT APPROVED:

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PREFACE

The production of cotton has become mechanized in every phase from seedbed preparation to harvesting operations. No machine that is used in cotton production has been developed to its fullest extent; more improvements in all machines are necessary to satisfy the requirements of most cotton farmers. The need for a better precision cotton planter is justified by the subsequent reduction in labor with the elimination of cotton chopping and with easier methods of grass and weed control. Thus, the purpose of this thesis problem was to develop and design a precision cotton planter that is superior to the existing planters.

The author is gratefully indebted to Professor W. J. Oates for his valuable leadership and advice on the project. Thanks and appreciation are also given to Professor E. W. Schroeder, Head of the Department of Agricultural Engineering, for the use of the staff and facilities of the department.

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I. INTRODUCTION

The complete mechanization of cotton production has grown out of slow progress. One reason for such slow progress is that the efficiency and usefulness of each machine depends primarily upon the cultural practices followed by the farmer and the machine used in the previous phase of cotton production. Much research has been done on each individual machine but research on a complete mechanization program has been limited. A need for such a program was expressed when Waterman stated[27], "To date almost all of the work has consisted in producing a machine to fit the cotton; future work must include that of producing cotton and cotton fields to fit the machine."

Researchers agree that uniformity in planting is essential for mechanized cotton production to be successful. The cotton plants must be spaced uniformly in the row and the rows should be the same distance apart. In the past farmers have attempted to obtain uniformly spaced plants by various thinning operations. Chopping cotton to a stand has been a common practice, but chopping requires a large amount of labor. Such labor is not always readily available. Mechanical and flame choppers and cross cultivation have been tried and were successful for some conditions. However, to obtain true uniformity, farmers must accept precision planting.

Planting cotton to a stand is becoming an accepted practice. A survey[22] in 1949 showed that approximately one third of the cotton grown in southwestern Oklahoma was planted to a stand. In order for the cotton producer to realize the most profit from his crop, he must be shown better methods of operation and approved cultural practices. Thus the researcher must determine successful methods of planting for the farmer who wishes to plant cotton to a stand.

In recent years, precision cotton planting has been accomplished by using special seed plates in regular corn planters. In 1950, Autry[1] developed a simplified precision cotton planter which retained only the hopper and driving mechanisms of a corn planter. Alterations were made on seed plates, knockout devices, plate speeds, hopper heights, and seed tube dispersion. Pertinent problems concerning the aforesaid simplified cotton planter that were investigated by the author are listed as follows:

a. hopper position
b. hopper height
c. ground speed-plate speed ratio
d. plant spacings
e. furrow openers
f. probability of hill size

This thesis contains the results of the above investigations.

II. OBJECT

The purpose of this study was to develop and design a precision cotton planter that embodied resulting laboratory principles for reducing to a minimum the dispersion of cotton seed as they were placed in the soil. In particular, the study was concerned with the determination of an optimum hopper position with respect to the planted row.

III. EQUIPMENT AND APPARATUS

A. Laboratory Equipment

The equipment used in the development and design of a precision cotton planter (Fig. 1) was a modified version of that used by Autry[2]. A conventional corn planter was mounted above an endless conveyor system. An electric motor furnished the power necessary to operate the conveyor system and the planter. Power was transmitted to those parts by a series of pulleys and V-belts, and sprockets and chains. The conveyor system was used to transport greased boards, which represented the ground, beneath the planter seed hopper. The purpose of the greased boards was to catch the planted seed; the grease prevented their movement on the board after the seed had made contact with the board. Thus, the conditions simulated the movement of the ground beneath the planter instead of the planter being moved over the ground.

Interchangeable pulleys and sprockets permitted the planter seed plate speed to be varied from 28.6 fpm to 55 fpm while the ground speed or speed of the greased boards was varied from 2.0 mph to 4.7 mph. The height of the hopper was adjustable from 12 in. to 29 in. The hopper height was measured as the distance from the bottom of the seed plate to the greased boards.

Other equipment for the planter included the 12-cell "C" type plate, star knockout device, and the trajectory type seed tube[3]. The above equipment is shown in Fig. 2. The lower end of the trajectory tube was placed 3/4 in. above the greased boards.

B. Field Equipment

The principles of operation and the equipment that gave the most desirable dispersion results in the laboratory were embodied in the design of a planter for field studies (Fig. 3). The planter design included conventional hopper mounting, "C" type plate, star knockout, trajectory tube, 18 in. hopper height and a ground speed-plate speed ratio of 8.32 to 1. Other equipment for the planter included a runner type furrow opener, a depth gauge shoe, and disk type covering devices. Two variations of runner openers were used; unrestricted, or conventional, and a restricted opener. The sides of the seed chamber for the restricted opener were reduced from 2 in. apart to 3/4 in. apart. Also, the opening edge was extended beneath the seed chamber into a V shape so that the seed were planted in a groove instead of on a flat surface as with the unrestricted opener. The furrow openers are shown in Figs. 4 and 5.

Empire variety of seed was used for all studies. The seed were acid delinted, flotation graded, unsized, and were supplied by the Sinkers Corporation.

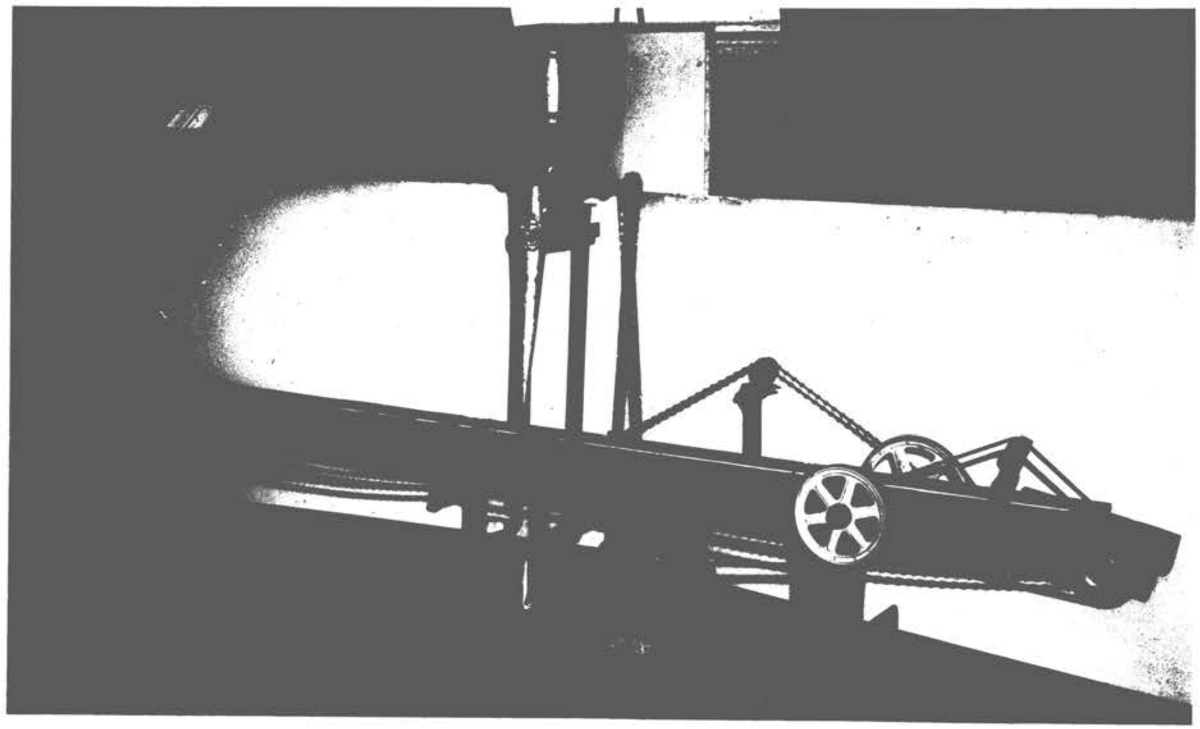

Fig. 1 Planter equipment used for laboratory studies

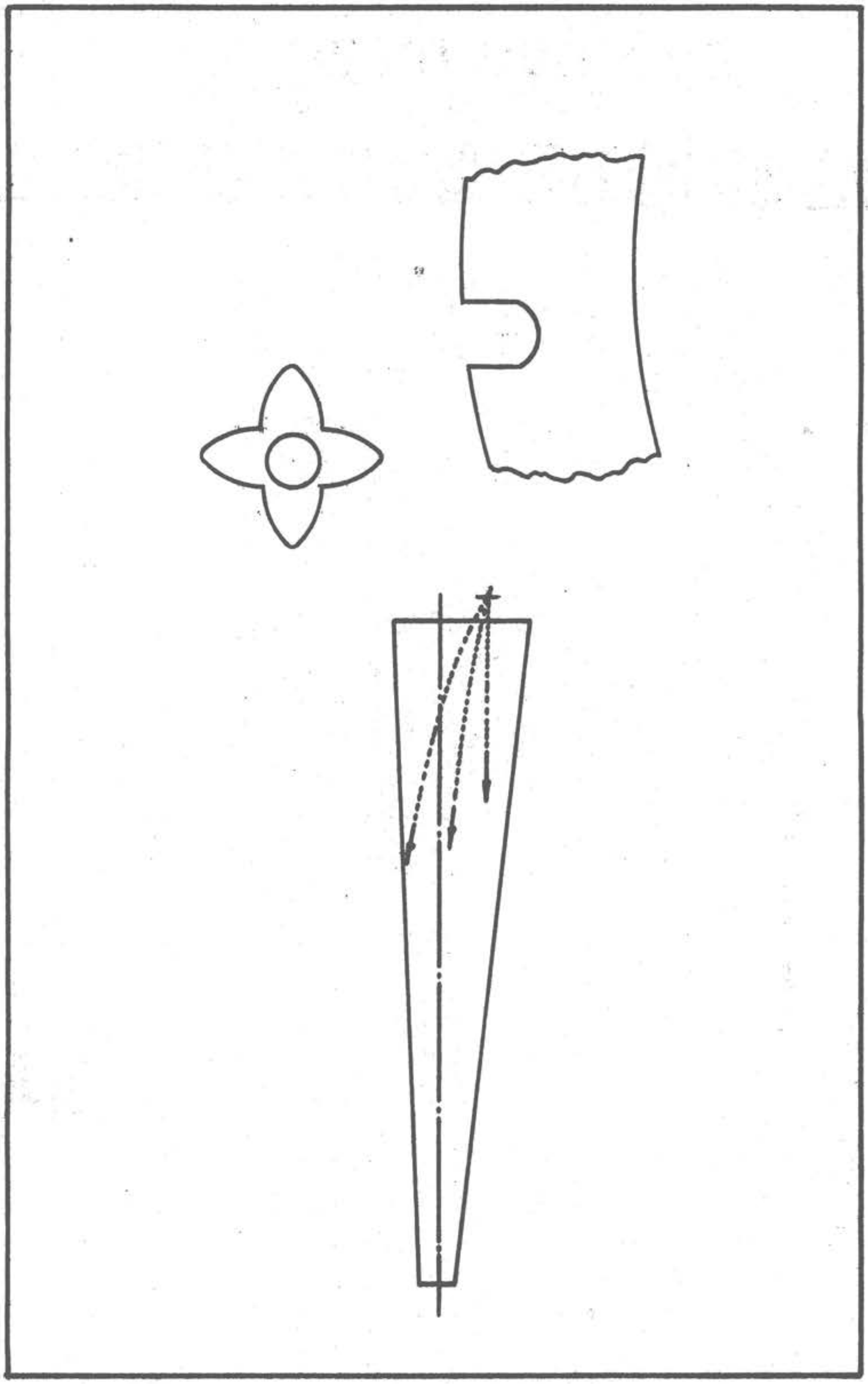

Fig. 2 Seed plate, knockout device, and seed tube used for all studies

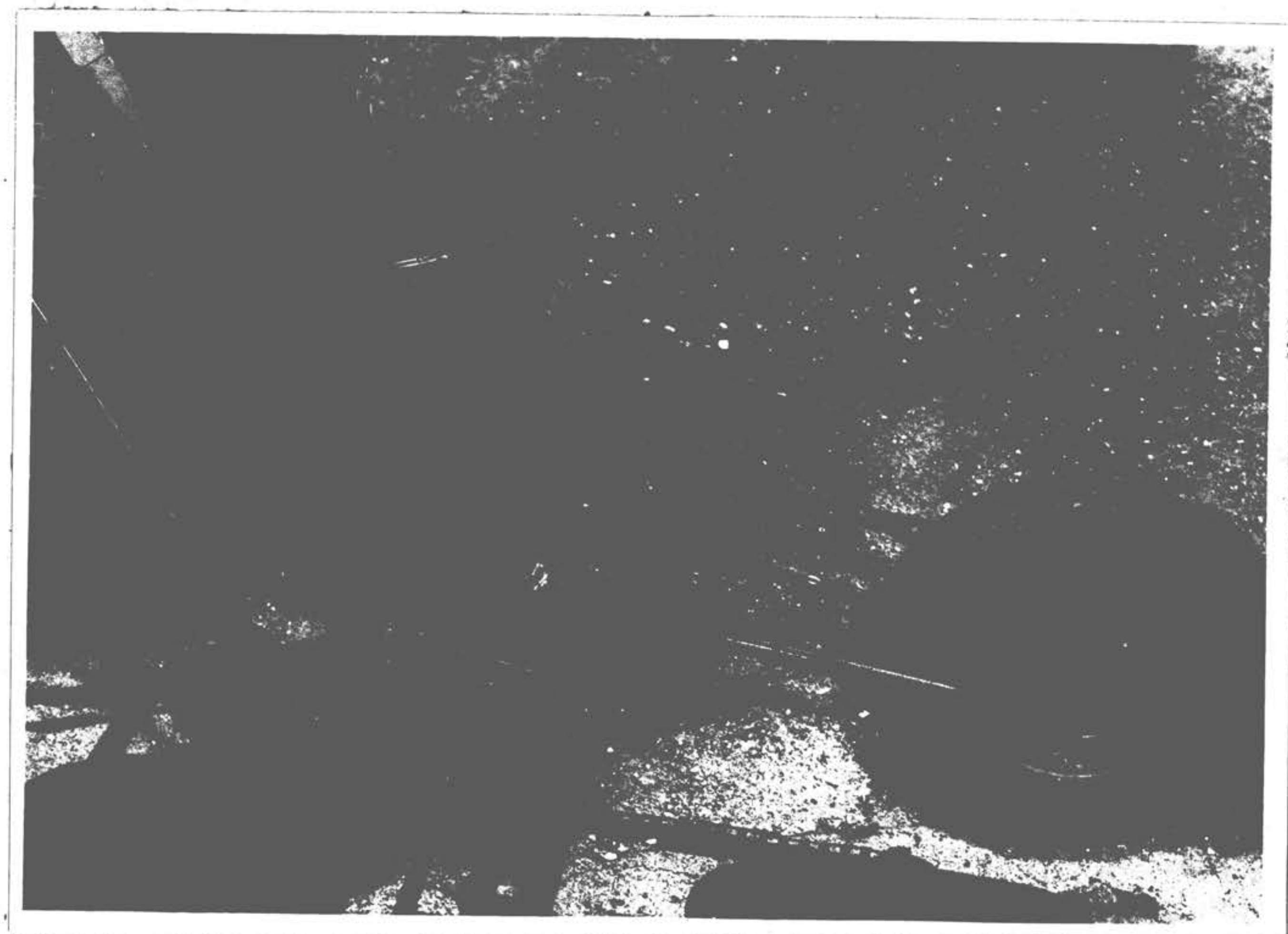

Fig. 3 Planter used for field studies

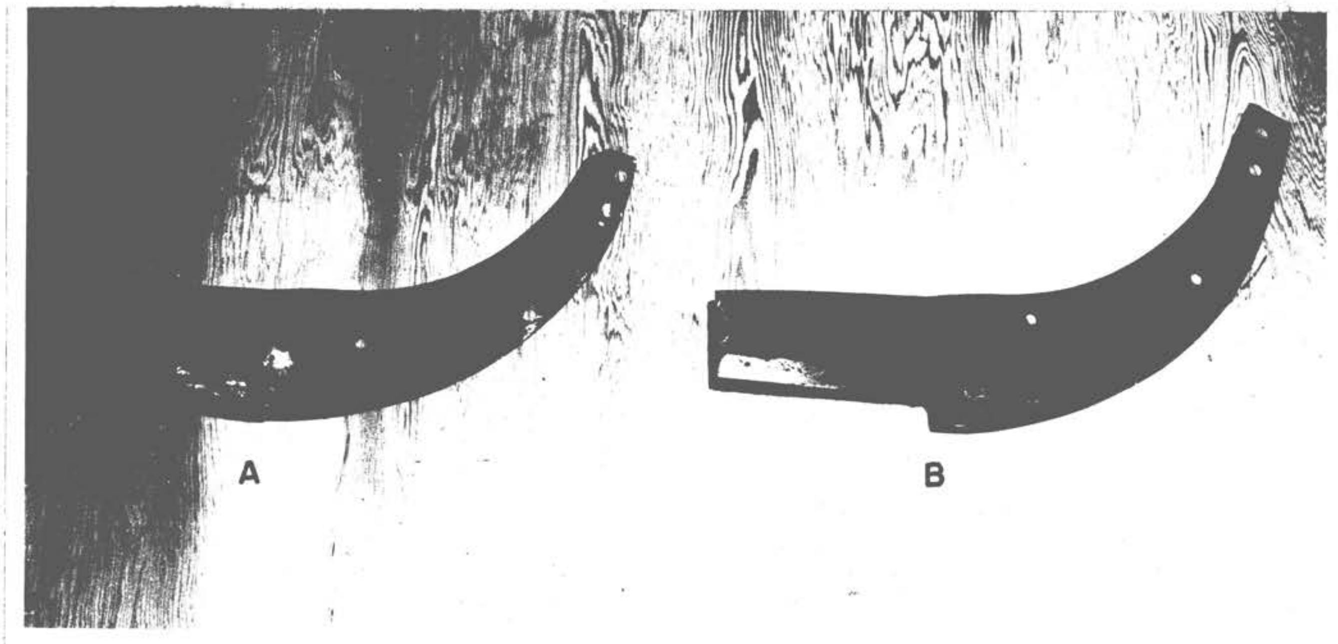

Fig. 4 Profile of furrow openers
A- restricted
B- unrestricted

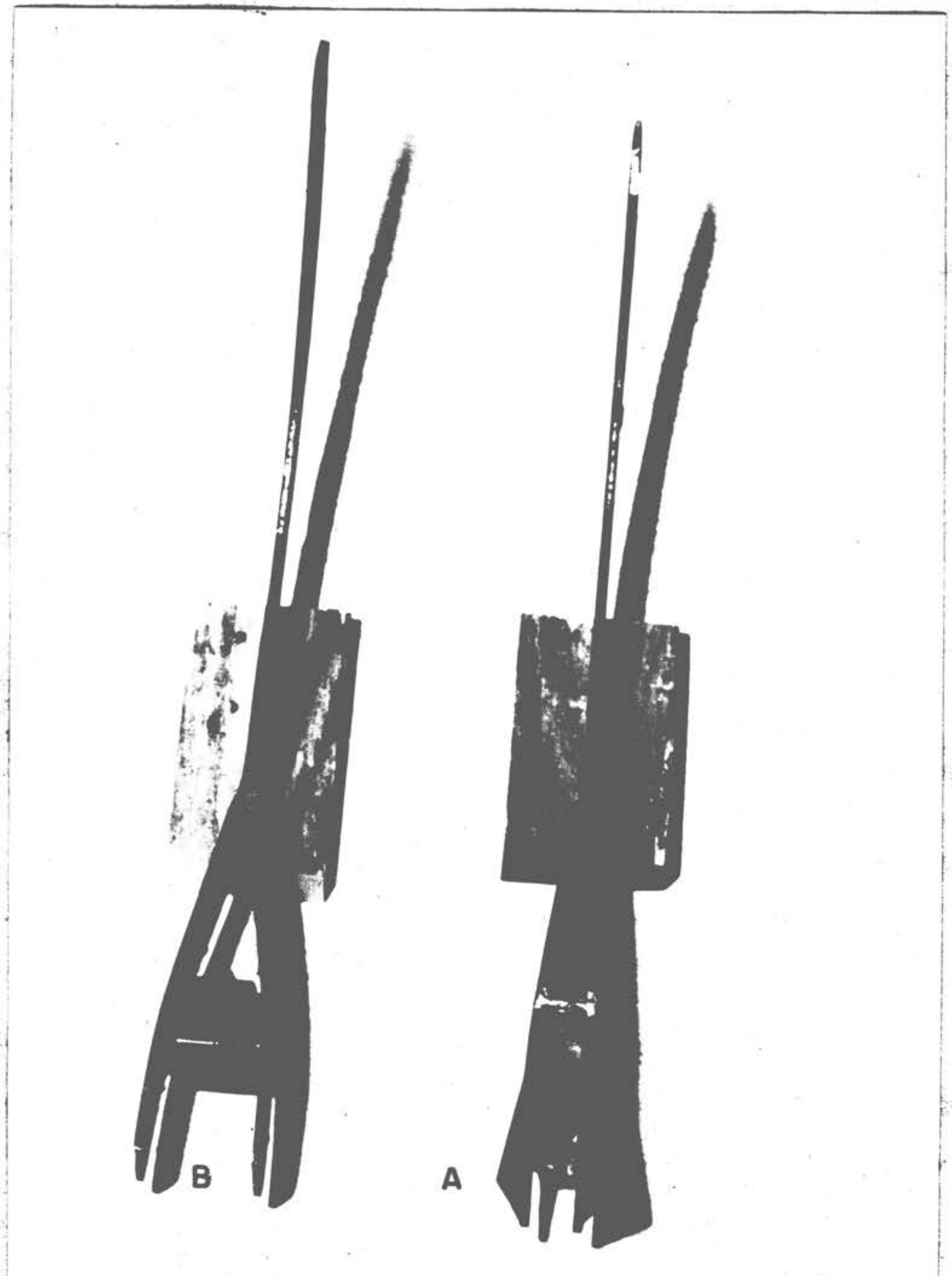

Fig. 5 Top view of furrow openers
A- restricted
B- unrestricted

IV PROCEDURE

A. Methods of Taking Data

The data that was recorded consisted of the overall length of each hill, the number of seed in each hill, and the distance the center of the hill was to the right or left of the calculated or theoretical center of the hill. The position of each seed in each hill was plotted on graph paper so that the seed pattern of the hills could be studied.

The term seed dispersion or dispersion relates to the distance over which a hill of cotton seed was scattered on the greased boards. A dispersion value was assigned each hill on the basis of a scoring table (Table I) compiled by Autry[4]. Fifty hills comprised a test for any one planting condition. The mean dispersion for the 50 hills was recorded as the dispersion value for a given condition.

To eliminate the effect of acceleration, the forward end of the boards was placed approximately 2 ft. from the end of the seed tube before starting each test. Also, the power was not cut off until the greased boards had completely passed the seed tube. In addition, no hill was recorded that was within 12 in. of either end of the greased boards.

When recording data, the first hill that was over 12 in. from the end of the board was assumed to have its center coinciding with the theoretical center. All measurements with respect to the distance between hills were made relative to the first hill. The above assumption is incorrect but a better method of determining the location of the center of the first hill was not known.

For field studies, the distance between the extremities of the plant stems in each hill and the number of emerged plants in each were recorded. The distance between the centers of hills was also recorded. Dispersion values were assigned to each hill and the mean dispersion value of each planting condition was calculated by the same method used for laboratory studies.

The effect of tractor acceleration was eliminated by disregarding for scoring purposes the first and last 10 ft. of each row. The middle 50 hills of each row comprised one test.

B. Laboratory Studies

The problems that were investigated in the laboratory were:

1. Does the position of the hopper have any effect on seed tube dispersion?

2. What effect does the height of hopper have on seed tube dispersion?

3. Does the ground speed-plate speed ratio of 8.2 to 1 hold for all hopper positions?

1. Hopper Position

Many articles and papers have been written on the subject of cotton planters, corn planters, and beet planters, but no information was found that concerned the position of the seed hopper relative to the ground or planted row. Thus, an investigation was made to determine the advantages or disadvantages, if any, of various hopper positions relative to the row being planted.

The ejected seed leave the planter on a tangent to the seed plate. All previous work was done with the seed hopper mounted in the conventional position. The tangential path of the seed for a conventionally mounted hopper is perpendicular to the direction of planter travel.

Tests were made to determine the dispersion characteristics of a right mounted hopper and of a left mounted hopper. A planter with a right mounted hopper was one for which the seed hopper was placed on the right side of the planted row. The tangential path of the seed was parallel to the direction of travel and was in the same direction. Likewise, a left mounted hopper position had the hopper on the left side of the planted row. The tangential path of the seed was also parallel to the direction of travel but the tangent was in the opposite direction. The above conditions are illustrated in Fig. 6.

The seed hopper was mounted on one side of the endless conveyor system to simulate a left mounted hopper position. The conditions for a right mounted hopper were obtained by twisting the driving belts on the endless conveyor and on the planter. Thus a right mounted hopper was obtained by reversing the direction of travel of the greased boards beneath the planter.

The above studies were made at plate speeds ranging from 28.6 fpm to 55.0 fpm and at ground speeds of 2.0 mph and 4.7 mph. The mean dispersion values for the studies are shown in Tables II, III, IV, and V. Curves were drawn with dispersion plotted as the ordinate and plate speed as the abscissa. The curves were drawn for three hopper heights and for two values of ground speed (Figs. 7, 8, 9, 10).

2. Hopper Height

Studies were made to determine what effect, if any, the height of the hopper would have on dispersion at various plate speeds and ground speeds. Autry recommended a hopper height of 18 in. for a conventionally mounted hopper[5]. The studies were made with the hopper placed at heights of 12 in., 19 in., and 29 in. for all conditions of the plate speeds, ground speeds, and hopper positions. The resulting data are shown in Tables II, III, IV, and V and were used to draw curves with the dispersion as the ordinate and hopper height as the abscissa (Figs. 11, 12, 13, and 14).

3. Ground Speed-Plate Speed Ratio

The plate speeds of the planter were varied from 28.6 fpm to 55.0 fpm for ground speeds of 2.0 mph and 4.7 mph and for hopper heights of 12 in., 19 in., and 29 in. Both hopper positions were included in this study. For a conventionally mounted hopper, Autry found that a ground speed-plate speed ratio of 8.2 to 1 was the best combination of speeds from the standpoint of dispersion[6]. The data were studied to determine a ground speed-plate speed ratio for optimum dispersion characteristics if such a ratio existed. Various ground speed-plate speed ratios were set up when a combination of certain speeds seemed desirable. The calculated ratios were then applied to the existing curves for any verification.

C. Field Studies

The purpose of field studies was to check the dispersion of the seed for actual planting conditions and to investigate the limits of precision planting.

To eliminate or reduce as many variables in planting as possible, the seed for all tests were planted at a constant depth of 1 in. Differences in soil conditions were reduced by planting all of the plots within a few hours. The field was laid out for 12 treatments and 3 replications of each treatment. The position of a plot in a replication was chosen by random methods.

1. Hill Spacing

An attempt was made to obtain spacings of hills at approximately 7 in., 11 in., and 15 in. with the unrestricted and the restricted furrow openers and at ground speeds of 3 1/2 mph and 4 1/2 mph. The hill spacings were obtained by varying the number of holes in the seed plate rather than by changing the plate speed.

2. Furrow Openers

The effect of furrow openers on dispersion was studied by using an unrestricted and a restricted furrow opener. The lower end of the seed tube was centered transversely in the furrow openers. The end of the seed tube was placed 3/4 in. from the bottom of the furrow, and the distance from the back edge of the opener to the center of the tube was 1/2 in. The purpose of placing the seed tube near the end of the furrow opener was to reduce dispersion by covering the seed quickly.

3. Probability of Hill Size

Field planting was used to study the probability of the occurrence of different size hills. The hill size and the frequency of their occurrence were obtained from laboratory studies. Indoor plantings were made to determine the germination percentage of the seed.

The occurrence of each size hill and the seed germination were used to make a probability estimate for field planting by the following formula which is a binomial or Bernoulli distribution function[15].

$$f\,P_{(x)} = f\,\frac{n!}{x!\,(n-x)!}\,p^x\,q^{n-x}$$

where:

P = probability of hill size

x = number of germinating seed

f = frequency of hills of certain size

n = number of seeds per hill

p = germination percentage of seed

q = 100% - germination percentage of seed

To illustrate the use of the above formula, a sample calculation follows.

Let:

$n = 2$ seed per hill

$f = 50$ hills of 2 seed each

$p = 72.5\%$ germination

$q = 27.5\%$

$$f\,P_{(x)} = 50 \frac{2!}{x!\,(2-x)!} (0.725)^{x} (0.275)^{2-x}$$

$$= 50\left[(0.725)^2 + 2\,(0.725)(0.275) + (0.275)^2\right]$$

$$= 50\,(0.526 + 0.398 + 0.076)$$

$$f\,P_{(x)} = 26.30 + 19.90 + 3.80$$

Thus, from 50 hills there would be 26.30 hills with 2 seed, 19.90 hills with 1 seed, and 3.80 hills of 0 seed.

Table VI shows the distribution of the number of germinating hills and are summarized in percentages in order that the probability of hill size may be applied to any number of hills.

Thus, for a 100 hill plot there would be approximately 5 hills of 0 plants, 23 hills of 1 plant, 39 hills of 2 plants, 26 hills of 3 plants, 6 hills of 4 plants, and 1 hill of 5 plants.

TABLE I

Scoring Chart for Dispersion

Seed per Hill	Dispersion Each Hill - Inches						
2	1.0 Or Below	1.1 - 1.4	1.5 - 1.8	1.9 - 2.7	2.3 - 2.6	2.7 - 3.0	Over 3.0
3	1.5 Or Below	1.6 - 2.1	2.2 - 2.7	2.8 - 3.3	3.4 - 3.9	4.0 - 4.5	Over 4.5
4	2.0 Or Below	2.1 - 2.8	2.9 - 3.6	3.7 - 4.4	4.5 - 5.2	5.3 - 6.0	Over 6.0
5	2.5 Or Below	2.6 - 3.5	3.6 - 4.5	4.6 - 5.5	5.6 - 6.5	6.6 - 7.5	Over 7.5
6	3.0 Or Below	3.1 - 4.2	4.3 - 5.4	5.5 - 6.6	6.7 - 7.8	7.9 - 9.0	Over 9.0
Score	1	2	3	4	5	6.5	9

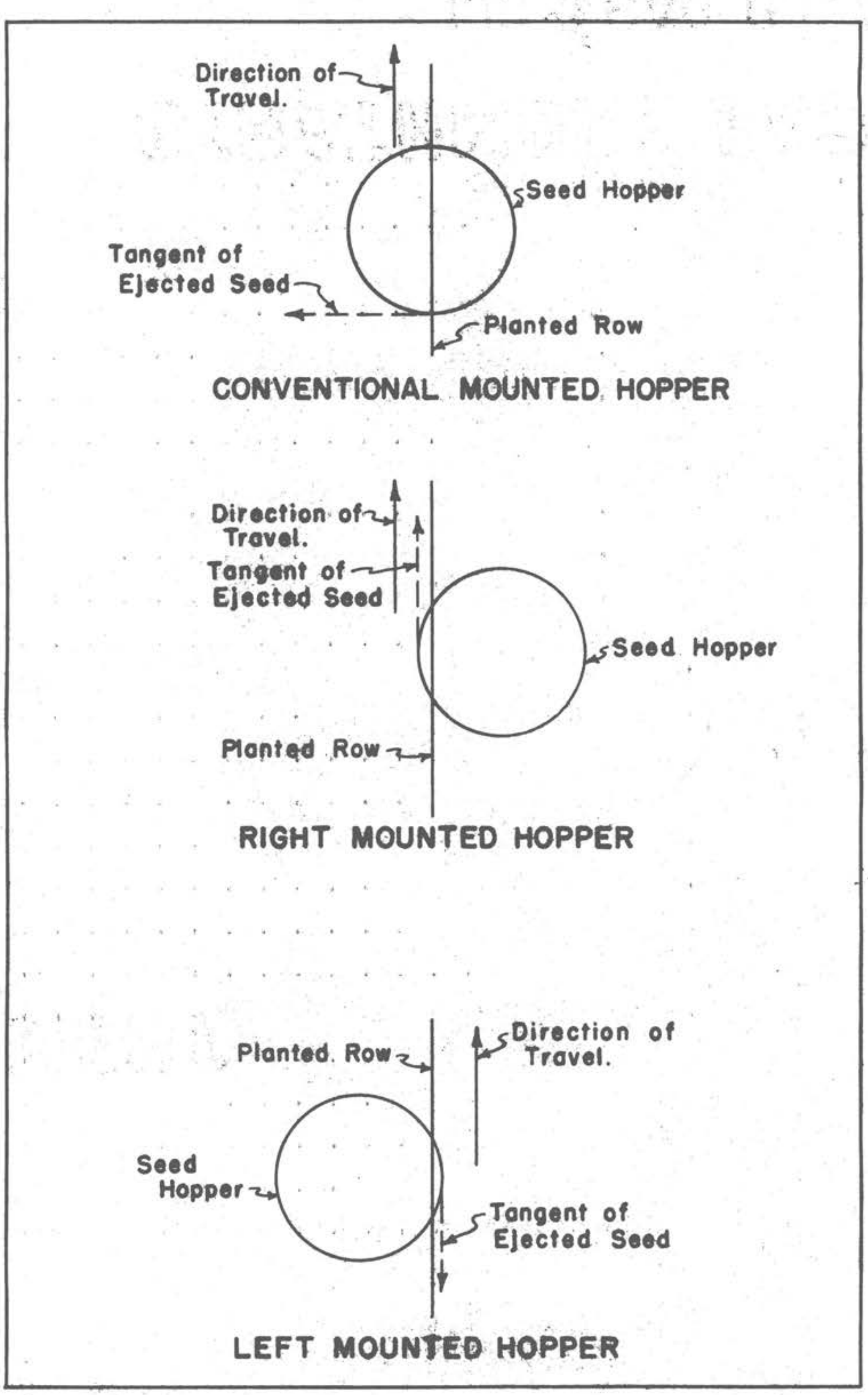

Fig. 6 Sketch of hopper mountings

TABLE II

Dispersion Values for Left Mounted Hopper
Ground Speed =2.0 mph

Hopper Height (in.)	Plate Speed (fpm)			
	28.6	36.6	45.7	55.0
12	2.22	2.38	2.67	7.60
19	1.96	1.81	2.47	8.50
29	1.76	2.50	2.68	4.33

TABLE III

Dispersion Values for Left Mounted Hopper
Ground Speed =4.7 mph

Hopper Height (in.)	Plate Speed (fpm)		
	28.5	42.7	54.5
12	2.97	4.47	3.93
19	2.73	3.24	3.06
29	2.73	3.37	4.01

TABLE IV

Dispersion Values for Right Mounted Hopper
Ground Speed 2.0 mph

Hopper Height (in.)	Plate Speed (fpm)		
	28.6	45.7	55.0
12	2.48	6.26	7.07
19	2.40	5.06	6.78
29	1.84	3.43	4.74

TABLE V

Dispersion Values for Right Mounted Hopper
Ground Speed 4.7 mph

Hopper Height (in.)	Plate Speed (fpm)		
	28.5	42.7	54.5
12	4.10	5.10	3.74
19	2.50	3.42	4.70
29	2.83	2.50	4.58

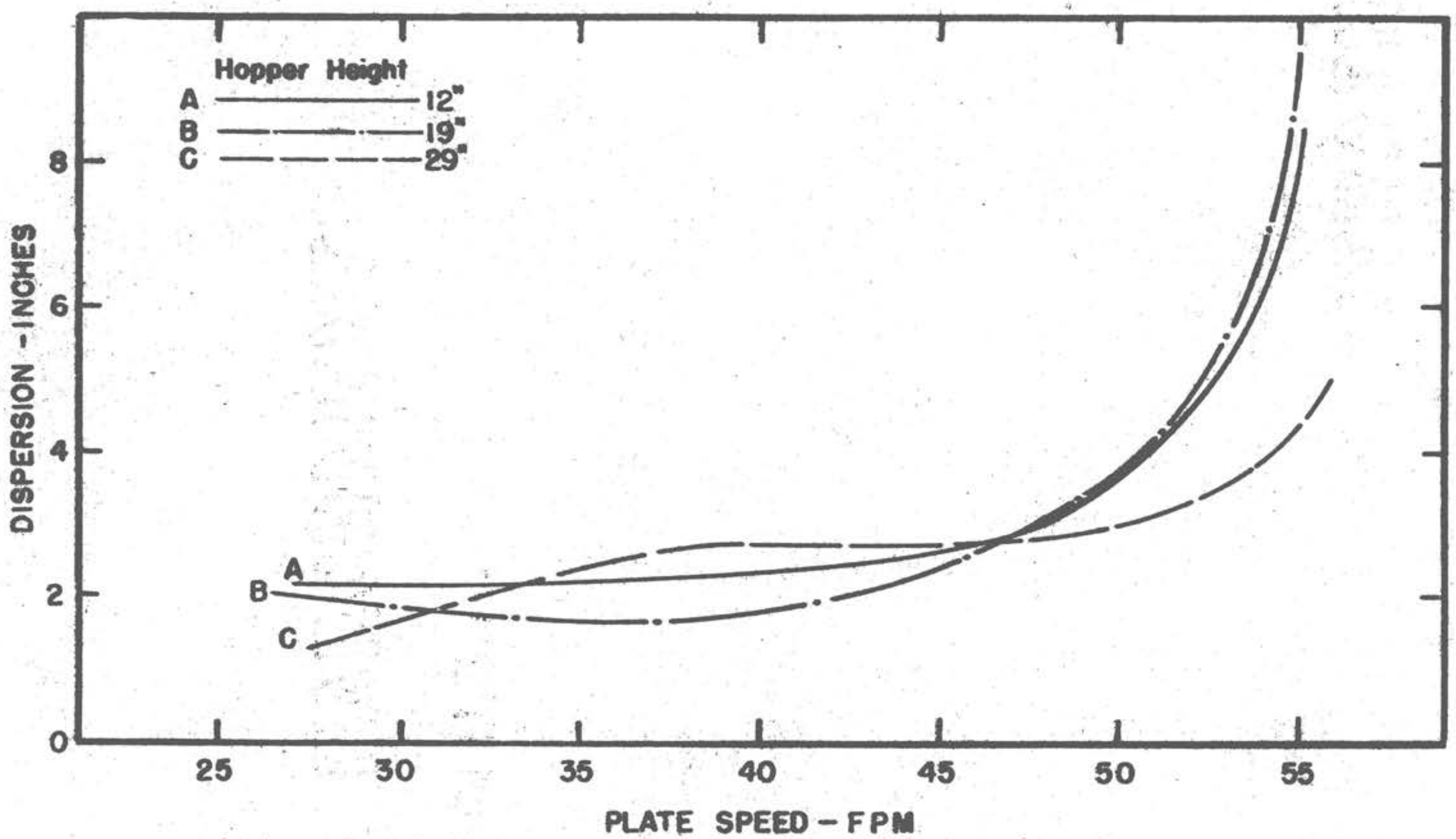

Fig. 7 Dispersion characteristics of left mounted hopper
Ground Speed = 2.0 mph

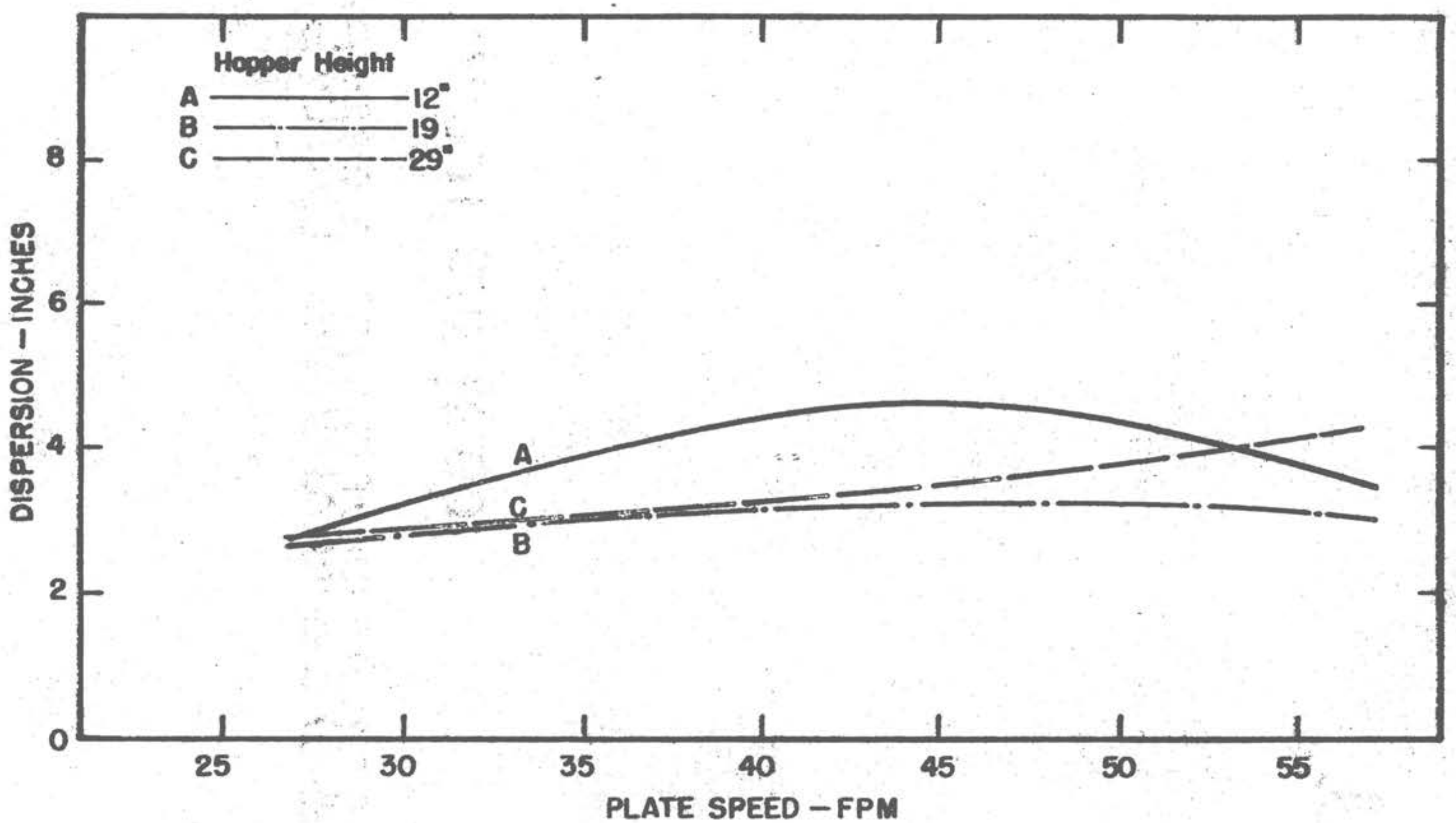

Fig. 8 Dispersion characteristics of left mounted hopper
Ground Speed = 4.7 mph

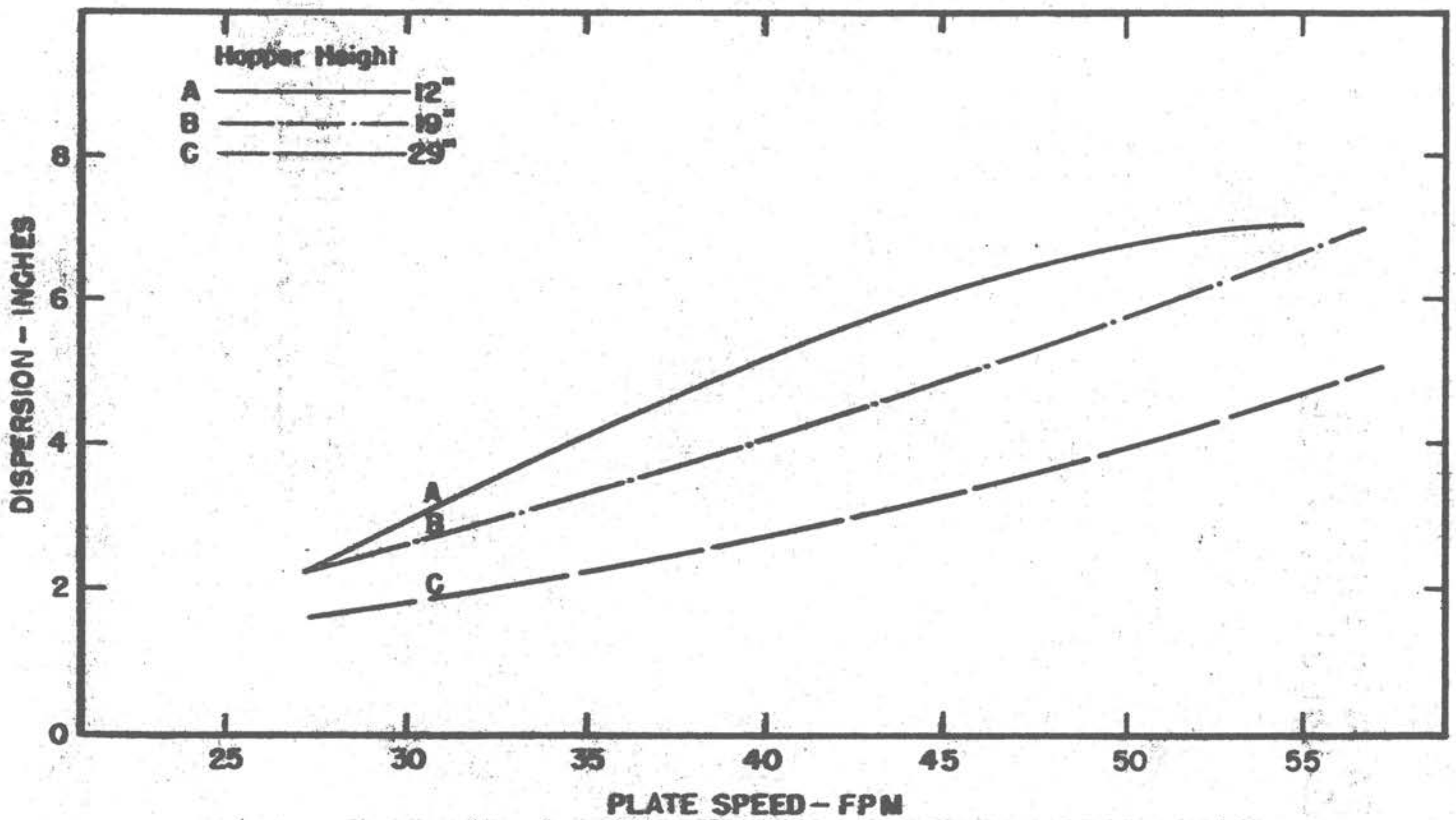

Fig. 9 Dispersion characteristics of right mounted hopper
Ground Speed = 2.0 mph

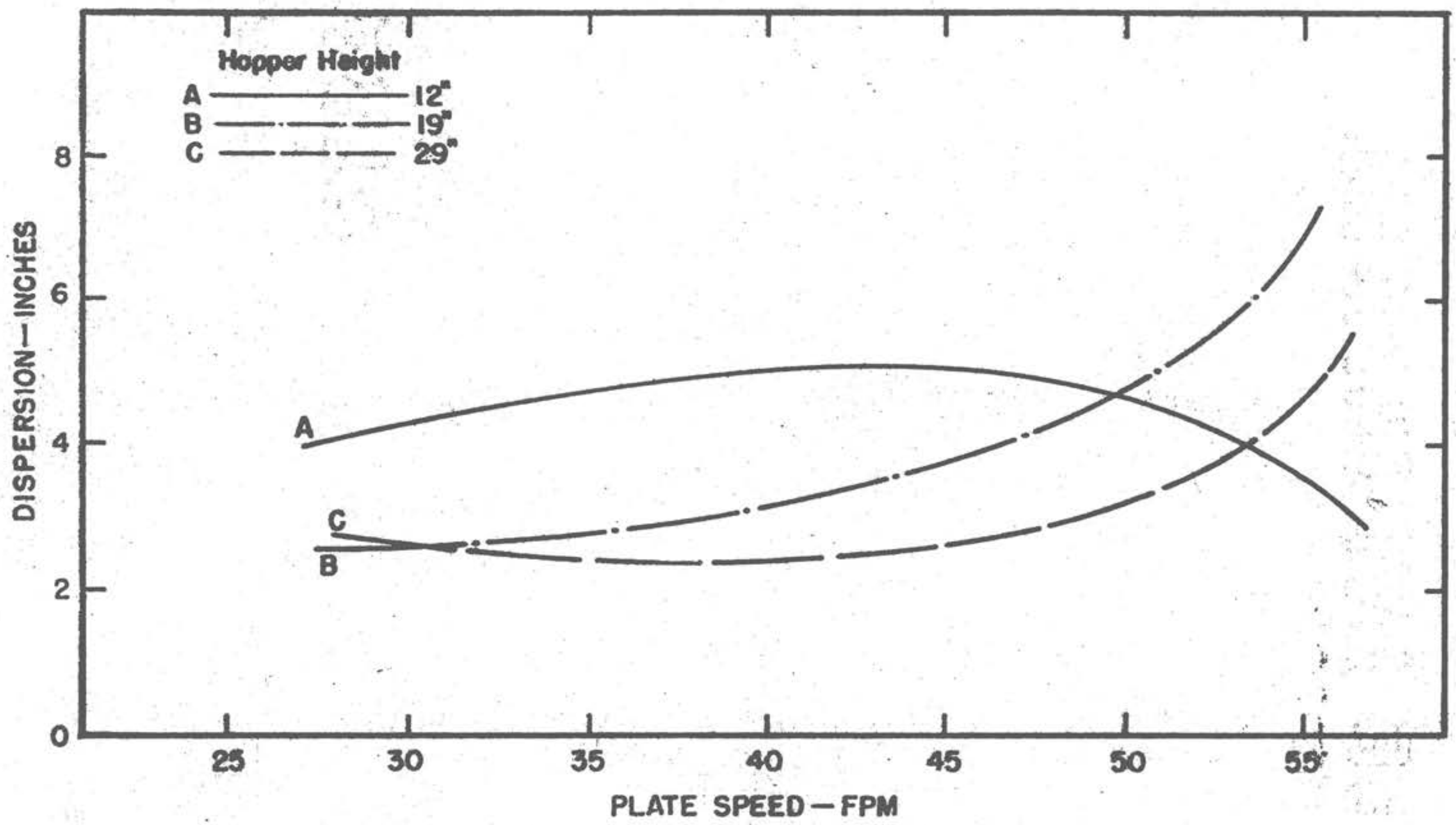

Fig. 10 Dispersion characteristics of right mounted hopper
Ground Speed = 4.7 mph

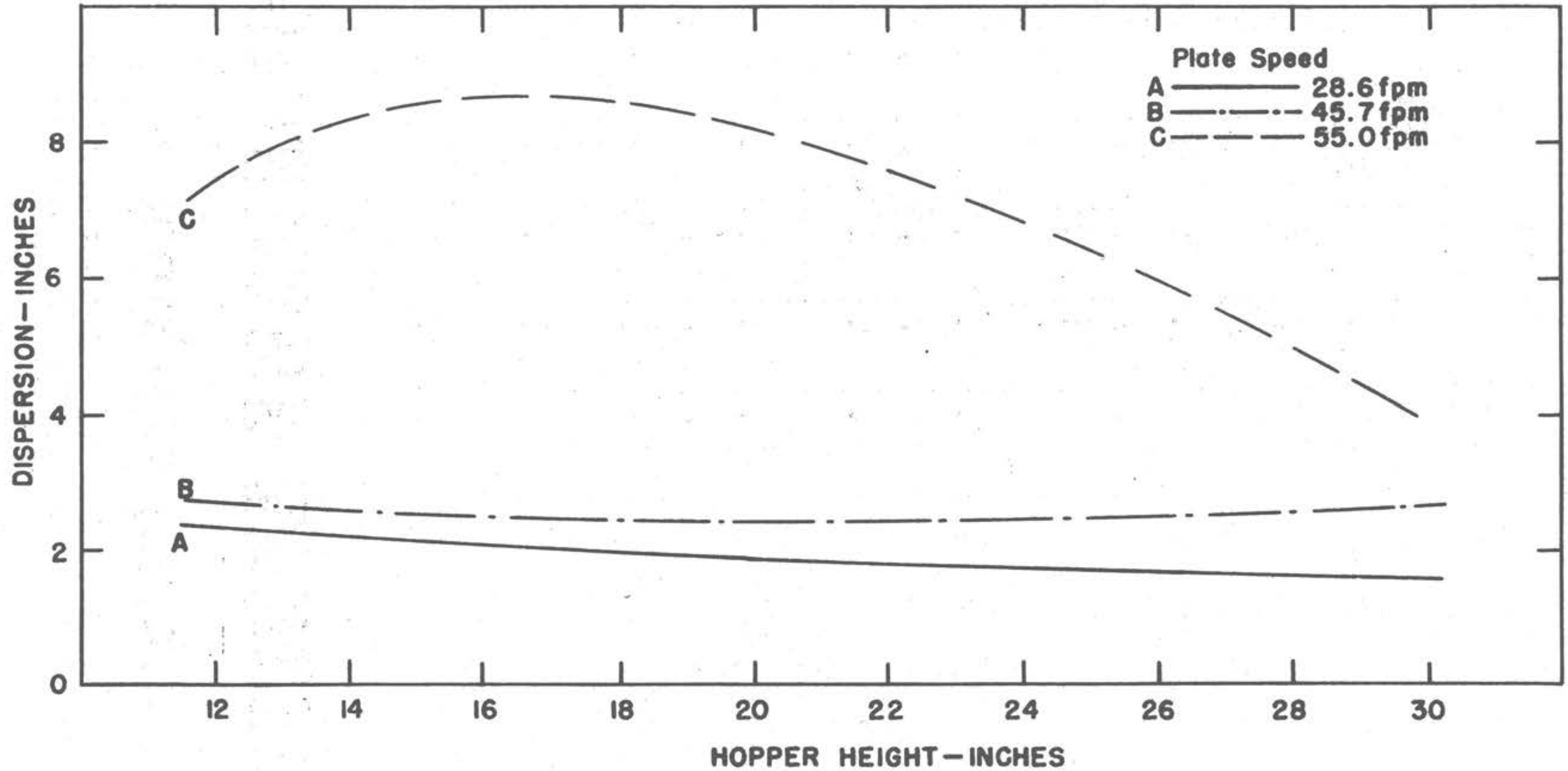

Fig. 11 Effect of hopper height on dispersion. Left mounted hopper
Ground Speed = 2.0 mph

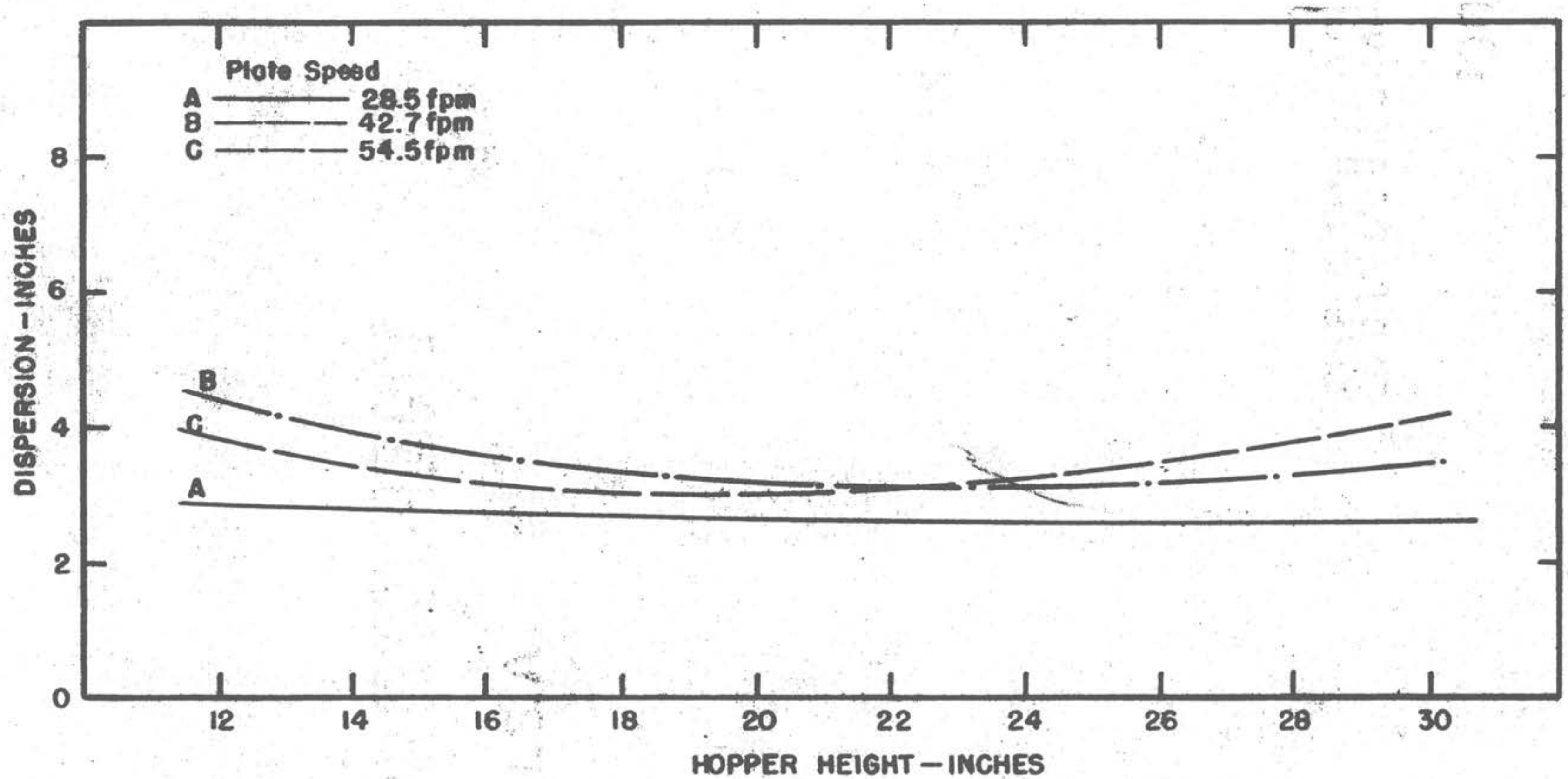

Fig. 12 Effect of hopper height on dispersion. Left mounted hopper
Ground Speed = 4.7 mph

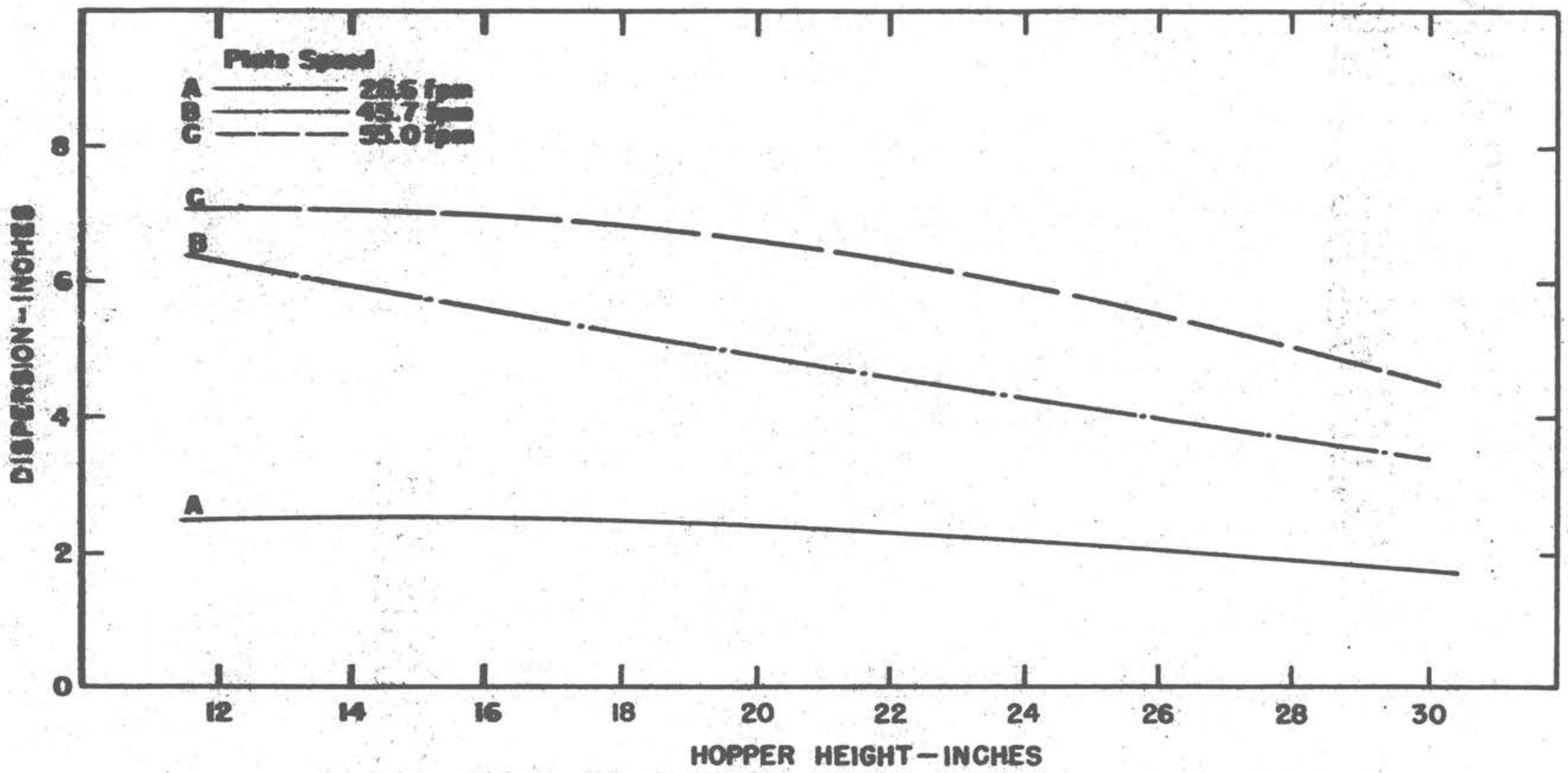

Fig. 13 Effect of hopper height on dispersion. Right mounted hopper
Ground Speed = 2.0 mph

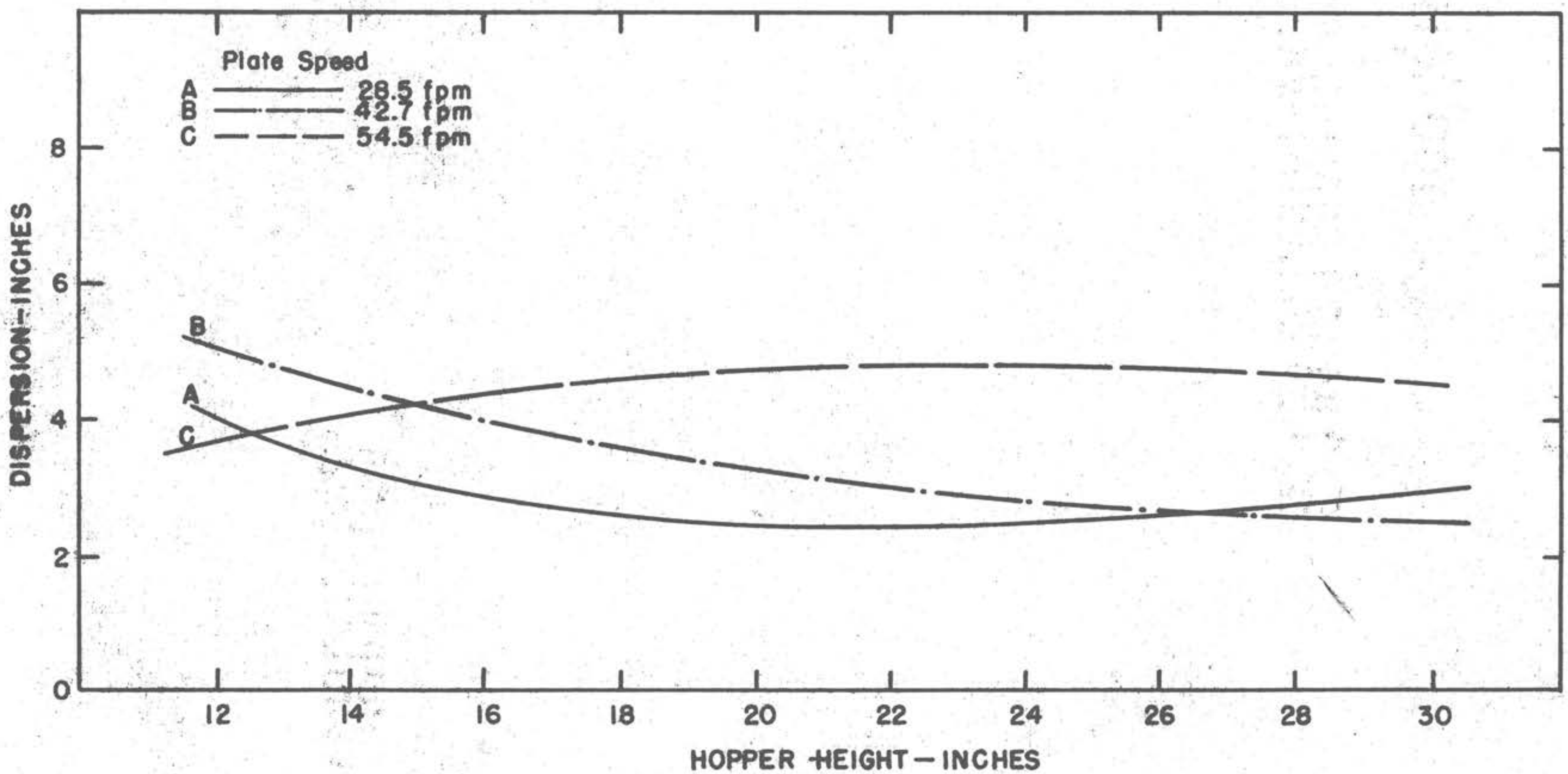

Fig. 14 Effect of hopper height on dispersion. Right mounted hopper
Ground Speed = 4.7 mph

TABLE VI

Probability of Hill Size

Seed per Hill (n)	Frequency of Hills (f)	Distribution of Number of Germinating Hills — Seed per Hill: 0	1	2	3	4	5
0	0	0.00					
1	12	3.30	8.70				
2	50	3.80	19.90	26.30			
3	98	2.06	16.17	42.63	37.34		
4	31	0.19	1.86	7.44	13.02	8.56	
5	7	0.01	0.14	0.77	2.03	2.66	1.40
Total	198	9.36	46.77	77.14	52.39	11.22	1.40
% occurrence		4.71	23.60	38.93	26.43	5.64	0.69

$$\% \text{ occurrence} = \frac{\text{Total}}{198}$$

V. DISCUSSION OF RESULTS

A. Laboratory Studies

1. Preliminary Results

After all the planter equipment had been set up, a few preliminary tests were made to determine the need for any adjustments in the machinery. Approximately 1 quart of seed was placed in the hopper. As the testing progressed, the number of 3 seed and 4 seed hills increased and the number of 5 seed and 6 seed hills decreased. Thus, the larger seed appeared to migrate toward the upper surface of the seed in the hopper. Several further tests were made with approximately 3 quarts of seed in the hopper for each test. About 70 hills comprised a test. Under such conditions, the tests did not indicate any sizing of the seed within the hopper. The previous sizing of the seed was due to the vibrations of the planter and equipment. Therefore, all future tests and experiments were made with approximately three quarts of seed in the hopper.

A preliminary check showed that better dispersion results were obtained at a plate speed of 55 fpm than at 45 fpm. Such results were contrary to previous findings. When using a 12-cell plate at 55 fpm, the hills were spaced approximately 5.8 in. apart. The same plate averaged 3+ seed per hill. Thus, for one to distinguish a hill and its location was a difficult problem. The hindrance was thought to be due to inaccuracy in taking data.

A 4-cell plate was tried but due to undetectable differences in the plates, the 4-cell plate planted hills with an average of only 2 seed per hill. Therefore, 8 cells of the 12-cell plate were filled with lead. This altered plate was used to repeat the tests for a speed of 55 fpm. The hill spacing with the altered plate was approximately 17 1/2 in. and the dispersion of each hill was determined more accurately.

Observations had shown that the magnitude of the trajectory path of the seed was increased as the plate speed was increased. On the bottom of the planter and near the seed opening was a small projection that interrupted the trajectory path of the seeds at higher speeds. After hitting the obstruction, the seed no longer conformed to the trajectory path. This was noted by removing the seed tube and holding the greased board stationary beneath the hopper while seed were being planted. As a result, the seed were widely scattered over the board and were not concentrated in any one spot. If the projection were removed, the dispersion results at high speeds might be comparable to those obtained at lower plate speeds.

2. Effect of Hopper Position on Dispersion

a. Left Mounted

Figure 7 shows the dispersion of the seed to be approximately 2 at low plate speeds. The dispersion, in general, increased slightly as the plate speed was increased to 45 fpm. At that point, the curves abruptly changed to higher values of dispersion in the vicinity of 8 at plate speeds over 50 fpm. The increased dispersion at higher plate speeds was partly caused by the small projection on the bottom of the planter. Curve C shows that the maximum value of dispersion was a little above 5. A possible explanation for the flatness of curve C is that the seed for one hill have more time to align and regroup themselves during the fall in a longer tube. The magnitude of the dispersion for the left mounted hopper was greater than the dispersion obtained for similar conditions with the conventionally mounted hopper.

At a ground speed of 4.7 mph, the curves for dispersion assumed an entirely different shape (Fig. 8). The magnitude of the dispersion was greater for low plate speeds at the increased ground speed. The dispersion had a tendency to reach a maximum value between the plate speeds of 40 fpm and 50 fpm. Curve C deviated from the above tendency in that the dispersion increased as the plate speed increased. The reason for the difference in curve C is not evident.

b. Right Mounted

Figure 9 shows the dispersion characteristics of a right mounted hopper at a ground speed of 2.0 mph and for various plate speeds. The curves are similar in shape. The dispersion increased as the plate speed was increased. The minimum values of dispersion were approximately 2 for low plate speeds and the maximum dispersion was about 7 for the high plate speeds.

When the ground speed was increased to 4.7 mph (Fig. 10), the corresponding curves, in general, became flatter; the increase in dispersion was more gradual. The minimum values of dispersion were higher than for 2.0 mph, but the maximum values were lower.

c. Summary

If a comparison is made between Fig. 7 and Fig. 9, one may observe the effects or differences with respect to dispersion between the left and right mounted hoppers. The dispersion for a left mounted hopper was relatively the same between the plate speeds of 28 fpm and 45 fpm. At that point, the dispersion increased abruptly. For the right mounted hopper, the dispersion increased rapidly with any increase in plate speed.

Similar statements can be made if Figs. 8 and 10 are compared. The curves are not similar in shape, but the values of dispersion are lower for the left mounted hopper. Actual dispersion results are shown in Figs. 15 and 16.

Fig. 15 Effect of plate speed on dispersion. Left mounted hopper
Ground speed - 4.7 mph
Hopper height - 29 in.
Plate Speed - A-28.5 fpm
B-34.2 fpm
C-42.7 fpm
D-54.5 fpm

Fig. 16 Effect of plate speed on dispersion. Right mounted hopper
Ground speed - 4.7 mph
Hopper height - 29 in.
Plate speeds - A-28.5 fpm
B-34.2 fpm
C-42.7 fpm
D-54.5 fpm

The above results can be explained by the use of vectors. When seed are ejected from the planter, they have two lateral velocity components with respect to the ground. One component is the velocity of the planter with respect to the ground. The velocity at which the seed leave the plate is the other lateral component. Let line A represent the velocity of the planter, 2.0 mph or 176 fpm, and line B represent the velocity of the seed as they drop from the seed plate. Since the seed are in contact with the plate before dropping, the velocity of the seed is equal to the peripheral speed of the plate at the instant the seed are ejected from the plate. For illustrative purposes, assume a plate speed of 30 fpm. Thus, a left mounted hopper would have vectors drawn from an origin, O, as shown below.

The resultant velocity of the seed with respect to the ground would be a vector in the direction of A and equal to A - B in magnitude or 146 fpm.

Now, assume a plate speed of 50 fpm with the ground speed remaining the same. The resultant velocity of the seed with respect to the ground is 126 fpm.

The horizontal velocity of the seed during their fall to the ground is reduced by gravity and by the seed tube, but the initial velocity of the seed determines the magnitude of their parabolic path. Thus, the lateral velocity of the seed upon reaching the ground would be greater for greater plate speeds. If there is a positive relationship between resultant velocity of the seed when they reach the ground and dispersion, and if the above reasoning is true, the dispersion values should decrease with increased plate speeds.

An examination of Fig. 7 shows that the dispersion values do not vary much between plate speeds of 28 fpm and 45 fpm. Figure 8 shows the dispersion values to vary more between the same plate speeds. As mentioned before, increased dispersion at high plate speeds was partly caused by a projection on the planter.

If the ground speed is increased and the plate speeds remain the same, the magnitude of the resultant velocity of the seed with respect to the ground would be greater. Thus, the dispersion values at 4.7 mph should be greater than those at 2.0 mph. A comparison of Fig. 7 and Fig. 8 shows the tendency of the above hypothesis to be correct.

Similar analysis is applied to a right mounted hopper. With the same assumptions, speed of planter is 2.0 mph and plate speed is 30 fpm, a vector diagram with the same notations as on previous diagrams would be as shown below.

The vectors are additive and the resultant velocity of the seed in magnitude and direction would be equal to A+B or 206 fpm.

Thus, for the same conditions, the seed being planted with a right mounted hopper have a greater initial velocity with respect to the ground than a left mounted hopper.

If the plate speed is increased to 50 fpm and the ground speed is held constant, the resultant velocity would be increased to 226 fpm.

Thus for a right mounted hopper, the dispersion would be increased with an increase in either plate speed or ground speed.

From the above analysis, the dispersion for a right mounted hopper should yield an increasing curve with an increase in plate speed. Figures 9 and 10 show tendencies of increased dispersion with increased plate speeds, but the figures do not show any tendency for the dispersion to be greater with increased ground speeds.

The velocity vectors for a conventionally mounted hopper would be drawn as below.

Vector A is the ground speed of the tractor, and B is the velocity of the ejected seed. The resultant velocity is found by the parallelogram method, and the magnitude of the resultant is equal to $\sqrt{A^2 + B^2}$.

3. Effect of Hopper Height on Dispersion

a. Left Mounted Hopper

With reference to Fig. 11, the curves that show the effect of hopper height on dispersion are not consistent in shape. At the lowest plate speed, the dispersion decreased as the hopper height was increased. When the plate speed was increased to 45.7 fpm, the dispersion remained nearly the same for all hopper heights with the 19 in. height having the least dispersion. The reason why curve C was not similar in shape to curves A and B is not known.

When the ground speed was increased to 4.7 mph (Fig. 12) the dispersion had a tendency to increase for all hopper heights. In general, the curves for both ground speeds tended to be much the same in shape. The curves show the dispersion to be best at a hopper height of 19 in. The above results tend to agree with similar results for a conventionally mounted hopper.

b. Right Mounted Hopper

Figure 13 shows the effect of hopper height on dispersion for a right mounted hopper at a ground speed of 2.0 mph. All curves show a decrease in dispersion as the hopper height was increased. The curves varied some in shape but the end result was always the same. A condition of low plate speed, low ground speed, and high hopper height gave the most desirable dispersion values.

When the ground speed was increased to 4.7 mph (Fig. 14), the curves had a different shape. The magnitude of the dispersion was less at the higher ground speed. Also, there was a trend for the dispersion to have a constant value at the hopper height of 29 in.

for the various plate speeds. The hopper height appeared to have some effect on dispersion, but the effect was not always the same.

If the curves of Figs. 13 and 14 are considered together, there is a marked trend for the 29 in. hopper height to have the most favorable dispersion characteristics. The curves also tend to confirm the idea that at high hopper heights, the seed had sufficient time to align and group themselves into a compact bunch before being planted.

c. Summary

An examination of all the hopper height curves shows that low plate speeds had lower dispersion values at all conditions of hopper position and ground speeds. There was a definite trend for the left mounted hopper to have more desirable dispersion characteristics than a right mounted hopper. Actual dispersion results are shown in Figs. 17 and 18.

4. Ground Speed-Plate Speed Ratio

No definite optimum ground speed-plate speed ratio was found to exist for either a left mounted or a right mounted hopper position. Autry's ratio of 8.2 to 1[1] may hold true for the low ground speeds in this study, but the ratio does not appear to hold true for the higher ground speeds. With reference to Figs. 8 and 10, a ratio of 8.2 would give a plate speed of 50.5 fpm. The curves show that plate speeds of 28 fpm had the lowest dispersion values.

B. Field Studies

Due to three weeks of inclement weather, the results of field studies were not available for publication. At a later date, the results will be available at the Department of Agricultural Engineering.

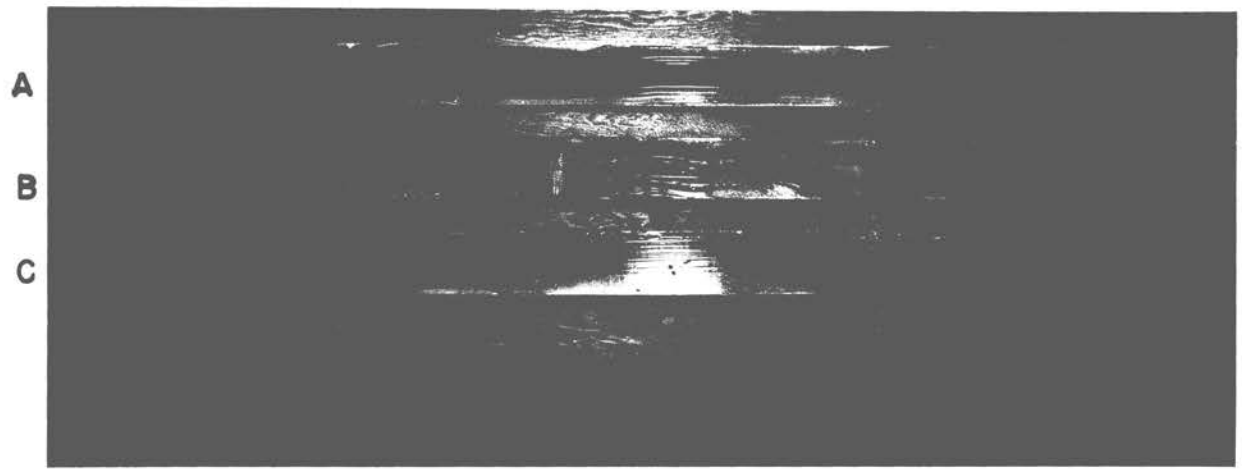

Fig. 17 Effect of hopper height on dispersion. Left mounted hopper
Ground speed - 4.7 mph
Plate speed - 42.7 fpm
Hopper height - A-12 in.
B-19 in.
C-29 in.

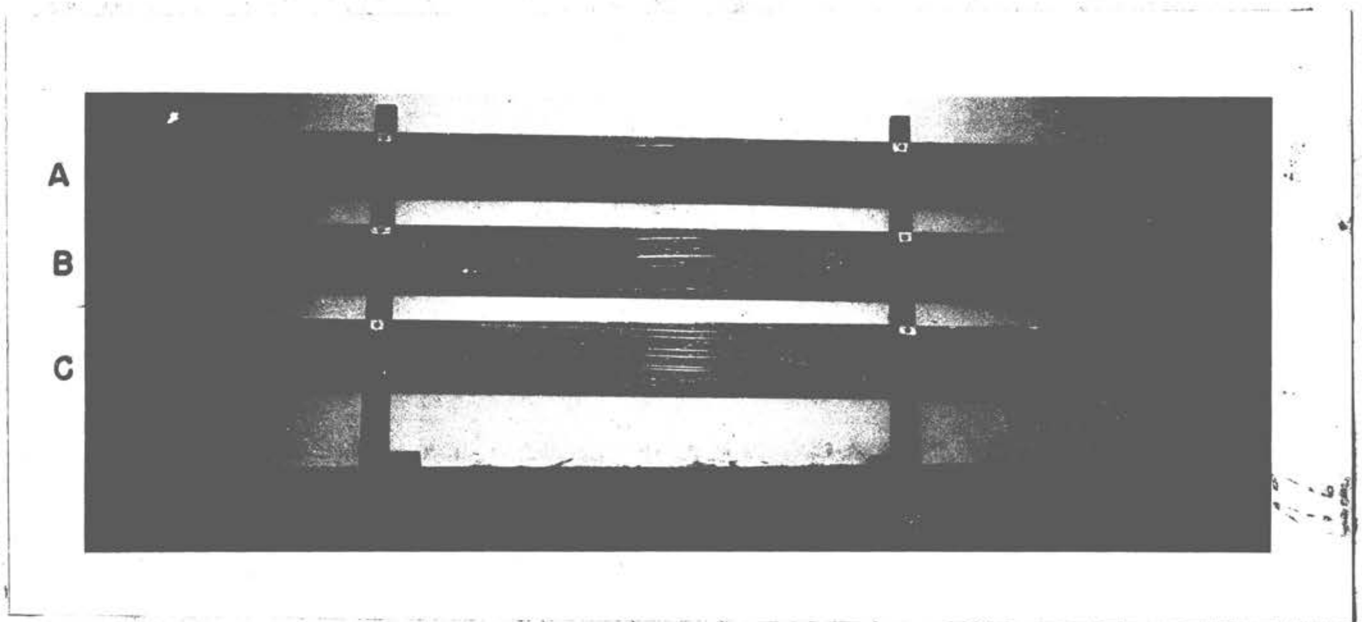

Fig. 18 Effect of hopper height on dispersion. Right mounted hopper
Ground speed - 4.7 mph
Plate speed - 42.7 fpm
Hopper height - A-12 in.
B-19 in.
C-29 in.

VI. SUMMARY AND CONCLUSIONS

The investigations and analysis of the data presented in this report support the following conclusions.

1. The right mounted hopper is not as satisfactory with respect to dispersion characteristics as a left mounted hopper, and both have a disadvantage when compared to the conventional mounting.

2. For a left mounted hopper, a hopper height of approximately 19 in. gives the optimum dispersion results.

3. For a right mounted hopper, a hopper height of approximately 29 in. gives the optimum dispersion results.

4. No definite optimum ground speed-plate speed ratio exists for either the left mounted or right mounted hopper position.

5. At any ground speed, better dispersion characteristics are obtained when the plate speeds are low (below 45 fpm).

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TYPIST PAGE

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