

THE DIFFUSION OF GRAIN SORGHUM
IN KANSAS

by

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CONTENTS

List of Tables.	vi
List of Figures	vii
List of Maps.	viii
Chapter	
1. INTRODUCTION.	1
Background of Grain Sorghum in Kansas.	1
Terminology	1
Introduction of Grain Sorghum into Kansas	2
Adaptability and Feeding Value.	3
Review of Related Literature	4
Background of Diffusion Studies	4
The Logistic Curve Theory	5
Patterns of Information Flow.	6
Adoption Behavior	10
Statement of Problem	11
Justification.	11
2. METHOD OF APPROACH.	15
Definitions and Assumptions.	15
Diffusion	15

Adopter	15
Adoption.	15
Time Unit	17
Research Procedure	18
Method for the Hypothesis Test.	18
Method for Describing the Diffusion Pattern	24
Data Collecting Method	25
Sources	25
Organizing the Data	26
3. ANALYSIS OF DATA.	29
Constructing the Observed Curve.	29
Constructing the Theoretical Curve	32
Hypothesis Test.	35
4. DISCUSSION.	41
A Comparison with Previous Researchers	41
The Patterns of Information Flow	45
Expansion Pattern	45
Contagious Pattern.	45
Hierarchical Pattern.	54
Spatial, Temporal, and Behavioral Aspects.	58
The Adopters' Behavior.	60
Innovators	60

Early Adopters	63
Early Majority	65
Late Majority.	68
Laggards	71
5. SUMMARY AND CONCLUSIONS	79
Methodological Problems.	82
Implication from Findings.	84
BIBLIOGRAPHY.	87
APPENDIX	
A. Percentages of Field Crop Acres as Occupied by Grain	
Sorghum, 1895 - 1975	91

TABLES

Table		Page
2.1	The Relationship Between the Value of P (Proportion of Adopters) and the Power of e (constant).	21
2.2	The Relationship Between the Value of a and the Value of P (Proportion of Adopters)	22
2.3	Comparison of the Rate of Two Curves Under Different Values of b	23
3.1	Cumulative Frequency Distribution of Proportion of Grain Sorghum Adopters in Kansas	30
3.2	Theoretical Cumulative Frequency Distribution of Adopters Under Different Values of the Parameters.	33
3.3	The Difference Between the Theoretical Distribution of Proportion of Grain Sorghum Adopters in Kansas and the Observed Distribution in the Same Case. . .	38
4.1	The Value Per Acre of Kafir and Corn in Kansas, 1901 - 1913	66
4.2	Corn Acreage in Kansas, 1933 - 1943	70

FIGURES

Figure		Page
1.1	The Logistic Curve.	6
1.2	Expansion Diffusion	7
1.3	Contagious Diffusion.	8
1.4	Hierarchical Diffusion.	9
1.5	Relocation Diffusion.	9
2.1	The Logistic Curve.	20
3.1	The Observed Curve Describing Cumulative Level of Adoption of Grain Sorghum in Kansas. . . .	31
3.2	Theoretical Logistic Curves Describing the Cumulative Level of Adoption as Compared to the Observed Curve in the Same Case	34
3.3	A Comparison Between the Observed Curve and the Theoretical Curve Describing Cumulative Level of Adoption of Grain Sorghum in Kansas. . . .	36
4.1	Distribution of Adopters in Diffusion Process . . .	42

MAPS

Map	Page
1. Diffusion of Grain Sorghum in Kansas, 1895	46
2. Diffusion of Grain Sorghum in Kansas, 1905	47
3. Diffusion of Grain Sorghum in Kansas, 1915	48
4. Diffusion of Grain Sorghum in Kansas, 1925	49
5. Diffusion of Grain Sorghum in Kansas, 1935	50
6. Diffusion of Grain Sorghum in Kansas, 1945	51
7. Diffusion of Grain Sorghum in Kansas, 1955	52
8. Diffusion of Grain Sorghum in Kansas, 1965	53
9. Counties Ranked by the Density of Grain Sorghum, 1895 - 1925.	56
10. Counties Ranked by the Density of Grain Sorghum, 1935 - 1955.	57

Chapter 1

INTRODUCTION

The diffusion of grain sorghum in Kansas has caused some tremendous change in Kansas agriculture. Kansas, once a wheat-and-corn state, became a wheat-and-sorghum state.¹

This study attempts to learn when, where and why such change has happened; with major focuses on the diffusion process through time, the diffusion pattern and the adopters' behavior in the case of grain sorghum in Kansas.

Chapter 1 examines the history of grain sorghum in Kansas and previous research on diffusion processes. A justification for the study and the statement of problem are included in the chapter.

Background of Grain Sorghum in Kansas

Grain sorghum in Kansas is viewed in terms of its terminology, its introduction into Kansas, its adaptability and feeding value.

Terminology

Grain sorghum (*sorghum vulgare*) belongs to the sorghum (*graminae*) family which is divided into four types:

- a) grain sorghum or nonsaccharin sorghum;
- b) sorgo or saccharin sorghum;
- c) broom corn; and
- d) grass corn.²

Grain sorghum still has many subgroups, as follows:

- kafir (caffrorum),
- feterita (caudatum),
- milo (subglabrescens),
- white durra (cernuum),
- brown durra (durra),
- shallu (roxburghii),
- kaoliang, and
- hegari.³

Most of these subgroups have their origins in Africa, except for Shallu which is from India and Kaoliang which is from China.⁴

Introduction of Grain Sorghum into Kansas

The first grain sorghum, called "Guinea-Corn", entered the United States long before the introduction of the first sorgo (sweet sorghum) in 1853. Other kinds of grain sorghum came to this country during the colonial period but failed to become permanently established.⁵

Grain sorghum subgroups that were introduced to the United States, later, and were sent to different parts of the country were:

- White Durra and Brown Durra in 1874,
- White and Red Kafir in 1876,
- Milo in 1885,
- Shallu in 1890,
- Feterita in 1906, and
- Hegari in 1908.⁶

Grain sorghum was introduced to Kansas during the 1880's, mostly through importation by the U. S. Department of Agriculture. Early varieties of grain sorghum that came to this state were White Durra, Whitehull White Kafir, Red Kafir, Milo, Blackhull White Kafir, Pink Kafir, and Feterita.⁷

At first, grain sorghum were grown experimentally by the Kansas Agricultural Experiment Stations at Hays, Garden City, Colby, and Manhattan. Then, seeds of grain sorghum were sent from these stations to farmers in the light-rainfall parts of the state. Thus, grain sorghum was grown cooperatively by the experiment stations and by farmers.⁸

As time passed, grain sorghum gained more and more popularity, due to its drought-resisting qualities and its livestock feeding value which could be a good substitute for corn.⁹ In fact, in 1895, some agronomists even announced that grain sorghum had passed out of the experimental stage and had become an important crop in Kansas.¹⁰

Adaptability and Feeding Value

Grain sorghum is well adapted to temperate regions which have warm summer weather, and it can be grown successfully on nearly all types of soil. Thus, it is well adapted to Kansas soil and climate.¹¹

The feeding value of grain sorghum is similar to corn, but it contains slightly more protein and less fat. Grain sorghum is a good substitute for corn in almost all places where corn is used as a livestock feed. Moreover, grain sorghum usually is a cheaper feed than corn.¹²

Review of Related Literature

The literature reviewed in this section include previous research on diffusion processes. The subjects reviewed are the background of diffusion studies, the logistic curve theory, patterns of information flow, and adoption behavior.

Background of Diffusion Studies

Modern diffusion studies are considered to be pioneered by sociologists. In 1903, Gabriel Tarde was the first sociologist to propose some ideas on diffusion processes. This subject was interesting to him because:

Our problem is to learn why, given one hundred different innovations conceived of at the same time - innovation in the form of words, in mythological ideas, in industrial processes, etc. Ten will spread abroad while ninety will be forgotten.¹³

One of Tarde's ideas which is an important contribution to diffusion studies is the use of a logistic curve (S-shaped curve) in describing diffusion processes. This idea was first applied in Chapin's study on the diffusion of social institutions in the United States in 1928.¹⁴

Geographers paid some attention to diffusion studies much later than sociologists did. A geographer who is considered a pioneer in diffusion studies is Torsten Hagerstrand (1952) who found that diffusion processes seemed to sweep across space in a wave-like manner from the origin.¹⁵

Since Hagerstrand, more geographers entered the field; such as, Brown, Morrill, Gould, and Casetti. Some of their contributions to diffusion studies will be reviewed in the topics concerning the logistic curve theory, patterns of information flow, and adoption behavior.

The Logistic Curve Theory

The logistic curve or the S-shaped curve is used to describe the course of a diffusion process in many cases. According to Jones (1966), this curve is:

A graph describing the course of an item's diffusion, expressed as a cumulative level of adoption at succeeding points in time.¹⁶

This curve was explained by Powell and Roseman (1972) that the curve:

.... described the relationship between time and the cumulative proportion of adopters of an innovation. With respect to time, the spread of a phenomenon through a given proportion of adopters in a given area usually begins slowly, then accelerates through a period with a high acceptance rate, and finally levels off to approach an equilibrium or ceiling level.¹⁷

A number of previous researchers found that the course of diffusion processes usually followed the logistic (S-shaped) curve.¹⁸ (See details in Chapter 4). However, recent research reported that diffusion processes do not always follow the logistic curve. A number of studies at North Carolina Agricultural Extension Service showed

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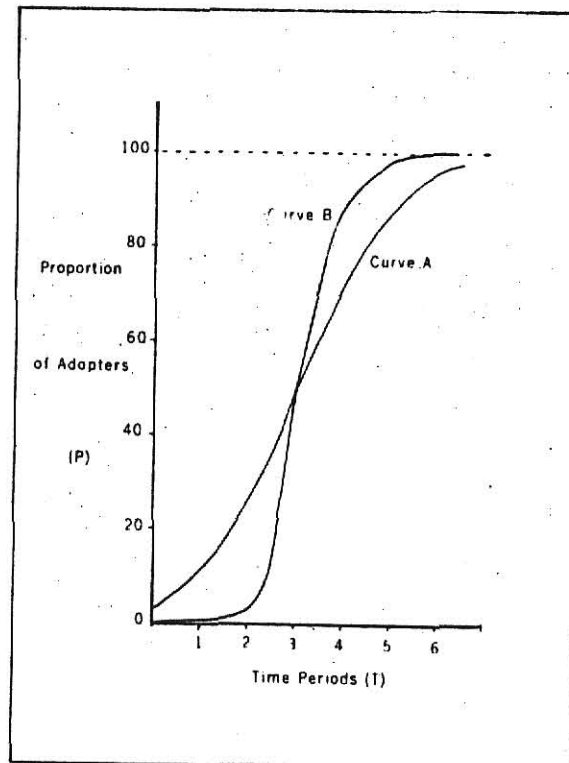


Figure 1.1 The Logistic Curve (Gould, 1969)

that there had been a rapid rate of initial adoption instead of a slow increasing rate at the beginning. The researchers suggested that:

Perhaps in American society, at least, innovation is rapidly becoming the norm and the diffusion curve will soon more nearly approximate a J-curve than an S-curve.¹⁹

Patterns of Information Flow

In diffusion processes, information flow usually has four patterns: expansion, contagious, relocation, and hierarchical.²⁰

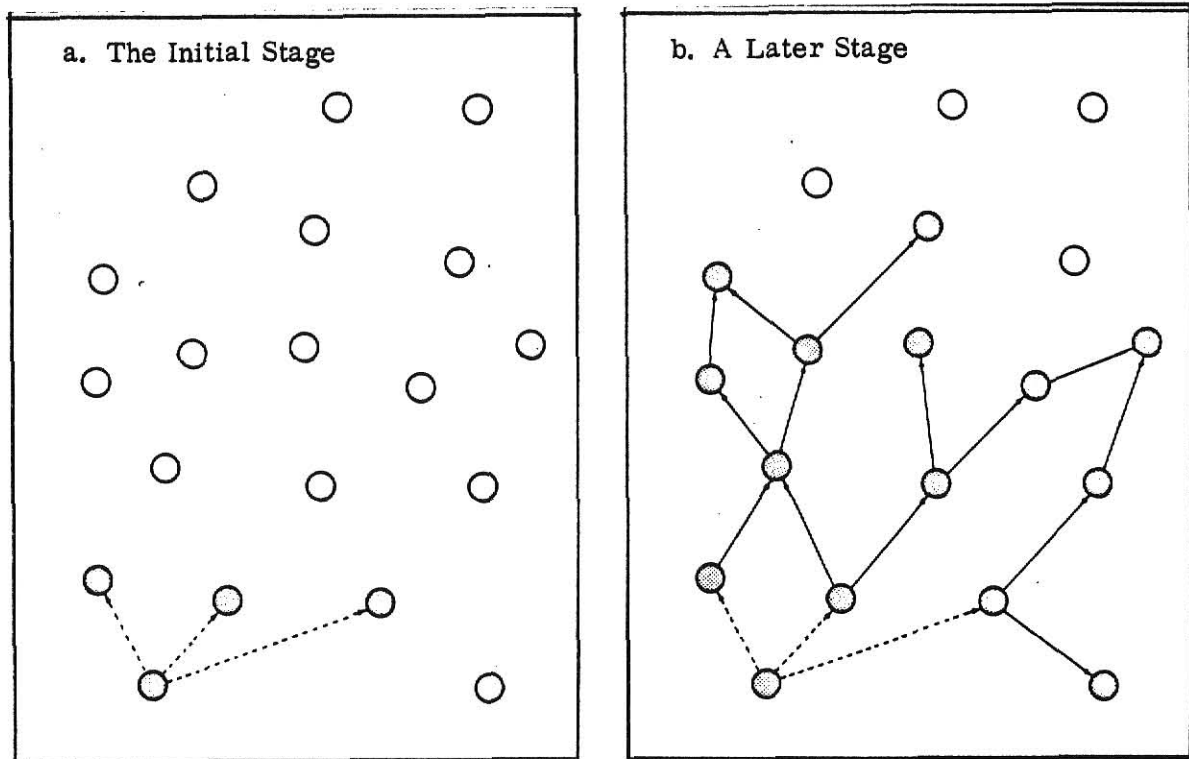


Figure 1.2 Expansion Diffusion (Brown, 1968)

In the expansion type of information flow, an idea is communicated by a person who knows about it to one who does not, and the sum total of adopters grows through time. This is similar to contagious pattern; but in contagious type, the frictional effect of distance strongly influences diffusion processes.²¹

Contagious diffusion occurs when the new item spreads through a direct contact. Ideas are passed to people close to those who already have them.²² This is rather different from hierarchical pattern in which ideas are passed through a regular sequence of order, classes or hierarchies. In hierarchical diffusion, more important places

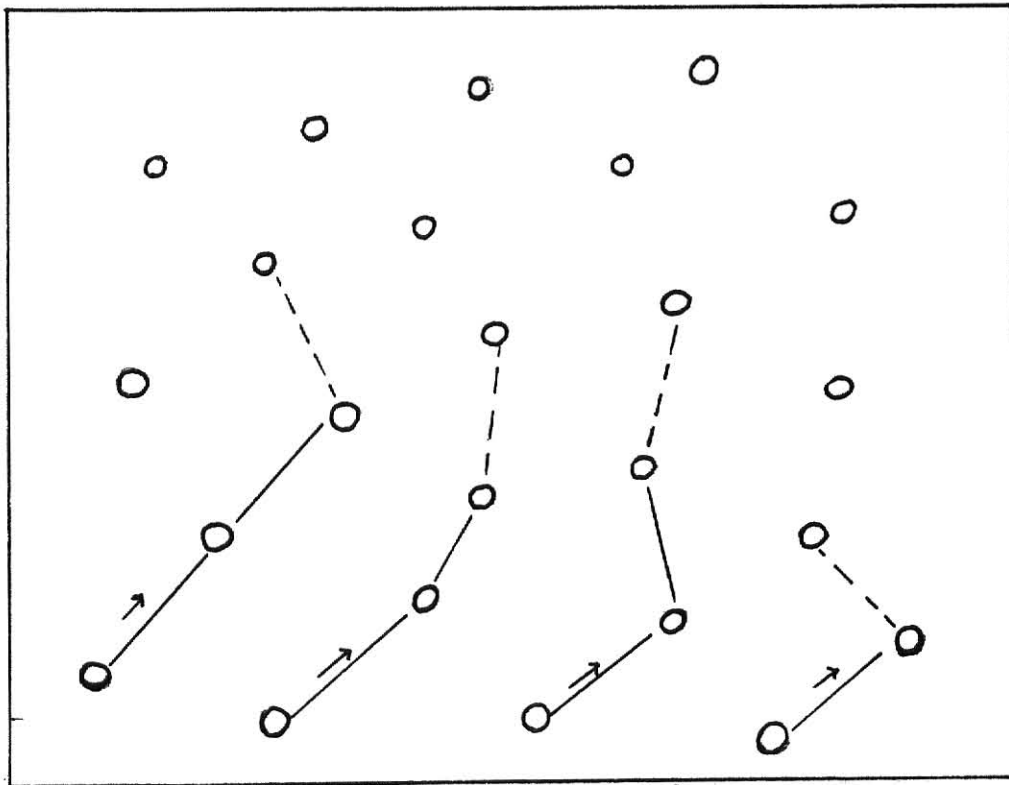


Figure 1.3 Contagious Diffusion

tend to adopt a new item earlier than less important ones. So, distance from the origin does not have the strongest influence in the hierarchical type,²³ as Hagerstrand (1952) observed:

In addition to the influence from the center, on the neighbouring districts, we find short circuits to the more important places at a greater distance.²⁴

Relocation patterns occur when people who know or adopt a new item move to new locations. The commonest example is that of migration.²⁵

In the real world, diffusion pattern can be a combination among these patterns, as Gould (1969) explained:

.. many expansion diffusions are of the contagious type. As an idea or an innovation spreads gradually outwards from a core area by a process of contagious, the sum total of adopters also grows...²⁶

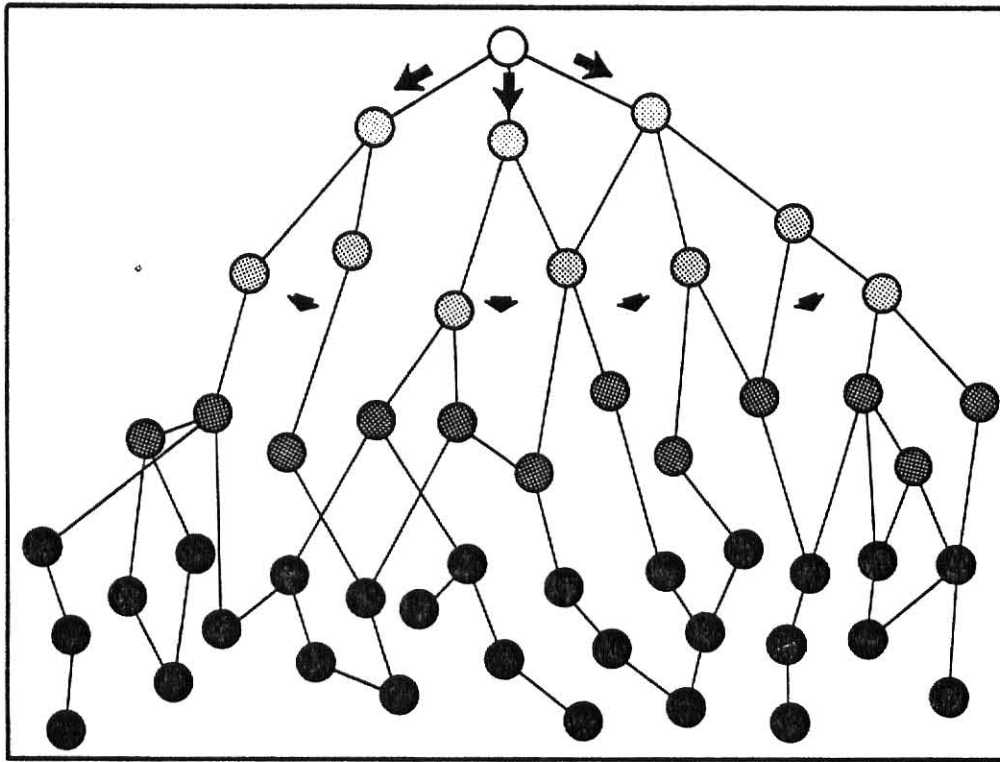


Figure 1.4 Hierarchical Diffusion (Gould, 1969)

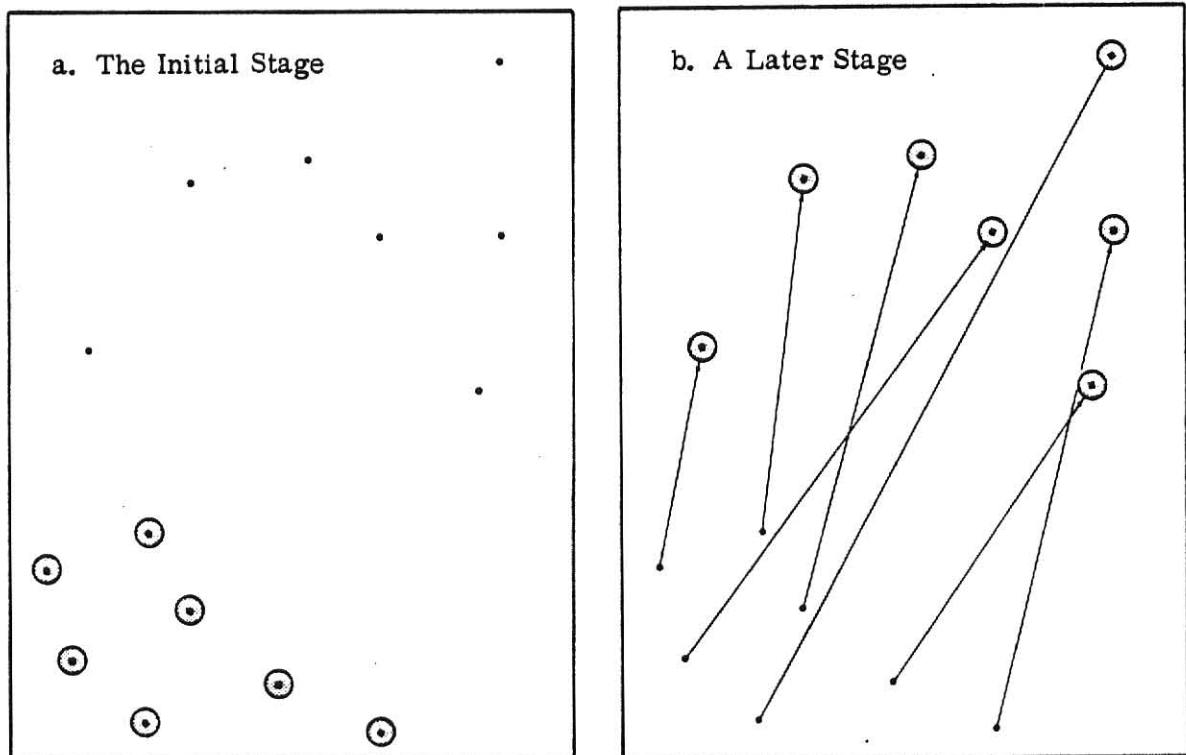


Figure 1.5 Relocation Diffusion (Gould, 1969)

Adoption Behavior

Human behavior in diffusion processes was paid much attention by many sociologists and geographers. Many researchers believe that the diffusion process is merely a persuasion and decision-making process.

Hagerstrand built a model based on the role of 'neighborhood effect'. His model is a network of social communication which was composed of individuals serving both as receivers and informers. In this model, mass media was separated from interpersonal communication which was considered much more important. The Monte Carlo Game Theory was utilized in this model to state certain rules of decision-making, based on probability theory.²⁷

Some researchers did not agree with the idea that 'neighborhood effect' was the most important factor in determining pattern of adoption behavior. Blaut (1977) thought that knowledge not only passed from neighbours, but also from social organization such as schools.²⁸ Lionberger and Hassinger (1954) thought that there were three sources of information: intimate associates, mass media, and institutionalized sources.²⁹

Another idea on this subject was suggested by Moulik, et. al. (1966), who thought that there was always a variation in the rate of adoption. The adoption behavior correlates with a variety of social and economic factors. It is dependent upon many forces characterized not only by the physical and economic factors of an individual's

environment, but also by his personality characteristics as shown by self-perception in his environment.³⁰

Statement of Problem

Previous empirical studies formulated a theory that the diffusion process can be described by the theoretical logistic (S-shaped) curve. Also, it has been observed that the process falls into either one or a combination of these patterns: expansion, contagious, relocation, and hierarchy.

The objective of this research is to determine whether the diffusion of grain sorghum in Kansas follows the logistic curve; to determine the pattern of grain sorghum diffusion in Kansas; and to explain the behavior of grain sorghum adopters in Kansas in general.

Justification

This investigation fits into the spatial tradition of geography because it investigates the change in spatial distribution of grain sorghum in Kansas. Besides, the result of the investigation may be helpful to those who plan to introduce new things to any regions, especially in an agricultural sector. This case can set an example of how much time it takes for the process to reach a saturation level. Finally, it may contribute to some knowledge in the area of diffusion studies per se.

FOOTNOTES

¹ Annual Reports of the Kansas State Board of Agriculture (Topeka: Kansas State Board of Agriculture, 1957), pp. 13-15.

² Warren H. Leonard and John H. Martin, Cereal Crops (New York: MacMillan, 1963), p. 681.

³ L. H. Bailey and E. Z. Bailey, Hortus Third: A Concise Dictionary of Plants Cultivated in the United States and Canada (New York: MacMillan, 1976), p. 1060; Leonard and Martin, op. cit., pp. 690-691.

⁴ Ibid.

⁵ Leonard and Martin, loc. cit.

⁶ Ibid.

⁷ A. E. Swanson and H. H. Laudi, "Sorghum for Kansas", Kansas State Agricultural College's Experiment Station. Bulletin No. 304, (September, 1942), pp. 10-12.

⁸ Annual Reports of the Kansas State Board of Agriculture (Topeka: Kansas State Board of Agriculture, 1888-1945, Inclusive).

⁹ Kansas State Agricultural College's Experiment Station. Bulletin No. 49-56, 1985, p. 161.

¹⁰ Kansas State Board of Agriculture: Quarterly Report. Topeka, (March, 1986), p. 124.

- ¹¹ Leonard and Martin, op. cit., pp. 682-683.
- ¹² Ibid., pp. 707-708.
- ¹³ Everette M. Rogers, Diffusion of Innovation (New York: The Free Press, 1962), p. 1
- ¹⁴ Ibid., p. 29; F. Stuart Chapin, Cultural Change (New York: The Century Co., 1928), pp. 357-384.
- ¹⁵ Torsten Hagerstrand, The Propagation of Innovation Wave (Sweden: Lund Studies in Geography, Series B., No. 4, 1952), pp. 16-17.
- ¹⁶ Lawrence A. Brown and Kevin R. Cox, "Empirical Regularities in the Diffusion of Innovation", Annals of the Association of American Geographers, 61 (1971) 551.
- ¹⁷ L. C. Powell and C. C. Roseman, "An Investigation of the Subprocess of Diffusion", Rural Sociology, 37 (1972) 221.
- ¹⁸ Rogers, op. cit., pp. 152-159.
- ¹⁹ Astor Perry, et. al., "The Adoption Process: S-curve or J-curve?", Rural Sociology, 32 (1967), 220-222.
- ²⁰ Peter Gould, Spatial Diffusion (Washington, D. C.: Association of American Geographers, 1969), pp. 3-6.
- ²¹ Ibid.
- ²² Ibid.
- ²³ Ibid.

²⁴ Brown and Cox, loc. cit.

²⁵ Gould, loc. cit.

²⁶ Ibid.

²⁷ Gould, op. cit., pp. 29-31; Lawrence A. Brown, Diffusion Dynamics (Lund, Sweden: C. W. K. Gleerup, 1968), pp. 12-13.

²⁸ James M. Blaut, "Two Views of Diffusion", Annals of the Association of American Geographers, 67 (1977) 344.

²⁹ Herbert F. Lionberger and Edward Hassinger, "Neighborhoods as a Factor in the Diffusion of Farm Innovation in Northwest Missouri", Rural Sociology, 19 (1954) 382.

³⁰ T. K. Moulik, J. P. Hrabovszky, and C. S. S. Rao, "Predictive Values of Some Factors of Adoption of Nitrogeneous Fertilizers by North Indian Farmers", Rural Sociology, 31 (1966) 465.

Chapter 2

METHOD OF APPROACH

This chapter focuses on definitions and assumptions, research procedure, and data collecting method.

Definition and Assumptions

It is necessary to define diffusion, adopter, adoption, and time units as follows:

Diffusion

'Diffusion' here is defined as the process by which an idea or an item spreads from limited origins through a susceptible population over time and space.

Adopter

'Adopter' here is 'a unit of adoption'. In this case, one Kansas county represents one unit of adoption.

It is not necessary that an adopter must be an individual. Traditional studies show that an adopter could be a person, a group of people, an institution, or an area unit. For instance, Chapin (1928), in his study on the diffusion of social institutions in the United States, used a city as an adopter.¹

The definition of 'adoption' in this study is given using the assumptions:

- 1) that a country is regarded as a grain sorghum adopter when it has at least three percent of field crops acres devoted to grain sorghum; and
- 2) that a grain sorghum adopter will retain its status regardless of the fluctuation in grain sorghum acreage that may occur in the latter periods.

The first assumption is used because the author considered that a certain unit of crop acres devoted to grain sorghum is needed to determine the state of adoption. According to Rogers (1962), before a new idea or item is completely adopted, a potential adopter uses the new item on a small scale in order to determine its utility in his own situation. Ryan and Gross (1943) found that most farmers insisted upon personal experimentation before they would adopt the innovation completely.² Thus, in this case, it is unreasonable to count a county as a grain sorghum adopter only by the fact that it has some acres of grain sorghum in its cropland.

The reason for using three percent of field crops acres devoted to grain sorghum to determine complete adoption of grain sorghum is based on previous research on diffusion processes which usually found that the rate of diffusion process begins slowly, then accelerates through a high acceptance rate before leveling off to approach an equilibrium. In determining the exact unit for complete adoption of grain sorghum, the author tried experimentally to see which percentage of field crops acres devoted to grain sorghum would optimize the idea

mentioned above. It was found that if three percent of crop acres devoted to grain sorghum were used as a state of complete adoption, the rate of grain sorghum diffusion through time would approximately conform to an S-curve which occurred in many cases of diffusion. Thus, three percent of crop acres devoted to grain sorghum is used to determine a stage of adoption. Less than three percent is considered here as a trial stage before complete adoption of grain sorghum.

The second assumption is used because 'diffusion' is considered a learning process. When a county has adopted grain sorghum, it means that it has learned about grain sorghum and has decided to accept it. The fluctuation in grain sorghum acreage in the latter years might be due to other factors; such as price and rainfall, which normally occur with respect to many kinds of crops.

Time Unit

Time unit in this study is a ten year interval. Nine points of time are set to cover the total period observed, ranging from the year 1895 to the year 1975.

The first point in time started from the year 1895, instead of from the year 1893 which was the first year that grain sorghum was reported statistically by the State Board of Agriculture. This is because for more simplicity in understanding and having a better correspondence with the time unit.

Time intervals of less than ten years were not preferred because this study concentrated on the continuous aspect of the process.

Diffusion of agricultural phenomena usually takes a long time for complete adoption, rather than a rapid change. Besides, the fluctuation in grain sorghum acreage which commonly occurred because of differences in rainfall each year would cause some confusion in observing the rate of diffusion process if a short-length interval were applied.

Research Procedure

The first question in the statement of problem concerned the theoretical logistic (S-shaped) curve, while the second question concerned the spatial pattern of the observed curve. To answer the first question, it is necessary to conduct a hypothesis test to determine whether there is a difference between the theoretical curve and the observed curve. For the second question, a series of maps must be compiled to show distributions of grain sorghum adopters at different points in time.

In this section, explanations will be provided on the methods for the hypothesis test and the methods for the investigation on diffusion patterns. We begin with a method for the hypothesis test concerning the association between the theoretical logistic curve and the observed curve.

Methods for the Hypothesis Test

Before testing the hypothesis, first, the null hypothesis and the research hypothesis must be formulated. In this research the null hypothesis formulated is that there is no significant difference

between the observed curve and the theoretical logistic curve describing the diffusion process of grain sorghum in Kansas. The alternative hypothesis formulated is that there is no significant difference between the observed curve and the theoretical logistic curve describing the diffusion process of grain sorghum in Kansas.

After having formulated the hypothesis, the next step is constructing the observed curve and the theoretical curve. It is necessary to construct the observed curve first, then constructing the logistic curve that would optimize the shape of the observed curve, as the shape of the logistic curve can vary from one problem to another.³

The observed curve is a graph of the cumulative frequency distribution of an observed proportion of adopters through time. The method is a very simple one. After collecting and organizing data, cumulative frequency distribution of grain sorghum adopters in Kansas will be tabulated and brought to plot a curve on T (time) axis ranges from zero (1895) to eight (1975). The scale on P axis ranges from zero to 100 (an upper limit). The proportion of adopters is a dependent variable, whereas time unit is an independent variable.

The theoretical logistic curve may be represented by a graph describing the course of a diffusion process. The curve was explained by Powell and Roseman (1972) in saying that,

With respect to time, the spread of a phenomenon through a given proportion of adopters usually begins slowly, then accelerated through a period

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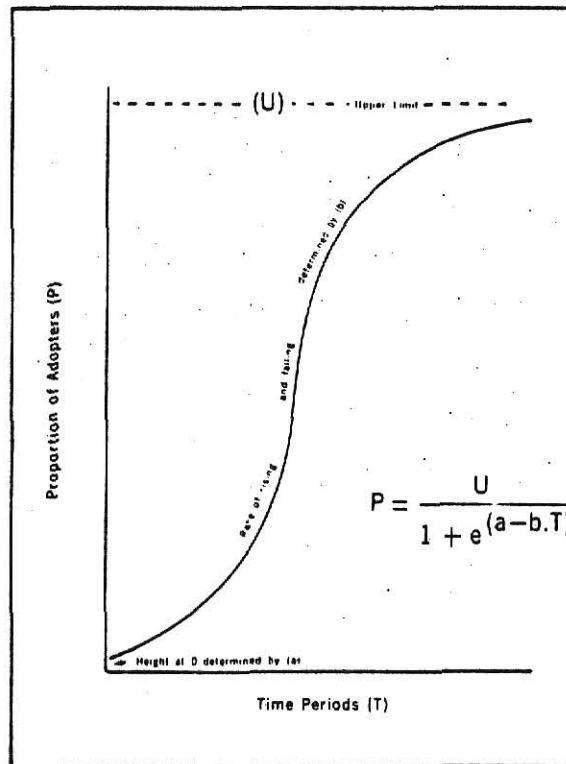


Figure 2.1. The Logistic Curve. (Gould, 1969)

An algebraic form for constructing the theoretical logistic curve for this research is borrowed from Gould (1969),⁵ as follows:

$$P = \frac{U}{1 + e^{(a-b.T)}}, \text{ in which:}$$

P = proportion of adopters,

U = upper limit, which substitutes 100 as an upper limit,

a = a parameter than controls the height above the T axis where the curve starts,

b = a parameter that determines how quickly the curve rises.

T = the time at some points in the diffusion process,

e = the constant = 2.7183.

This equation was formed in a way that when the value of T (time) is small, the value of P (proportion of adopters) is also small. This is because as T is small, the power of the constant e is raised high and causes the denominator to be a large number. So, this results in a small P at the beginning. However, when time passes, the T gets bigger, the power of e (constant) would be lower, and causes P to be bigger.⁶

Table 2.1. The Relationship Between the Value of P (Proportion of Adopters) and the Power of e (Constant).

Power of e^* (constant)	Value of P
10	0.00
9	0.10
8	0.03
7	0.09
6	0.24
5	0.66
4	1.79
3	4.74
2	11.92
1	26.89
0	50.00
-1	73.10
-2	88.07
-3	95.25
-4	98.20
-5	99.33

* e is lower than T (time) is bigger.

Source: Computed from Gould's $p = \frac{U}{1 + e^{(a-b.T)}}$, $U = 100$.

From the equation $p = \frac{U}{1 + e^{(a-b.T)}}$, the shape of the curve is controlled by the two parameters a and b . The greater the value of a , the smaller the value of P becomes, as shown in Table 2.2.

Table 2.2. The Relationship Between the Value of a and the Value of P (Proportion of Adopters).

a	P
2	11.92
3	4.74
4	1.79
5	0.66

Source: Computed from Gould's $p = \frac{U}{1 + e^{(a-b.T)}}$, when $U = 100$, $b = 1$,
 $T = 0$

The parameter b is the adjustment co-efficient. It indicated how much the value of the logistic transform will change per time unit.⁷
 The greater the value of b , the faster the curve rises.

Table 2.3. Comparison of the Rate of Two Curves Under Different Values of b.

Time	P* when b = 1	P* when b = 2
0	1.79	1.79
1	4.74	11.92
2	11.92	50.00
3	26.89	88.07
4	50.00	98.20
5	73.10	99.75
6	88.07	99.96
7	95.26	99.99
8	98.20	99.99

P* is a proportion of adopters.

Source: Computed from $p = \frac{U}{1 + e^{(a-b.T)}}$ by Gould (1969), using
 $U = 100, a = 4.$

The theoretical logistic curve for the hypothesis test will be constructed by using the equation $p = \frac{U}{1 + e^{(a-b.T)}}$. The value of a and b will be given in a way that it will approach the shape of the observed curve as much as possible. This is necessary because the shape of the theoretical curve is controlled by the parameters a and b. The value of these two parameters can change from one diffusion problem to another.⁸

After having constructed the observed curve and the theoretical logistic curve, the Kolmogorov-Smirnov test is used to determine the significant difference between these two curves. The test statistic used in the Kolmogorov-Smirnov test is the maximum difference between the two cumulative distributions. If the maximum difference exceeds what would be expected by chance under the null hypothesis, the null hypothesis would be rejected.⁹

The Kolmogorov-Smirnow test is mostly used as a two-sample test under the assumption that if the null hypothesis that independent random samples have been drawn from identical population is correct, then the cumulative frequency distribution for the two samples are expected to be essentially similar.¹⁰

An alternative use of the Kolmogorov-Smirnow test is as a one-sample test to compare observed frequencies with those predicted theoretically.¹¹ This made the test useful in some cases of diffusion research. For instance, Brown (1968) employed the test for the goodness of fit of the predicted to the observed curves in his study concerning the adoption and diffusion of television receivers in Central Skane (in Southern Sweden).¹²

Methods for Describing the Diffusion Pattern

The difference among diffusion patterns; i.e., expansion, contagious, relocation, and hierarchical, has been explained in Chapter 1. To describe the diffusion pattern of grain sorghum in Kansas, a series of

maps showing the distribution of grain sorghum adopters during each period is used as a research tool. The expansion pattern can be determined by seeing whether the number of adopters become greater through time. The contagious pattern can be determined by seeing whether new adopters located close to those who already adopted it. The relocation pattern need not be examined in this case because a county, as an adopter, could not move or relocate.

It is not easy to determine the hierarchical pattern in this diffusion. The location of adopters in Kansas cannot be ranked by the system of urban hierarchy, or by population size. The method employed here is to use the same series of maps as mentioned above, to see if new adopters of grain sorghum locate at some distance from those who have already adopted it, to determine if there is some order or hierarchy among the adopters.

Data Collecting Method

Sources

The data needed are acres of grain sorghum and acres of total field crops for 105 Kansas counties at different points in time, from the year 1895 to the year 1975, using ten year intervals. From this original data, acres of grain sorghum as a percentage of total field crops acres will be computed.

The information was collected from the statistical annual reports on Kansas crops prepared by the Kansas State Board of Agriculture.

However, some confusion in collecting data is caused by the use of various systems to report grain sorghum statistics by the State Board of Agriculture, as follows:

- 1893 - 1915: separate reports on acres of milo maize and acres of kafir corn;
- 1916 - 1932: separate reports on acres of milo for grain, kafir for grain, and feterita for grain;
- 1933 - 1934: separate reports on acres of milo for grain, acres of kafir for grain, and acres of other grain sorghum;
- 1935 - 1936: report on acres (planted) of grain sorghum;
- 1937: reports on both acres (planted) and acres (harvested) of grain sorghum; and
- 1938 - 1979: reports on acres (harvested) of grain sorghum.

Another problem for obtaining reliable data is that the acres harvested and acres planted are not the same. Moreover, during early periods, only acres appeared in the reports. Fortunately, the problem could be solved because acres of total field crops were reported in a similar manner. Thus, we could have a reliable data on percentage of field crops acres occupied by grain sorghum.

Organizing the Data

After having obtained the scale of grain sorghum as a percentage of field crops acres, cumulative frequency distribution of proportion of grain sorghum adopters will be tabulated, using the assumptions

given as noted in the first section of this chapter. Then, the observed curve will be plotted from this cumulative frequency distribution. The observed curve will be tested whether it is significantly different from the theoretical logistic curve, as presented in Chapter 3.

FOOTNOTES

¹ Chapin, Cultural Change (New York: The Century Co., 1928), pp. 357-384.

² Rogers, Diffusion of Innovation (New York: The Free Press, 1962), pp. 81-86.

³ Gould, Spatial Diffusion (Washington D. C.: Association of American Geographers, 1969), pp. 19-21.

⁴ Powell and Roseman, "An investigation of the Subprocess of Diffusion", Rural Sociology, 37 (1972) 221.

⁵ Gould, loc. cit.

⁶ Ibid.

⁷ Zvi Griliches, "Hybrid Corn: An Exploration in the Economics of Technological Change", Econometrica, 25 (1957) 515.

⁸ Gould, loc. cit.

⁹ Basil P. Korin, Statistical Concepts for the Social Sciences (Massachusetts: Winthrop, 1975), pp. 297-298.

¹⁰ Ibid.

¹¹ Ibid.

¹² Brown, Diffusion Dynamics. Lund Studies in Geography, Series B., No. 29 (Lund, Sweden: C. W. K. Gleerup, 1968), pp. 61-68.

Chapter 3

ANALYSIS OF DATA

This chapter presents the analysis of data in testing the hypothesis concerning the association between the theoretical logistic curve and the observed curve describing the diffusion of grain sorghum in Kansas. On the other hand, the description of the diffusion pattern of grain sorghum in Kansas will be provided in Chapter 4.

For testing the hypothesis, the null hypothesis is that there is no significant difference between the theoretical logistic curve and the observed curve describing the diffusion of grain sorghum in Kansas. The alternative (research) hypothesis is that there is a significant difference between the theoretical logistic curve and the observed curve describing the same course of diffusion.

Steps in approaching the test are:

- (a) constructing the observed curve;
- (b) constructing the theoretical curve; and
- (c) testing the difference between the two curves.

Constructing the Observed Curve

The method in constructing the observed curve was explained in Chapter 2. From data on the percentage of acres in field crops devoted to grain sorghum in Kansas between the years 1895 and 1975 (ten-year intervals), the cumulative frequency distribution of proportion of

adopters was tabulated, based on the assumption that a county became an adopter when it has at least three percent of its crops acres in grain sorghum, and that an adopter will retain its status even though its fluctuation in grain sorghum acreage would occur in the latter periods.

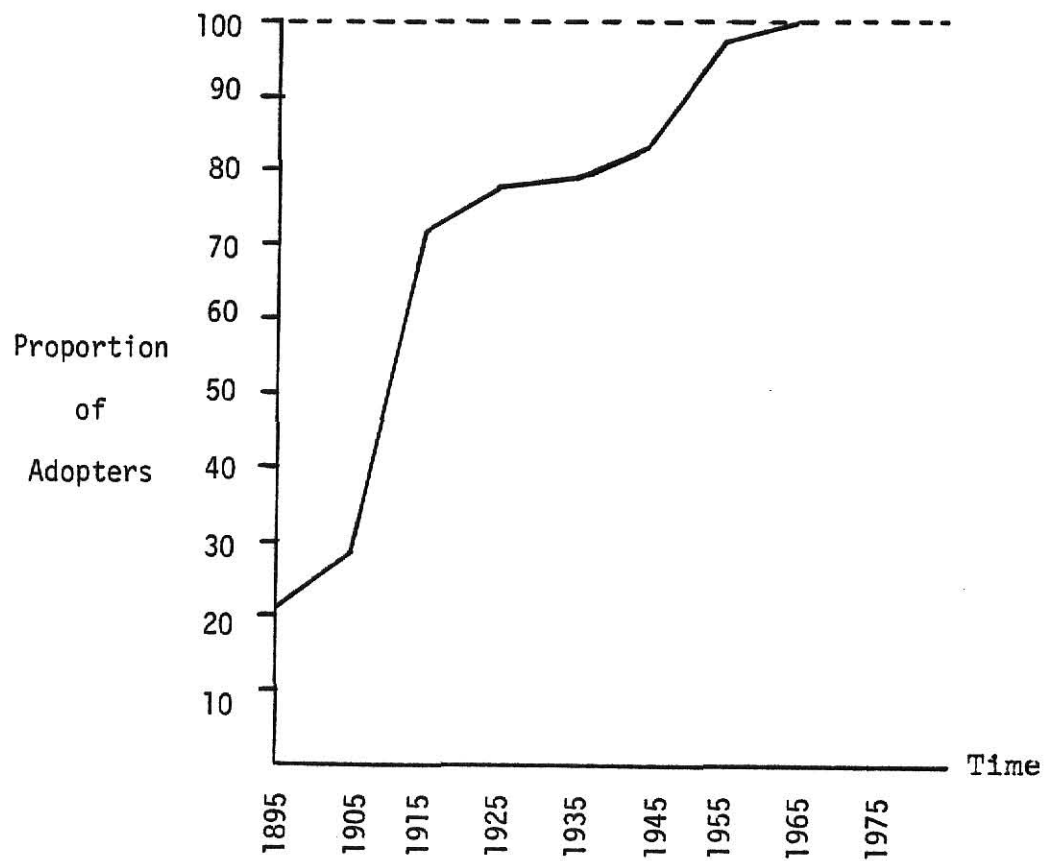
The cumulative frequency distribution of proportion of the adopters is tabulated as shown in Table 3.1. The observed curve is constructed from this distribution, as shown in Figure 3.1.

Table 3.1. Cumulative Frequency Distribution of Proportion of Grain Sorghum Adopters in Kansas

Year	f.	cum. f.	Percent
1895	22	22	20.95
1905	8	30	28.57
1915	42	75	71.42
1925	9	81	77.14
1935	2	83	79.04
1945	5	88	83.80
1955	14	102	97.14
1965	3	105	100.00
1975	0	105	100.00

Source: Computed from the original data on grain sorghum acreage and field crop acreage reported by the Kansas State Board of Agriculture.

Figure 3.1 The Observed Curve Describing Cumulative Level of Adoption of Grain Sorghum in Kansas.



Source: Computed by the author.

Constructing the Theoretical Curve

The shape of the theoretical logistic curve, constructed by the equation $p = \frac{U}{1 + e^{(a-b.T)}}$, is controlled by the two parameters a and b. The parameter a controls the height above the T axis where the curve starts, and the parameter b determines how quickly the curve rises.

In this case, the values of the parameters a and b are given in a way that they conform to the shape as similar to the observed curve as possible.

At the experimental stage, a set of theoretical curves under different values of the parameters a and b are constructed in order to select the most appropriate one for the hypothesis test. Table 3.2 shows a set of theoretical cumulative frequency distributions, using different values of the parameters a and b. Figure 3.2 shows a set of theoretical curves constructed from Table 3.2, compared to the observed curve.

Table 3.2 Theoretical Cumulative Frequency Distributions of Adopters
Under Different Values of the Parameters.

Year	Time	P* (a=2.5, b=1.0)	P* (a=2.0, b=1.0)	P* (a=1.5, b=1.0)
1985	0	7.58	11.92	18.24
1905	1	18.24	26.89	37.75
1915	2	37.75	50.00	62.24
1925	3	62.24	73.10	81.75
1935	4	81.75	88.07	92.41
1945	5	92.41	95.26	97.26
1955	6	97.26	98.20	98.90
1965	7	98.90	99.33	99.59
1975	8	99.59	99.75	99.84

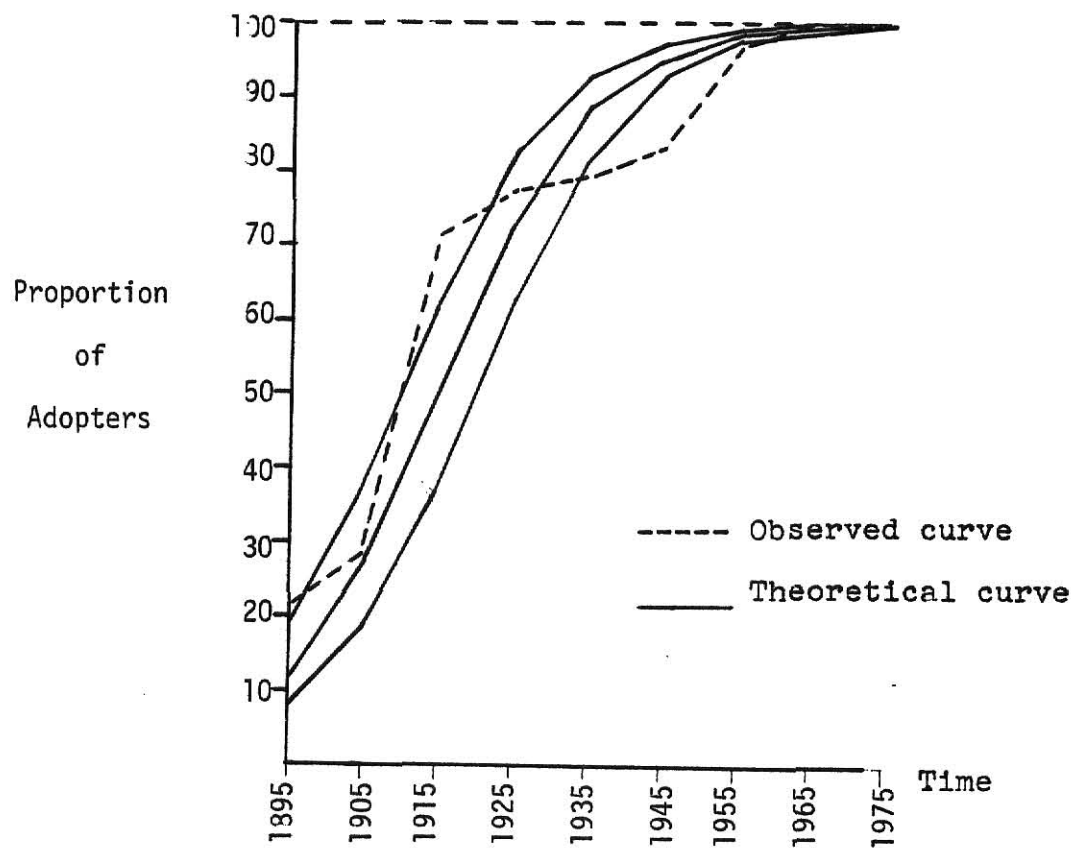
P* is Proportion of adopters

Source: Computed from the equation $p = \frac{U}{1 + e^{(a-b.T)}}$, (Gould 1969)

Using visual comparison, it appears that the theoretical curve that has shape similar to the observed curve is the one that has the values of the parameter a equal to 1.5 and the parameter b equal to 1.0.

Therefore, this one is selected for the hypothesis test.

Figure 3.2. Theoretical Logistic Curves Describing the Cumulative Level of Adoption as Compared to the Observed Curve in the Same Case.



Source: Computed by the author.

Hypothesis Test

A visual comparison between the observed curve and the theoretical curve describing cumulative level of adoption of grain sorghum in Kansas, as shown in Figure 3.3, shows a high correlation between these two curves. The maximum difference between them appears at the fourth point of time (the year 1935).

A visual comparison alone cannot tell whether there is a significant difference between these two curves. A statistical method is employed to test for significant difference. The Kolmogorov-Smirnov Test is considered appropriate for this step. The following paragraphs will present this test in four parts:

- (a) Hypothesis,
 - (b) Level of significance and critical region,
 - (c) Computing the test statistic, and
 - (d) Making a decision.
- (a) Hypothesis:

Let $F(x)$ be the theoretical relative cumulative distribution of proportion of adopters that entered the diffusion process at different points in time.

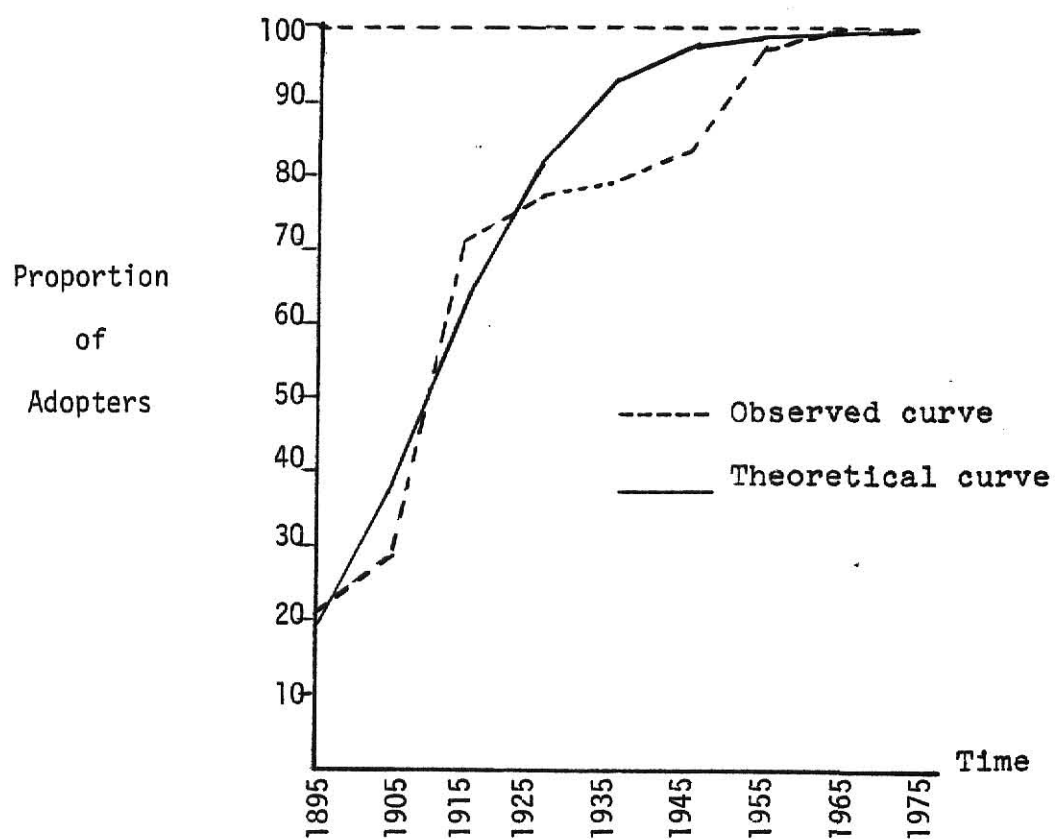
Let $F_1(x)$ be the observed relative cumulative distribution of proportion of adopters in the same process.

$$H_0: F(x) = F_1(x)$$

$$H_1: F(x) \neq F_1(x)$$

- (b) Level of significance and critical region.

Figure 3.3. A Comparison Between the Observed Curve and the Theoretical Curve Describing Cumulative Level of Adoption of Grain Sorghum in Kansas.



Source: Computed by the author.

This study preferred 0.01 level of significance. This means the probability of making an error in analyzing the data is only one out of 100 times. This level is chosen because the data are systematically obtained from government records, so they are rather reliable.

If the maximum difference (D) between the theoretical relative cumulative distribution and the observed relative cumulative distribution is greater or equal to $\frac{1.63}{\sqrt{n}}$; then, the null hypothesis would be rejected at the .01 level.

(c) Computing the test statistics.

$$D = \max [F(x) - F_1(x)].$$

The difference (D) between the theoretical relative cumulative distribution and the observed relative cumulative distribution is computed as shown in Table 3.3. It appears that the maximum difference between the two distributions is equal to 0.1337.

Table 3.3. The Difference Between the Theoretical Distribution of Proportion of Grain Sorghum Adopters in Kansas, and the Observed Distribution in the Same Case.

Year	Time	$F(x)^a$	$F_1(x)^b$	$F(x) - F_1(x)$
1895	0	.1824	.2095	.0271
1905	1	.3775	.2857	.0918
1915	2	.6224	.7142	.0918
1925	3	.8175	.7714	.0461
1935	4	.9241	.7904	.1337 (D)
1945	5	.9726	.8380	.1326
1955	6	.9890	.9714	.0176
1965	7	.9959	1.0000	.0041
1975	8	.9984	1.0000	.0016

^a The Theoretical Distribution

^b The Observed Distribution

(d) Making Decision

From the statistic computed, the maximum difference (D) between $F(x)$ and $F_1(x)$ is 0.1337.

According to the critical region at 0.01 level, if the computed D is greater or equal to $\frac{1.63}{\sqrt{n}}$, the null hypothesis would be rejected.²

As n is equal to 105, in this case, so the critical region is $\frac{1.63}{\sqrt{105}}$, or 0.1590 at 0.01 level.

The computed D (0.1337) is smaller than the critical region (0.1590), so the null hypothesis is accepted.

It can be stated here that at 0.01 level of significance, there is no difference between the theoretical curve and the observed curve describing a cumulative level of adoption of grain sorghum in Kansas.

FOOTNOTES

¹ Korin, Statistical Concepts for the Social Sciences,
(Massachusetts: Winthrop, 1975), pp. 297-298.

² Ibid., p. 383.

Chapter 4

DISCUSSION

From Chapter 3, the result of the hypothesis test was: the diffusion of grain sorghum in Kansas followed the logistic S-shaped curve. The observed curve of the diffusion process was constructed using the assumptions that a county became an adopter when its acres in grain sorghum constituted at least three percent of its total field crop acres, and that the adopter would keep its status regardless of subsequent fluctuation in acres of grain sorghum during the latter periods.

The evaluation and implications of the findings will be discussed as follows:

- a) the results of the research concerning the logistic curve theory will be compared to that of other researchers;
- b) the patterns of information flow, expansion, contagion, and hierarchy will be described; and the
- c) implication of the spatial-temporal-behavioral pattern of the diffusion process will be discussed.

A Comparison with Previous Research

It was noted that earlier the cumulative processes followed an S-shaped curve. According to the hypothesis test in Chapter 3, the

case of the diffusion of grain sorghums in Kansas also conformed to the S-curve.

If the absolute gain in adopter per unit time were plotted, it would approach a normal frequency distribution, as shown in Figure 4.1

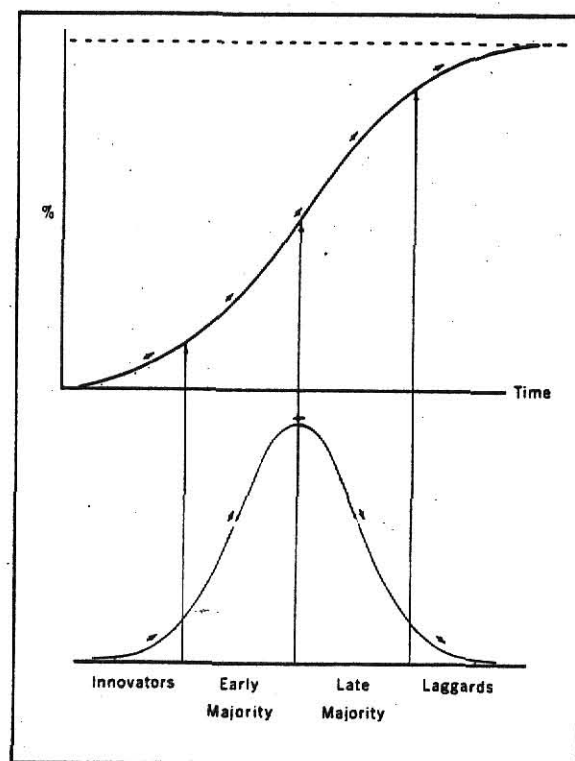


Figure 4.1. Distribution of Adopters in Diffusion Process.

Rogers (1962) investigated past researches on diffusion processes. He found that usually the distributions of adopters followed a bell-shaped curve over time and approached normality; while cumulative distributions of adopters followed an S-shaped curve.¹ Some of these diffusion studies included those by:

- 1) Ryan and Gross (1943) who found that the distribution of dates of first use of hybrid corn was nearly normal;²
- 2) Griliches (1957) who found that hybrid corn adopter distribution closely followed the logistic curve;³
- 3) Rahim (1961) who concluded that the adopter distributions for three farm innovations in a Pakistani village were normal;⁴
- 4) Mansfield (1961) on twelve major innovations in the coal, steel, brewing and railroad industries. He found that, "..... the growth in the number of users of an innovation can be approximated by a logistic curve";⁵
- 5) Powell and Roseman (1972) who found that the spread of soybean production in Illinois followed a logistic curve;⁶ and
- 6) Rogers (1958) who found that eight adopter distributions in the cases of farm innovations were bell-shaped and all approached normality.⁷

However, no claim has been made that adopter distributions for all diffusion processes are necessarily normal. The belief in the logistic curve theory or the normality in diffusion processes was based on

many previous investigations which had found that distributions of adopters followed normality or followed the logistic curve in the case of cumulative distributions. The test in this study also produced such a result. However, it is not necessary for all cases in diffusion processes to follow an S-shaped curve or a normality. Many researches by Perry et. al. (1967)⁸, for example, showed that the diffusion curve more nearly approximated a J-curve.

The Kolmogov-Smirnov Test employed in this study was also used to test for normality and for a goodness-of-fit curve in much diffusion research.⁹ For instance, Brown (1968) employed this test to see whether there was significant difference between the predicted curves and the observed curves in his study on the diffusion of television receivers for twelve central places in Sweden. His predicted curves were constructed from a mathematical model, the same way as used in this research, but with a more complex equation. The result from his test was: 10 of 12 predicted curves were acceptable at 0.05 level of significance.¹⁰

As this research is merely an investigation of a diffusion process that has already reached its saturation level, the theoretical curve for the test should not be called the 'predicted' curve. However, the theoretical curve can be used as an 'ideal type' when one wants to predict the course of any diffusion processes that have not yet reached an equilibrium or have just started from the point of origin.

The Patterns of Information Flow

The second question in the statement of problem concerns the spatial diffusion patterns or the patterns of information flow. This question is answered in this chapter in a descriptive fashion. A series of maps concerning the diffusion of grain sorghum in Kansas is used as a device for the description.

Following are descriptions of three patterns in the process: expansion, contagion, and hierarchial. It has been stated in Chapter 2 that relocation pattern does not appear in this case because a country, which is an adopter, does not relocate.

Expansion Pattern

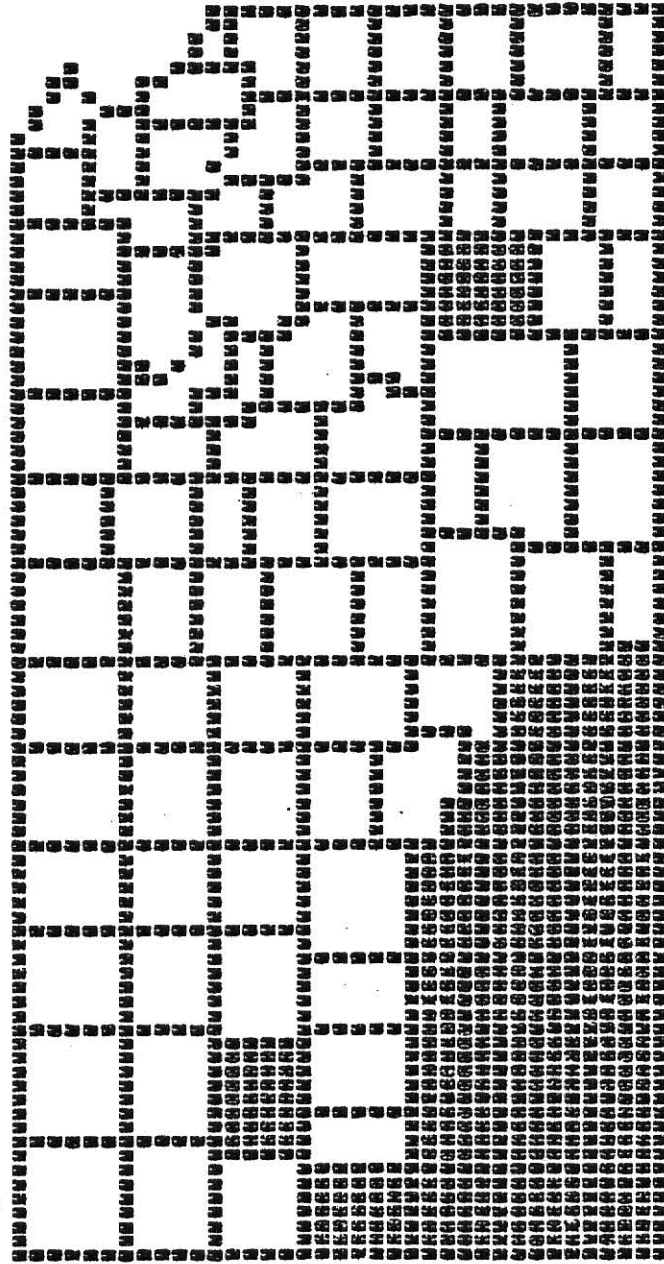
It is obvious that the diffusion pattern of grain sorghum in Kansas falls into an expansion type. (An expansion pattern means that the number of knowers become greater through time, implying that the number of adopters is greater through time.) From Table 3.1 and Figure 3.1, cumulative levels of adoption of grain sorghum in Kansas expanded from 20.95 percent of adopters in 1895 to 100.00 percent of adopters in 1965. Moreover, a series of maps that showed adoption of grain sorghum in Kansas at different points in time (Maps 1 to Map 8), demonstrates that the number of the adopters expanded through time.

Contagious Pattern

In a contagious pattern, a new item diffuses through a population by direct contact. Ideas are passed to potential adopters close to those who already adopted them.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1895



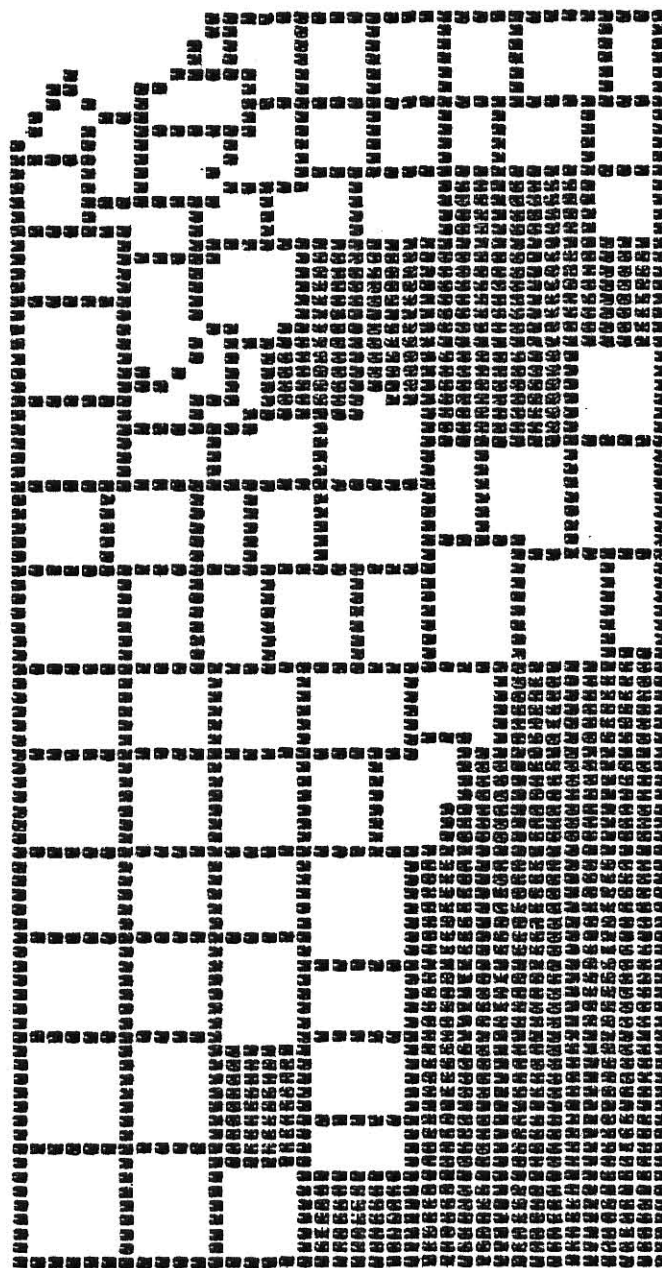
source: Kansas State Board of Agriculture, Topeka

Grain Sorghum Adopter

Map 1. Diffusion of Grain Sorghum in Kansas, 1895.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1905

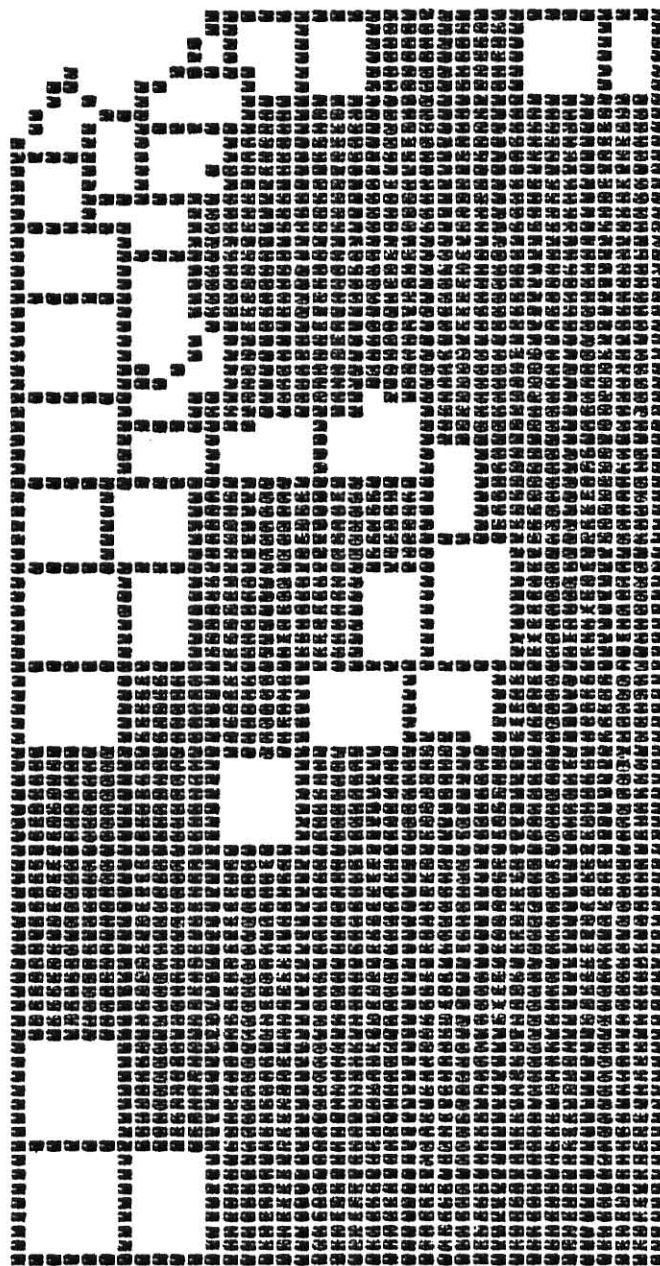


source: Kansas State Board of Agriculture, Topeka
 Grain Sorghum Adopter

Map 2. Diffusion of Grain Sorghum in Kansas, 1905.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1915



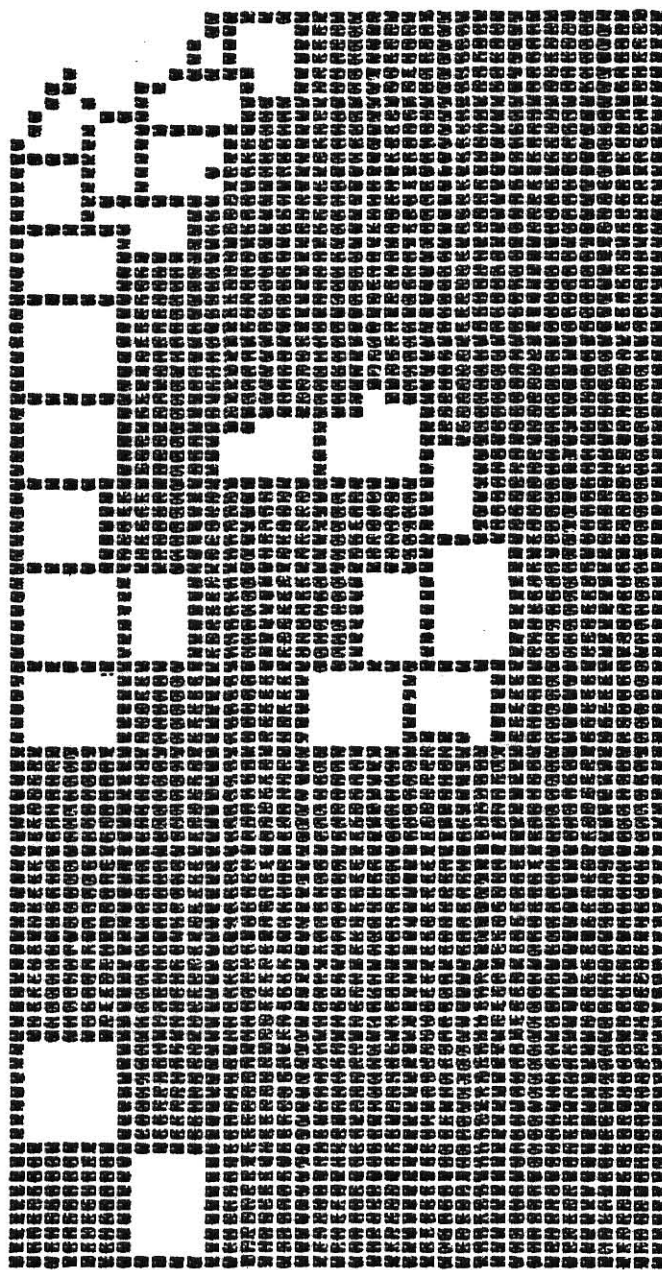
source: Kansas State Board of Agriculture, Topeka

Grain Sorghum Adopter

Map 3. Diffusion of Grain Sorghum in Kansas, 1915.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1925



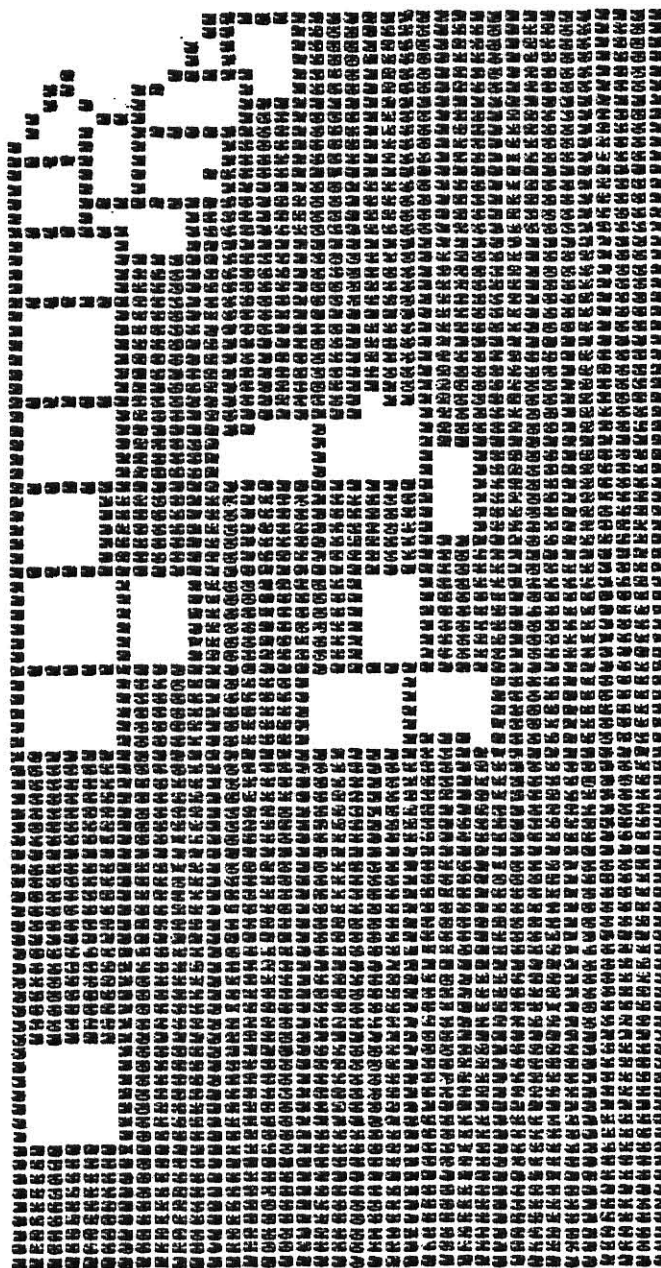
source: Kansas State Board of Agriculture, Topeka

Grain Sorghum Adopter

Map 4. Diffusion of Grain Sorghum in Kansas, 1925.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1935



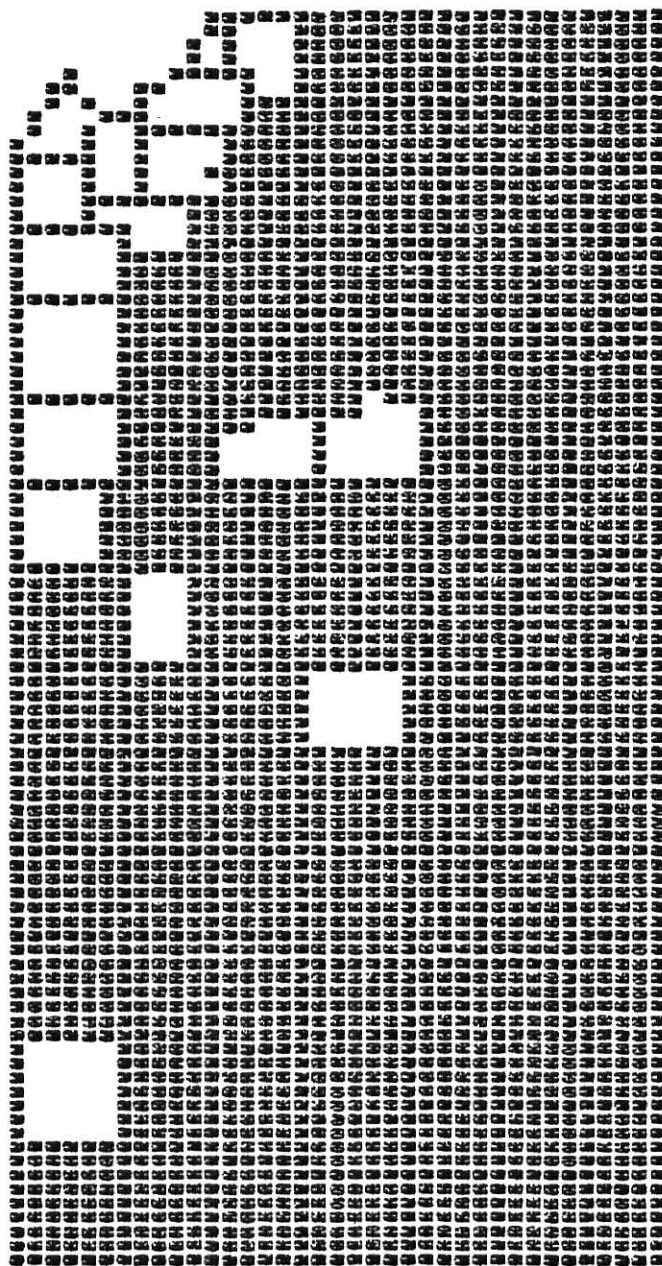
source : Kansas State Board of Agriculture, Topeka

Grain Sorghum Adopter

Map 5. Diffusion of Grain Sorghum in Kansas, 1935.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1945



Source: Kansas State Board of Agriculture, Topeka

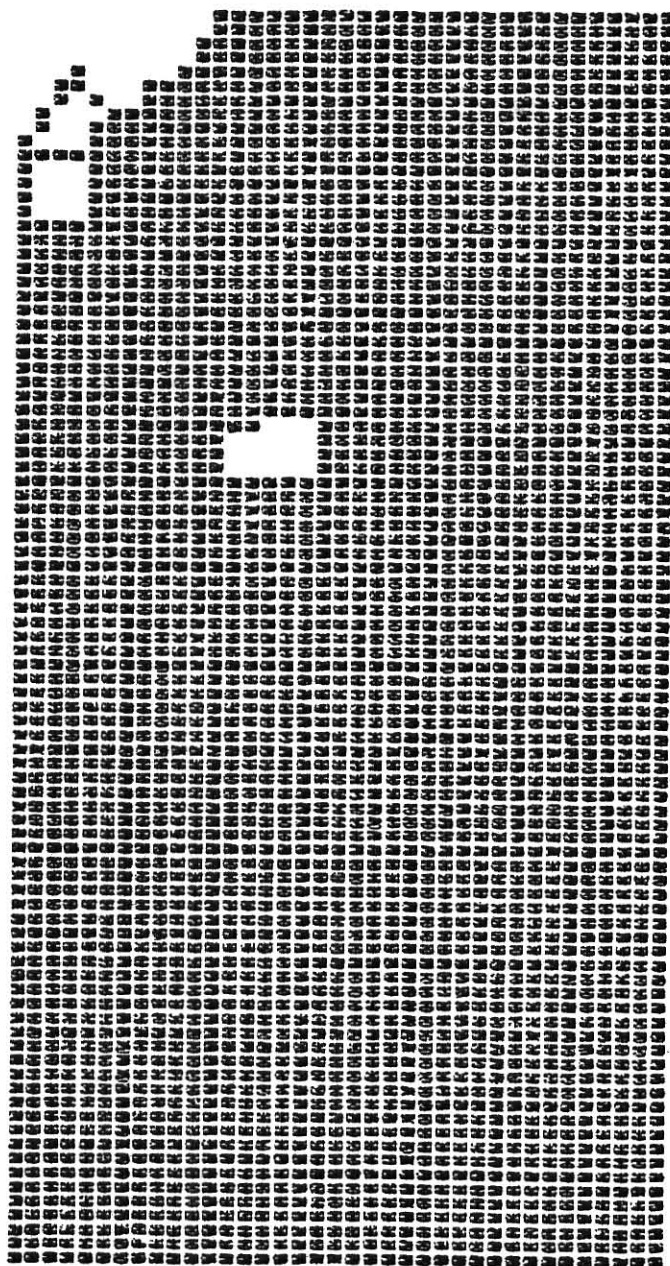
资料来源：堪萨斯州农业委员会，托皮卡

Grain Sorghum Adopter

Map 6. Diffusion of Grain Sorghum in Kansas, 1945.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1955

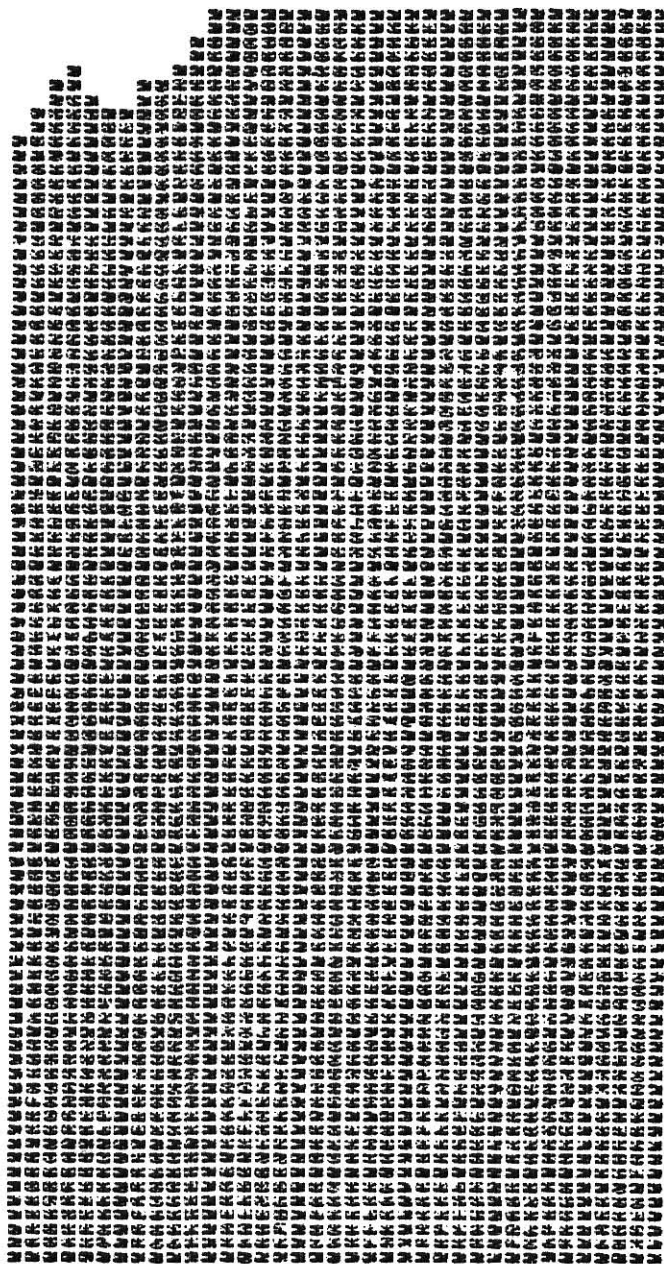


source : Kansas State Board of Agriculture, Topeka
 Grain Sorghum Adopter

Map 7. Diffusion of Grain Sorghum in Kansas, 1955.

DIFFUSION OF GRAIN SORGHUM IN KANSAS

1965



source: Kansas State Board of Agriculture, Topeka
Grain Sorghum Adopter

Map 8. Diffusion of Grain Sorghum in Kansas, 1965.

Map 1 shows that most of the adopters in the year 1895 were in the southwestern part of Kansas. However, there was one adopter that appeared to be isolated from the others. That adopter was in the southeastern part of the state. From visual analysis, it could not be claimed that a contagious pattern existed at this point of time.

Map 2 shows additional adopters between the years 1895 and 1905. These new adopters clustered around the one that had already adopted. It is interesting to see that all of the new adopters were located in the southeastern part of the state. The contagious fashion appeared during this period. Map 3 shows a great number of new adopters locating around the ones who had just previously adopted grain sorghum. During this period, the pattern still appeared contagious. Map 4 to Map 8 showed that additional adopters during each period, from the year 1925 to the year 1965, always located close to the ones who had already adopted grain sorghum. This supports the notion of a contagious pattern.

The first groups of adopters originated in the southwestern and the southeastern parts of Kansas, and more and more adopters were added around these first groups; the new ones located close to the old ones. The spread of grain sorghum was contagious between the years 1895 and 1965.

Hierarchical Pattern

In hierarchical processes, a new idea or new item spreads through an order of classes. Brown (1968) said that if an item diffused

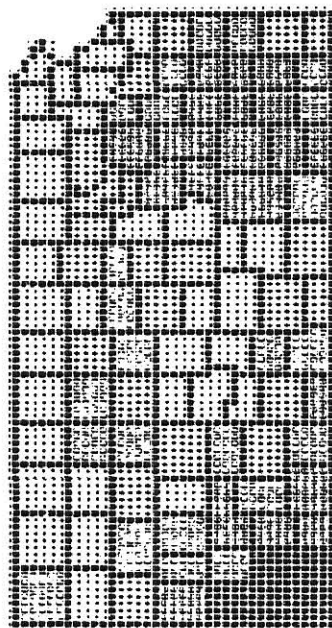
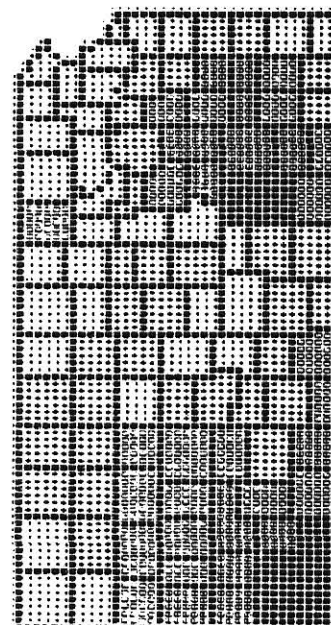
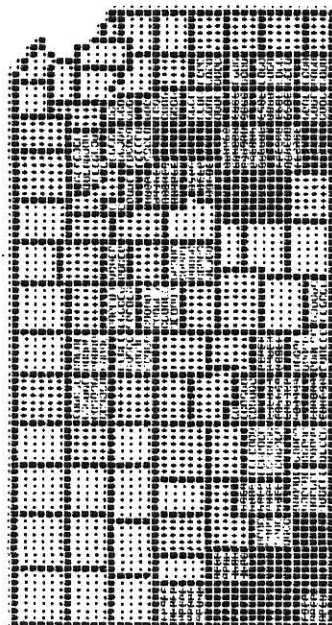
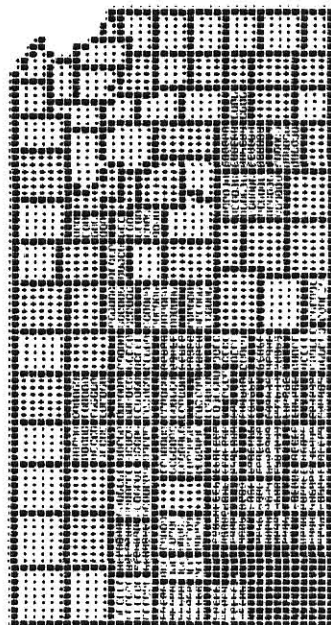
was a commercial or manufactured good, the process tended to follow the central place hierarchy.¹¹ This is much different from the contagious fashion in which a new idea is passed through a population by direct contact, which means that the potential adopters who are close to the ones who already adopted the new item, have more chances to adopt it earlier than those at a greater distance.

It has been found that since the year 1895, grain sorghum had spread throughout the whole state in a contagious fashion. Therefore, the part that was left to be investigated was the year 1895. It appeared that in that year there was one adopter isolated at a great distance from other adopters. This isolated one was in the southeastern part of Kansas, while the others were in the west. Therefore, there might be some hierarchy effect among these early adopters.

If it were assumed that the most important places tended to adopt a new item earlier than the less important ones, then the adopters in the year 1895 were in the most important areas for grain sorghum. As the group in the southwest was bigger than the one in the southeast, the southwest could be ranked as the most important place in this case and the southeast could be ranked as the second most important place. Then, from these two centers, grain sorghum spread to the other parts of the state in a contagious fashion.

Ranking the counties by means of the density of grain sorghum cultivated could help to see whether the origin areas (southwestern and southeastern Kansas) still preserved their importance through time.

**COUNTRIES RANKED BY THE DENSITY OF GRAIN SORGHUM
1895 - 1925**



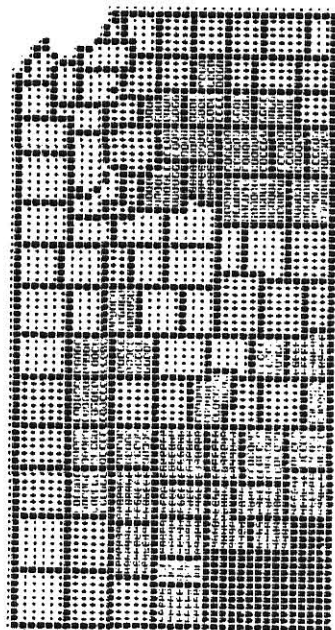
source: Kansas State Board of Agriculture, Topeka

	first rank	second rank	third rank	fourth rank	fifth rank	Density
highest	highest
high	high
average	average
low	low
lowest	lowest

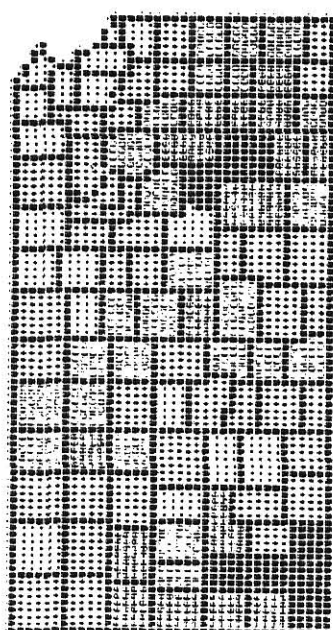
S. Nilchang

Map 9. Counties Ranked by the Density of Grain Sorghum, 1895-1925.

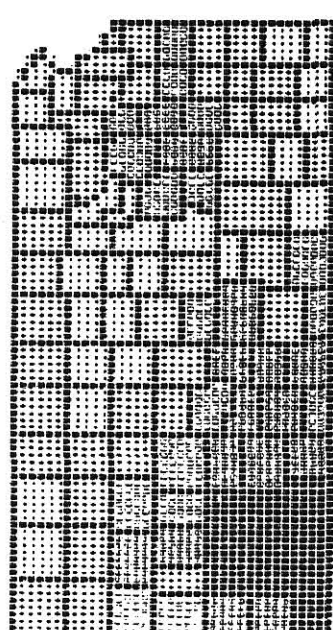
COUNTIES RANKED BY THE DENSITY OF GRAIN SORGHUM
1935 - 1955



1935



1945



1955

source : Kansas State Board of Agriculture, Topeka

.....	first	rank	Density
.....	second	rank	highest
.....	third	rank	high
.....	fourth	rank	average
.....	fifth	rank	low
.....		rank	lowest

S. Milchang

Map 10. Counties Ranked by the Density of Grain Sorghum, 1935-1955.

Thus, a series of maps was constructed for this purpose. (See Map 9 and Map 10.) The maps showed that between the years 1895 and 1955 (the diffusion had reached a saturation level in the year 1965), greatest density of grain sorghum was always in the two origin areas: southwestern and southeastern Kansas. Moreover, during these periods, it often appeared that the density of acres in grain sorghum decreased at a greater distance from the origins.

In conclusion, the hierarchical pattern did not show up in this diffusion process. Even though there were two areas of origin which were located at a great distance from each other, it does not have enough basis for being hierarchical fashion. So the patterns of this diffusion process are more expansion and contagion than any other types.

Spatial, Temporal, and Behavioral Aspects

Some explanations will be provided in this section in order to understand some of the spatial, temporal, and behavioral aspects of the diffusion of grain sorghums in Kansas. This understanding can be inferred from the results of the investigation previously done in this paper. It is also useful to refer to previous research concerning these aspects of the processes.

Some previous studies that are helpful here are: the observation on the temporal and behavioral patterns of adopters as described by the logistic curve by Gould (1969),¹² the empirical study on spatial-temporal-behavioral pattern of adopters by Casetti (1969),¹³ the study

on the same subject by Morrill (1970),¹⁴ and the study on a method of adopter categorization by Rogers (1962).¹⁵

Diffusion processes, according to Casetti, conform to logistic trends because of adopters' behavior. Potential users become adopters under the influence of previous adopters in the course of direct contacts. However, potential users have different degrees of resistance to change, and the resistance may be overcome by an adequate number of messages. This type of behavior causes the curve to rise slowly at first, then rapidly, then slowly again until it reaches a saturation level.¹⁶

Morrill thought that diffusion processes are under the influence of time and distance. After having received a message, people need time to make a decision to adopt it. However, the influence of distance may be greater, as the spatial separation of potential adopters restricted the location of one's contact.¹⁷

Adopters in diffusion processes can be classified according to their behavioral pattern. Gould (1969) said that adopters can be classified into four groups: innovators, early majority, late majority, and laggards. The innovators enter the process first, then are followed by the early majority. Later, when the process is halfway through, the late majority comes in. The last group to enter the process is the laggards.¹⁸

According to Rogers (1962), adopters can be classified into five groups: innovators, early adopters, early majority, late majority

and laggards. Innovators are people who are eager to try new ideas. The early adopters are people who play a role of leadership, set a model for other members of a social system. The early majority adopt new ideas just before the average member of a social system. They may deliberate for some time before completely adopting a new idea.¹⁹

Based on the ideas mentioned above, the following discussion will focus on the adopters' behavior and the influence of time and distance in the diffusion of grain sorghum in Kansas.

The Adopters' Behavior

In this study, an adopter or a unit of adoption is a county. A county is composed of groups of people so this study tried to understand patterns of aggregate behavior in this process.

The author preferred to classify the adopters according to Roger's system: innovators, early adopters, early majority, later majority and laggards.

a) Innovators

Innovators are those who had the lowest degree of resistance to change. In this case, they were eager to try grain sorghum which was a new kind of crop in those days. From the observed curve, the innovators were the adopters that entered the process in the year 1895, which was the beginning of the process. The curve showed that the innovators accounted for 20 percent of total adopters.

Looking at Map 1, the innovators were located in the entire region of the southwest crop reporting district, in the western half of the south central district, in some parts of west central district, and east of the Flint Hills region in the southeast district.

According to the history of Kansas agriculture, these parts of the state often faced a problem of lacking sufficient rainfall for corn.²⁰ A severe drought during the 1890's caused many counties in western Kansas to lose over half their population because it was difficult for the farmers to remain on their land during that period.²¹

Fortunately, during the 1880's and the early 1890's, some varieties of grain sorghum were introduced to Kansas. At first they were grown experimentally at the agricultural stations (Garden City, Hays, Colby, Manhattan, Hutchinson and Wichita). Then, they were introduced from the experiment stations to the areas that had light rainfall, especially the western part of the state.

During that period, many farmers in the drier section of the state were looking for a substitute for corn crops. Consequently, they were eager to try various varieties of grain sorghum sent to them by the experiment stations. They reported the results to the stations and to other farmers.²² For instance, N. Mayrath, a farmer from Luxemburg who came to settle down in Dodge City in southwestern Kansas, reported to his fellow farmers in the annual

meeting among farmers and agronomists held by the State Board of Agriculture in 1894:

As we want a substitute for corn, I have planted largely, and will continue to do so, of the different kinds of Kafir corn, white milo-maize, sugar cane, Brown, branching Dhourra, Jerusalem corn, and black rice corn....of the different varieties of sorghum plants that I have raised on my farm, I prefer the Red Kafir Corn.²³

Agronomists from the experiment stations and from the State Agricultural College helped to promote grain sorghum during the early 1890's. For instance, in the annual meeting among farmers and agronomists in 1894, Professor Georgeson from the State College told the farmers that grain sorghum was profitable:

As to the feeding qualities of the seed, it has been proved by repeated experiments that it is equal to corn. With such facts before us, it is a question if it would not be the better part of wisdom to increase the area in those varieties of sorghum which are grown chiefly for grain, and correspondingly decrease the area in corn over the entire region of the west.²⁴

Even the professor from Oklahoma Agricultural College helped to support this idea in the annual meeting among farmers and agronomists held by the Kansas State Board of Agriculture in 1896:

I do not expect western Kansas to be a corn-growing region. Even in the best-adapted portions it has been shown there is possibility of failure. Great wisdom is shown in the widening area given to sorghums, sweet and non-sweet varieties.²⁵

From the literature, it seemed that the innovators in this process had a very low degree of resistance mainly because of unfavorable climatic conditions. Lacking sufficient rainfall, many

farmers failed with corn. Thus, they were eager to adopt anything that could be a substitute for corn, in order to feed livestock. The reports by the State Board of Agriculture did not refer to any other kinds of crops that could be a substitute for corn, except grain sorghum. So it seemed that the farmers did not have much choice in making the decision.

b) The Early Adopters

Early adopters entered the process at the second point of time, the year 1905. They added nearly 10 percent of adopters to the process. The diffusion curve showed that the rate of the process from the year 1895 to the year 1905 increased very slowly.

The early adopters located around the innovators in the southeastern part of the state, the Flint Hills region where cattle were raised. According to the literature, this group had tried grain sorghum after the year 1895.²⁶ However, they had not adopted it until the year 1905. For example, in 1896, some farmers from these areas participated in the annual meeting held by the State Board of Agriculture, and they expressed their interest in grain sorghum; such as D. R. Kilbourne from Osage County, who said:

I am enthusiastic upon the subject of Kafir-corn.
I have put up this year not less than 500 tons, and,
I have had quite a successful experience in raising
Kafir-corn.²⁷

In Bulter County, which was also an early adopter, farmers there planted corn since the beginning of their settlement. However,

they had learned something about Kafir-corn during the late 1890's, and they tried it for just a few acres because corn was still the most important crop in their areas. During the early 1900's, their acres in Kafir-corn and other kinds of grain sorghum had expanded until it reached the state of adoption.²⁸

Not much information was recorded on the subject of grain sorghum during this period. From the author's point of view, the early adopters may be the group that had tried grain sorghum since the beginning but they just accepted it after it had proved to be a success for them.

Rogers (1962) said that early adopters may be deliberate for some time before completely adopting a new item.²⁹ This may be the reason that caused the early adopters in the Flint Hills Region to enter the process later than the innovators. Their degree of resistance was higher than the innovators because perhaps they still could raise corn.³⁰ Moreover, this region (Flint Hills) had more rainfall than the southwestern part of the state and the farmers were not in as desperate a situation as those in the southwest.

It should be noted here that a trial stage is not the same as an adoption stage. According to Rogers (1962), stages in adoption processes included the awareness stage, the trial stage, and the adoption stage. It took time for potential adopters, after having received the news, to make a decision to try a new idea and to accept it.³¹

c) Early Majority

The early majority entered the process between the years 1905 and 1915. The diffusion curve showed a very rapid increase in the rate of adoption process. The number of adopters increased from about 30 percent of total adopters in 1905 to about 70 percent in 1915. This group accounted for about 40 percent of total adopters.

During this period, the adoption of grain sorghum spread from southwestern Kansas and southeastern Kansas to those surrounding areas, and covered almost the entire region in the south and in the west parts of the state. Moreover, it spread to the north which usually had a higher degree of resistance than the south. The part of the north that located the group of adopters during this period were the northwestern and the north central parts of the state. (See Map 3.)

Some reasons for the rapid increase in the rate of adoption from the year 1905 to the year 1915 could be explained by referring to the report of the Kansas State Board of Agriculture during that time. It appeared that one reason was that grain sorghum had proved to be more profitable than corn, as shown in Table 4.1.

Another reason was that grain sorghum was a sure money crop. From the 1890's to the 1910's, most farmers who had grown grain sorghum never experienced even a single failure from it.³² In Kansas the average cash return, or profits, from an acre of Kafir

Table 4.1 The Value Per Acre of Kafir and Corn in Kansas, 1901-1913.

Year	Kafir	Corn
1901	\$10.32	\$ 3.23
1902	12.69	11.20
1903	9.30	8.74
1904	9.72	7.81
1905	9.94	10.11
1906	9.18	9.89
1907	11.13	9.25
1908	10.88	11.70
1909	11.23	10.77
1910	12.92	8.89
1911	15.72	7.68
1912	13.81	12.12
1913	<u>8.78</u>	<u>2.01</u>
Total	145.62	111.40
Average	11.20	8.72

Source: The 19th Biennial Report of the State Board of Agriculture.

during the years from 1901 to 1913 was 28.32 percent greater than from an acre of corn.³³

The test of different varieties of sorghum at the experiment stations since 1905, helped to increase the popularity of grain sorghum.

During the early periods, only White and Red Kafir were known among those who tried grain sorghum, and Red Kafir proved to be the best. Later, more varieties of grain sorghum were presented to the farmers. For instance, Blackhull Kafir which was best adapted to many parts of the state, Pink Kafir was best adapted to the areas that had shorter growing seasons and drier conditions, Dwarf Milo was best grown in the western part of the state, and Feterita would survive more heat and drought than most other sorghums.³⁴

The early majority spread into the previous corn-growing regions. In fact, they should have entered the process earlier than this because grain sorghum proved to be better adapted to their soil and climatic conditions than corn. However, they had a higher degree of resistance than the first two groups of adopters because they were used to the corn-growing habit. This fact was stated by an agronomist from the experiment stations in 1915:

... the farmer should grow crops adapted to his soil and climate, ... the sorghum crops in Kansas have been more valuable, acre for acre, than corn ... and yet on many farms more land is given to the growing of corn... when such is the condition ... the farmer is wasting money as well as time and labor.³⁵

Thus, it may be concluded that the degree of resistance of the group of the early majority was caused mainly by their corn-growing habit. Their resistance was overcome when it took two

decades to prove that grain sorghum was profitable. The evidence came from the examples set by the innovators and the early adopters. Even they themselves had tried grain sorghum since the beginning but did not grow it on enough scale to reach the state of adoption.

d) The Late Majority

After the year 1915, the diffusion curve showed a rise at a decreasing rate until the year 1945. Then, the rate increased at an increasing rate until 1955. The author considered the period from the year 1915 to the year 1955 as a period during which the late majority entered the process. This group accounted for about 25 percent of total adopters. The number of total adopters increased from about 70 percent in the year 1915 to about 96 percent in the year 1955. It took four decades for all of the late majority to enter the process.

As can be seen from Map 4 through Map 6, most of the late majority were located in the northeastern part of the state. Some of them were in the central part and some in the northwestern corner of the state.

From the reports of the State Board of Agriculture and of the Kansas Agricultural Experiment Stations, it seemed that a factor that caused a high degree of resistance to change to grain sorghum was the corn crop. In this area, corn was usually a more profitable

grain crop than sorghum. The soil and climate in this region were adequately adapted to corn, and the rainfall was sufficient to mature good crops.³⁶

In the northwestern corner of the state, corn and sorghum were about equal in productiveness and value. However, in general, corn proved to be more profitable than sorghum, especially when grown as a cash crop or when grown in a rotation with winter wheat.³⁷

In central Kansas, sorghum usually yielded more than corn and was more profitable except on the best land.³⁸ The reason that this area had a high degree of resistance may have been because this area devoted most of its cropland to wheat. Therefore, farmers in this area did not want to try any other crops than wheat which became very profitable to them.³⁹

The reasons mentioned above were probably responsible for the late majority entering the process at a late point in time. The diffusion curve showed that the adoption by the late majority occurred very slowly. From the year 1915 to the year 1945, only about ten percent of total adopters were added to the process.

The rapid increase in the rate of adoption from the year 1945 to the year 1955 may be due to the fact that during the 1930's, Kansas experienced a very long period of severe drought which destroyed the corn crop.⁴⁰ The drought might cause the decreasing in corn acreage in the following periods, as shown in Table 4.2.

New hybrid varieties of grain sorghum made the crop more popular in the northeastern part of the state. Farmers in this area had experienced the advantages of hybrid crops with hybrid corn, so they were eager to try hybrid sorghum which proved to be well adapted in their region.⁴¹

Table 4.2. Corn Acreage in Kansas, 1933 - 1943.

Year	Acres Planted (thousands)
1933	7,764
1934	5,174
1935	5,600
1936	5,109
1937	2,995
1938	2,456
1939	3,316
1940	3,051
1941	2,624
1942	3,021
1943	3,713

Sources: Kansas State Board of Agriculture: Farm Facts, 1965 - 1966.

According to the State Board of Agriculture, the important factors that caused the rapid acceptance of grain sorghum during

the early 1950's were the federal program to restrict wheat acreage; and the abandonment of wheat due to a surplus of its production during the previous decade.⁴² It may be concluded here that the late majority had a high degree of resistance to change to grain sorghum due to corn and wheat which were more profitable for them. However, the unfavorable weather for corn and the abandonment of wheat under the federal program during the 1940's and the 1950's made this group pay more attention to grain sorghum, and come to adopt it.

e) The Laggards

The laggards entered the process between the years 1955 and 1965. This group accounted for about 4 percent of the total adopters, including those counties in the northeastern corner and in the central part of the state.

The reasons that this group came last in the process may be the same as those by the late majority because both of these groups were in the same regions. Perhaps their resistance was finally overcome because they saw that the others in the same regions had adopted grain sorghum and the crop became a success for those adopters.

In conclusion, according to the Kansas State Board of Agriculture, climatic conditions play an important role in this case of diffusion. The innovators had the lowest degree of resistance because their region was too dry to grow any other cash crops.

After the innovators had adopted grain sorghum, the crop proved to be so profitable that other potential adopters tried it and came to accept it. The late majority and the laggards had a high degree of resistance because their regions had sufficient rainfall for other crops which were predominant in those areas. They turned to accept grain sorghums during the late periods because of the federal program to restrict wheat and the unfavorable weather for corn.

Referring to Casetti (1969), it takes time for potential adopters to overcome their resistance to change:

... knowledge of an innovation does not necessarily induce immediate adoption. The potential users may have to adjust themselves psychologically to a change in outlook and habits, and also may have to accept some temporary difficulty in order to acquire the necessary technological know-how.⁴³

In the case of grain sorghum in Kansas, the main problem was not that potential users lacked the necessary technological know-how. It is true that grain sorghum was a new kind of crop to them, and they never before had knowledge of how to plant it. However, it did not take too much time to learn that method, thanks to the help of agronomists from the experiment stations and the State Agriculture College at Manhattan.

It took seven decades for grain sorghum to reach a saturation level in Kansas because, from the author's point of view, farmers do not accept new crops so quickly if they still have a choice to go with the traditional ones which seem to them more reliable. In many regions in Kansas, the corn-growing habit made the farmers stay with corn until corn repeatedly proved to be a failure.

The influence of distance in this process has been described in the previous section concerning the patterns of the process. According to Morrill (1970), the influence of distance may be greater than the influence of time. The spatial separation of potential adopters restricts the location of one's contact.⁴⁴ In the case of grain sorghum in Kansas, it is true that additional (new) adopters appeared to be located close to the ones that already adopted grain sorghum. The location of the laggards even was at a great distance from the location of the innovators. From this fact, the influence of distance in this process could not be rejected.

It may be interesting to see if distance from an agricultural experiment station had any influence on the diffusion of grain sorghum. From the investigation, the distance from the stations did not have any significant influence on the process. Although these experiment stations were located in various parts of Kansas, only one station, Garden City Station in Finney County, is located in the territory of the innovators. As a matter of fact, Riley County, where the State Agricultural College and the Manhattan Experiment Station are located, was in the group of the late majority.

It is not surprising to see that the first groups of the adopters were not near the location where most of the stations were located. The literature described that the objective of these stations was to introduce grain sorghum to the areas that had light

rainfall rather than to the areas nearby.

It should be noted that explanation and description concerning the adopters' behavior in this chapter are very general. There might be other factors that influenced the adopters' behavior in each period; for example, the spread of irrigation practices, new farm machinery, the World War, etc.

FOOTNOTES

- ¹ Rogers, Diffusion of Innovation (New York: The Free Press, 1962), p. 1
- ² Ibid.
- ³ Ibid.
- ⁴ Ibid.
- ⁵ Ibid.
- ⁶ Powell and Roseman, "An Investigation of the Subprocess of Diffusion", Rural Sociology, 37 (1972) 221.
- ⁷ Rogers, loc. cit.
- ⁸ Perry et. al., "The Adoption Process: S-curve or J-curve?", Rural Sociology, 32 (1967), pp. 202-222.
- ⁹ Brown, Diffusion Dynamics: Lund Studies in Geography, Series B., No. 29. (Lund, Sweden: C. W. K. Gleerup, 1968), pp. 61-68.
- ¹⁰ Ibid.
- ¹¹ Brown, op. cit., pp. 8-9.
- ¹² Gould, Spatial Diffusion (Washington D. C.: Association of American Geographers, 1969), pp. 19-21
- ¹³ E. Casetti, "Why Do Diffusion Processes Conform to Logistic Trends?", Geographical Analysis, 1 (1969) pp. 254-259.

- ¹⁴ Richard L. Morrill, "The Shape of Diffusion in Space and Time", Economic Geography, 46 (1970), pp. 259-268.
- ¹⁵ Rogers, op. cit., pp. 159-171.
- ¹⁶ Casetti, op. cit., p. 105.
- ¹⁷ Morrill, op. cit., p. 267.
- ¹⁸ Gould, loc. cit.
- ¹⁹ Rogers, loc. cit.
- ²⁰ Biennial Reports of the Kansas State Board of Agriculture, (Topeka: Kansas State Board of Agriculture, 1888-1945, Inclusive).
- ²¹ Huber Self, Environment and Man in Kansas (Lawrence: The Regent Press of Kansas, 1978), p. 28.
- ²² Biennial Report of the Kansas State Board of Agriculture, (Topeka: Kansas State Board of Agriculture, 1892-1893) pp. 92-149.
- ²³ Ibid.
- ²⁴ Annual Report of the Kansas State Board of Agriculture (Topeka: Kansas State Board of Agriculture, 1894), p. 45.
- ²⁵ Annual Report of the Kansas State Board of Agriculture (Topeka: Kansas State Board of Agriculture, 1896), p. 51.
- ²⁶ Ibid., p. 119.

²⁷ Ibid.

²⁸ Biennial Reports of the Kansas State Board of Agriculture. Topeka. 1888-1945, Inclusive.

²⁹ Rogers, op. cit., pp. 76-86.

³⁰ Biennial Reports of the Kansas State Board of Agriculture. Topeka. 1888-1945, Inclusive.

³¹ Rogers, loc. cit.

³² T. A. Borman, Sorghum: Sorghum: Sure Money Crops (Topeka: The Kansas Farmer, 1974); Annual Report of the Kansas State Board of Agriculture (Topeka: Kansas State Board of Agriculture, 1894), pp. 44-45.

³³ The 19th Biennial Report of the Kansas State Board of Agriculture (Topeka: Kansas State Board of Agriculture, 1913-1914), p. 520.

³⁴ Swanson and Laudi, "Sorghum for Kansas, Kansas State Agricultural College Experiment Station. Bul #304, (September, 1962), p. 20-25.

³⁵ Annual Report of the Kansas State Board of Agriculture. (Topeka: Kansas State Board of Agriculture, 1915) p. 58.

³⁶ Kansas State Agricultural College's Experiment Station, Bulletin No. 49-56, 1895; and Bulletin No. 340, 1942.

³⁷ Ibid.

³⁸ Ibid.

³⁹ Ibid.

⁴⁰ The 30th Biennial Report of the Kansas State Board of Agriculture.
(Topeka: Kansas State Board of Agriculture, 1935-1936), pp. 7-10.

⁴¹ Annual Report of the Kansas State Board of Agriculture.
(Topeka: Kansas State Board of Agriculture, 1957-1958) p. 15.

⁴² The 39th Report of the Kansas State Board of Agriculture. (Topeka:
Kansas State Board of Agriculture, 1953-1956) pp. 6-9.

⁴³ Casetti, op. cit., p. 104

⁴⁴ Morrill, loc. cit.

Chapter 5

SUMMARY AND CONCLUSIONS

The purpose of this research was to understand and explain the diffusion process of grain sorghum in Kansas. The question answered concerned whether the diffusion process followed the logistic S-shaped curve through time and whether the patterns of information flows in the process were expansion, contagion, relocation, or heirarchical. In addition, a literature review was undertaken to explain varying rates of adoption throughout Kansas.

Basic assumptions and definitions in this research concerned these terms: adopter, adoption, and time unit. An adopter was represented by a Kansas county. It was assumed that a county became a grain sorghum adopter when its acres in grain sorghum constituted at least three percent of its total field crop acres, and that it remained an adopter regardless of the fluctuation in grain sorghum acreage during later periods. The total time period for this process was between the years 1895 and 1975. Ten-year intervals were used to fix different periods of time.

The Kolmogorov-Smirnov Test was used to determine whether the diffusion process followed the logistic S-shaped curve. The null hypothesis formulated was that there was no significant difference between the logistic curve and the observed curve describing the diffusion of grain sorghum in Kansas. The alternative or research

hypothesis was that there was a significant difference between these two curves.

The observed curve was constructed under the definitions and assumptions given, using the original data on grain sorghum acreage and field crop acreage in Kansas, reported by the Kansas State Board of Agriculture.

The logistic curve for the hypothesis test was taken from Gould's model, $P = \frac{U}{1 + e^{(a-b.T)}}$, in which P is the proportion of adopters; U is the upper limit; T is the time unit; e is a constant; and a and b are the parameters that control the shape of the curve.¹

The result from the test was that there was no significant difference between the observed curve and the logistic curve at the 0.01 level of significance. This means the diffusion process of grain sorghum in Kansas followed the S-shaped pattern through time.

A visual analysis, utilizing a series of maps describing the distribution of adopters at different points in time, was used to examine the diffusion pattern. The result was that the pattern was expansion-contagion. It was an expansion type because the number of adopters became greater through time. It was a contagious type because most of the new adopters were located close to those who had already adopted it.

It was found that there were two sources of origin located at a great distance from each other; but this fact was not enough to prove that a hierarchical type appeared in this process. Also, a

relocation type was impossible in this case because a county, as an adopter, could not relocate.

From these findings, further explanations were made concerning the adopters' behavior. The adopters were classified into five groups: innovators, early adopters, early majority, late majority, and laggards. Methods in classifying the adopters were borrowed from previous research on diffusion processes.

The explanations were based on references from the literature; most of them were government records. It was generally found that the first groups of adopters had a low degree of resistance because they were located in the areas that had an unfavorable climate for corn. They were eager to try and adopt grain sorghum because of its adaptability to soil and climate in their areas.

The adopters that entered the process very late had a high degree of resistance because they were located in the areas that had favorable climate for corn and wheat, which were traditional crops. They just entered the process when there was a long period of bad weather for corn and when the surplus of wheat caused the abandonment of some wheat acreage under the federal program.

The innovators and the early adopters entered the process between the years 1895 and 1905. They were located in the southwestern, south central, and the southeastern parts of the state. The early majority came in during the following decade, and were located in the areas surrounding the origin areas, from south to north. The late majority

and the laggards came in during the year 1915 and the year 1965. They were located in the northwestern corner, the southeastern corner, the northeastern and the central parts of the state.

Methodological Problems

Methodological problems in this research concerned problems in determining the state of adoption, the unit of adoption, and time units. A problem was also associated with fixing the shape of the theoretical logistic curve, finding a method to test for a hierarchical fashion, and a problem in obtaining information to explain the behavioral aspect.

Determining the state of adoption is not easy. Rogers (1962) said that a potential adopter will try some units of a new item before they accept it.² In this case, the problem was what unit of grain sorghum acreage will show that it had passed out of a 'trial' stage and had reached an 'adoption' stage. Moreover, the author could not find any literature review that had established a method to fix an adoption stage of grain sorghum. Therefore, a method used in the research was to find out which unit of grain sorghum acreage, when used as an adoption stage, would cause the shape of the observed curve to be similar to the S-curve.

Another problem was establishing a unit of adoption. At first, when starting this research, the author had an idea that an adopter should be an individual; such as a farmer. However, data limitation made this impractical. There were no records on growing grain sorghum

on an individual basis. Therefore, an adopter here had to be defined as a unit of adoption which was represented by a county.

Fixing the time unit was also a problem. In this case the problem was when did the saturation level of this process occur, and how many points of time should the author observe? In this case, eight periods of time were used because the author considered it appropriate for the observation. The problem concerning the saturation level was solved when the observed curve had been constructed under the assumptions and definitions given.

The shape of the hypothetical logistic curve can be varied depending on different assumptions concerning the diffusion. The problem was, how to fix the value of the parameters that control the shape of the curve. In this case, the problem was solved by building the theoretical curve that optimized the shape of the observed curve.

The value of using the theoretical model for predicting diffusion processes appeared doubtful in that while the value of the parameters could be fixed to match the observed curve, there is little basis for predicting the value of b which would determine how quickly the curve rises in the future.

A problem in testing for a hierarchical pattern results from the process studied being done using an adoption unit for which there are no exact orders or hierarchies according to the central place system. If it had been done at the larger scale; such as, in the Midwest, perhaps a hierarchical effect could be seen from an order of

a region, a state and a county. The author suggest that one might conduct further research on this case at a large scale.

The last problem was one of obtaining sufficient information to explain the behavioral aspect of adopters in the process. The fact was that during the diffusion process, not everything had been recorded. So, explanations on the reasons for adoption were very broad, and some factors affecting the rate of adoption might be overlooked in this research.

In conclusion, there were some difficulties and limitations during the conduct of the research, and most of them related to the diffusion having occurred during the past. However, these problems had been solved mostly by making some assumptions and definitions which were considered reasonable for this case. The same problems could occur to any research on diffusion processes of past events, and the author hoped that this study would provide some ideas to solve the problems. Also, suggestions were made on further research on this case or a similar case on a wider scale and in more specific aspects of diffusion processes.

Implication of the Findings

Most of the findings in this study helped to verify many ideas and theories formed by researchers in previous diffusion studies. Those ideas and theories were the logistic curve theory, the pattern of information flow and the adopters' behavior.

Some methods used in this research may be helpful for those who attempt to do diffusion research in the future. In testing whether the observed diffusion process followed the logistic S-shaped curve, the Kolmogorov-Smirnow test proved to be an efficient device. The theoretical logistic curve in this research was constructed using Gould's algebraic equation $P = \frac{U}{1 + e^{(a-b.T)}}$, which proved to produce a satisfactory theoretical curve. In investigating patterns of information flow over space, the best method may be the use of maps that show the distribution of adopters through time.

An attempt to understand and explain the rate of adoption based on a literature review may not provide a valid result. This research used a literature review because of time limitations, and found that it only provided a general explanation. Better methods might be obtained by using statistical analysis to determine factors affecting the rate of adoption.

FOOTNOTES

¹ Gould, Spatial Diffusion (Washington, D. C.: Association of American Geographers, 1969), pp. 19-20.

² Rogers, Diffusion of Innovation (New York: The Free Press, 1962), pp. 84-85.

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APPENDIX A

Table A.1 Percentage of Field Crop Acres as Occupied by Grain Sorghum in Kansas, 1895 - 1975.

Districts	Years								
	1895	1905	1915	1925	1935	1945	1955	1965	1975
Northwest									
Cheyenne	0.12	0.08	1.26	5.14	1.84	2.04	6.55	15.79	3.47
Decatur	0.05	0.68	4.57	1.20	3.19	2.30	4.63	13.85	10.24
Graham	1.40	1.52	7.32	5.06	8.31	8.17	6.10	10.08	12.01
Norton	0.05	0.69	6.38	2.40	3.98	5.95	8.01	17.32	14.89
Rawlins	0.22	0.37	2.85	0.52	1.76	1.14	3.35	6.86	3.98
Sheridan	0.61	0.95	5.73	1.23	8.22	3.42	6.13	12.67	8.11
Sherman	0.25	0.16	2.11	0.56	3.27	2.41	6.76	10.37	1.20
Thomas	0.55	0.86	6.28	1.40	5.45	3.69	6.74	5.55	0.38
West Central									
Gove	1.73	0.17	10.76	4.77	13.40	3.24	13.83	14.62	17.20
Greeley	5.74	3.84	24.51	10.50	10.61	8.66	13.80	17.36	3.48
Lane	0.95	0.94	10.87	2.55	13.51	1.68	14.08	9.48	8.81
Logan	3.21	0.77	12.24	4.97	10.27	10.37	15.24	8.27	5.43
Ness	2.87	1.45	10.27	4.02	12.88	1.91	12.16	7.20	7.44
Scott	1.32	1.05	15.09	6.49	12.15	6.07	22.17	21.02	12.45
Trego	2.81	0.94	9.95	3.86	10.17	2.91	8.63	8.89	8.74
Wallace	2.72	0.33	13.91	3.17	5.76	10.92	14.59	16.69	4.18
Wichita	2.07	0.73	18.18	6.23	9.35	4.26	8.75	21.03	7.08

Table A.1 (continued)

Districts	Years									
	1895	1905	1915	1925	1935	1945	1955	1965	1975	
Southwest										
Clark	5.90	2.16	20.37	8.74	8.33	2.74	18.23	4.04	4.87	
Finney	8.75	1.63	23.41	17.51	19.54	9.17	45.77	23.80	11.37	
Ford	3.72	2.28	6.40	4.26	9.48	1.08	23.28	6.17	3.33	
Grant	23.33	11.69	55.21	28.90	22.62	15.35	67.57	38.43	20.83	
Gray	5.73	3.86	17.44	7.89	15.23	3.36	45.28	12.47	8.55	
Hamilton	6.15	5.24	25.42	28.90	21.07	8.49	30.64	53.63	12.07	
Haskell	6.48	2.95	27.07	10.12	18.89	2.51	53.74	18.83	7.73	
Hodgeman	3.62	1.84	17.82	6.12	15.82	1.64	21.69	8.90	6.20	
Kearney	10.59	3.91	26.34	9.88	21.94	12.51	46.29	28.32	8.15	
Meade	5.43	1.97	15.67	13.77	10.09	2.97	43.49	8.81	12.82	
Morton	26.13	4.79	63.80	37.98	25.59	24.53	71.63	67.45	38.65	
Seward	7.63	7.29	32.80	19.54	20.79	14.10	75.06	24.82	26.06	
Stanton	17.08	19.80	46.85	36.11	24.72	9.92	32.06	41.22	13.17	
Stevens	17.91	5.03	48.84	38.31	25.64	29.67	76.74	55.55	49.09	
North Central										
Clay	1.75	1.67	1.62	3.27	1.44	2.43	1.98	18.57	27.58	
Cloud	0.46	1.45	1.05	3.47	2.10	1.66	4.64	14.44	17.50	
Jewell	0.29	0.54	1.66	1.24	2.44	3.85	8.80	28.40	29.97	
Mitchell	0.67	1.33	1.20	2.24	2.62	1.88	3.59	9.49	16.21	
Osborne	0.49	2.15	3.43	4.87	6.27	4.77	4.66	13.85	14.33	
Ottawa	1.12	2.24	3.80	5.94	3.38	3.40	3.86	6.95	8.23	
Phillips	0.39	1.00	3.57	2.28	3.26	4.07	7.84	18.03	16.88	
Republic	0.12	0.16	0.41	0.39	0.73	0.82	9.89	26.58	25.76	
Rooks	1.65	2.12	3.97	5.86	6.61	4.84	4.72	10.15	8.05	
Smith	0.19	0.48	1.47	0.96	2.71	3.05	6.80	22.17	28.15	
Washington	0.22	0.57	1.30	1.35	0.53	0.99	5.36	29.38	42.82	

Table A.1 (continued)

Districts	Years									
	1895	1905	1915	1925	1935	1945	1955	1965	1975	
Central										
Barton	1.91	0.97	1.35	0.92	1.63	2.97	8.22	10.19	13.81	
Dickinson	1.20	1.63	1.90	2.01	1.37	2.34	1.93	18.44	25.07	
Ellis	2.43	1.64	2.72	3.78	4.20	3.24	6.20	7.05	11.92	
Ellsworth	1.33	2.00	4.26	3.36	2.55	4.37	6.29	5.20	9.89	
Lincoln	2.79	2.42	3.25	5.47	6.50	6.14	4.31	9.26	12.95	
McPherson	0.52	1.10	1.69	2.00	1.19	2.55	3.39	11.01	21.53	
Marion	0.27	1.98	6.02	3.49	2.06	5.16	5.05	23.04	26.85	
Rice	1.37	1.59	2.14	2.12	1.99	7.29	13.10	20.38	21.12	
Rush	2.38	1.16	4.87	2.11	3.16	1.67	6.94	6.13	10.77	
Russell	2.05	2.82	3.29	5.99	7.29	6.15	3.62	7.30	10.99	
Saline	0.21	1.27	3.02	3.29	2.36	2.64	2.88	9.49	14.16	
South Central										
Barber	7.94	2.40	10.40	8.97	12.00	4.36	18.43	6.82	5.28	
Comanche	6.78	3.74	12.09	10.32	9.25	3.16	12.42	12.02	5.80	
Edwards	3.30	2.10	3.20	1.47	3.96	2.80	22.73	10.98	12.80	
Harper	2.39	2.52	5.38	4.42	5.33	2.83	13.37	4.43	1.66	
Harvey	0.38	0.55	1.94	2.53	2.78	3.12	3.94	22.57	30.10	
Kingman	0.19	0.28	5.04	3.92	5.09	3.14	9.81	8.51	5.57	
Kiowa	5.82	4.41	4.92	3.06	5.34	3.44	19.42	9.47	10.67	
Pawnee	2.06	1.94	4.07	2.71	8.40	2.64	11.73	10.45	10.38	
Pratt	4.51	4.57	6.68	5.51	5.93	5.84	23.04	14.84	11.51	
Reno	0.97	0.97	2.89	2.66	3.51	6.70	15.63	16.66	15.56	
Sedgewick	0.33	0.65	3.84	2.21	2.81	2.18	6.03	15.91	18.11	
Stafford	1.61	1.10	1.31	0.76	2.74	5.43	17.64	15.62	16.14	
Sumner	0.94	0.58	5.31	4.59	3.92	2.31	11.11	4.97	2.94	

Table A.1 (continued)

Districts	Years									
	1895	1905	1915	1925	1935	1945	1955	1965	1975	
Northeast										
Atchison	0.00	0.16	0.26	0.50	0.50	0.90	3.04	14.51	19.19	
Brown	0.03	0.11	0.15	0.19	0.19	0.19	1.68	19.37	19.96	
Doniphan	0.01	0.05	0.01	0.04	0.12	0.11	0.07	13.73	7.60	
Jackson	0.00	1.17	1.10	2.91	1.40	1.97	9.85	17.55	25.42	
Jefferson	0.00	0.64	0.47	2.48	1.87	1.03	7.27	18.75	19.58	
Leavenworth	0.01	0.12	0.58	1.17	1.17	0.91	7.53	12.88	16.09	
Marshall	0.03	0.37	0.73	0.75	0.64	1.11	4.44	33.74	42.58	
Nemaha	0.02	1.25	0.81	1.25	0.83	1.10	4.10	30.50	40.77	
Pottawatomie	0.05	2.48	2.99	4.31	1.65	2.37	7.83	24.99	22.48	
Riley	0.33	1.44	2.89	3.89	1.73	2.69	3.97	27.92	31.34	
Wyandotte	0.00	0.14	0.42	0.37	0.45	0.51	5.12	5.19	0.64	
East Central										
Anderson	0.37	2.11	21.51	11.95	6.11	4.13	8.48	6.69	9.94	
Chase	0.14	4.19	23.57	15.68	10.40	14.90	13.89	17.25	15.13	
Coffey	0.15	2.02	18.43	12.28	6.03	7.94	13.87	15.85	12.94	
Douglas	0.77	0.74	3.07	4.44	3.94	2.22	8.07	9.04	18.36	
Franklin	0.05	1.47	8.25	8.71	5.56	3.61	12.38	14.65	14.70	
Geary	0.32	2.47	3.55	4.23	5.17	3.60	3.34	4.01	24.61	
Johnson	0.02	0.15	0.54	1.78	1.88	1.30	9.65	11.97	13.73	
Linn	0.06	1.19	8.10	8.92	4.87	4.17	8.10	9.98	24.32	
Lyon	0.86	4.98	26.66	16.75	8.71	8.29	15.04	20.03	18.74	
Miami	0.01	0.41	2.51	4.04	3.78	2.74	11.76	12.12	17.43	
Morris	0.98	4.29	15.67	11.95	7.04	6.71	10.80	18.82	21.31	
Osage	0.20	2.53	14.08	9.88	5.93	5.08	20.35	19.37	20.86	
Shawnee	0.04	2.09	4.34	5.19	3.57	2.45	10.44	15.01	19.08	
Wabaunsee	0.25	2.68	9.53	10.41	5.33	6.62	12.96	23.01	16.37	

Table A.1 (continued)

Districts	Years									
	1895	1905	1915	1925	1935	1945	1955	1965	1975	
Southeast										
Allen	0.55	2.77	20.36	15.42	4.62	6.11	6.71	7.42	13.75	
Bourbon	0.03	1.63	9.39	9.94	4.46	4.96	5.61	9.40	20.17	
Butler	1.19	5.40	31.40	12.12	9.28	10.65	6.63	22.40	24.27	
Chautauqua	0.93	5.24	19.20	18.67	8.27	10.16	6.38	9.54	6.39	
Cherokee	0.05	1.13	2.67	3.74	2.73	2.83	1.99	4.24	13.78	
Cowley	0.94	1.77	14.87	9.96	5.96	6.42	4.68	12.22	9.97	
Crawford	0.01	1.47	2.88	4.21	4.58	4.77	4.40	6.72	23.22	
Elk	1.12	3.35	21.17	16.16	8.62	10.69	3.88	6.97	11.94	
Greenwood	3.17	4.82	27.17	18.57	9.38	13.60	7.42	8.37	13.72	
Labette	0.29	1.98	6.72	5.43	3.33	3.84	3.85	8.18	16.07	
Montgomery	0.17	2.95	9.67	9.10	4.38	6.04	3.70	12.84	21.38	
Neosho	0.62	2.13	11.30	10.14	5.79	8.48	5.98	8.14	17.16	
Wilson	0.61	3.41	18.48	14.37	6.29	7.32	6.40	8.71	16.60	
Woodson	2.75	3.58	21.33	16.97	6.06	8.26	6.91	10.28	16.56	

Sources: Computed from data on grain sorghum acreage and field crops acreage in Kansas,
 Kansas State Board of Agriculture.

THE DIFFUSION OF GRAIN SORGHUM
IN KANSAS

by

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ABSTRACT

This research investigated the diffusion of grain sorghum in Kansas. It examined whether the diffusion process of grain sorghum in Kansas followed the logistic S-shaped curve through time; and whether the pattern of information flows in this process was either one or a combination of these types: expansion, relocation, contagion and hierarchical. Besides, a literature review was made to explain the reasons for adoption and resistance in different regions in Kansas over time.

The total period for the observation was between the years 1895 and 1975, using ten-year intervals to fix each point of time observed. It was assumed that a county was a potential adopter, and that a county became an adopter when grain sorghum constituted at least three percent of its total field crop acres. It was also assumed that an adopter would keep its status regardless of its fluctuation in grain sorghum acreage in the latter periods. The data for the observation were obtained from government records.

The results of the investigation were that there was no significant difference between the theoretical logistic curve and the observed curve describing the diffusion process of grain sorghum in Kansas, using 0.01 level of significance, and that the pattern of diffusion in this process was both expansion and contagious because the number of adopters became greater through time and the adoption spread out from the origin areas in a contagious fashion; i.e., new adopters were close to those who had already adopted it.

Based on a literature review, it was determined that the early adopters had a low degree of resistance because they were located in the sections of the state that had unfavorable climate for corn and wheat. These areas were the south, west and the Flint Hills Region. On the contrary, the late adopters had a high degree of resistance because they were located in the sections of the state that had enough moisture for corn and wheat: the central and northeastern parts of the state. The late adopters just entered the process when the weather was unfavorable for corn for a long period and when wheat acreage was restricted under the federal program to avoid a surplus of wheat production. Another reason that made many adopters enter the process very late was they were used to corn-growing habits, even though the cash return from grain sorghum was higher than from corn since the 1910's.

It took the process seven decades, from the year 1895 to the year 1965, to reach the saturation level.