A method of measuring the comparative general level of management for farm operators on the Jocko Valley Division of the Flathead Irrigation Project
by Carl Edmund Olson

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of MASTER GF SCIENCE in Agricultural Economics
Montana State University


Abstract:
This study is an attempt to test the significance of differences in the level of management as this is represented by differences in crop yields.

Yield is made up of several inputs including management as defined here, soil and weather conditions. By subtracting out the effects of soil characteristics and weather conditions on yield, variations in the residuals can be attributed to variations in the management input.

The data used for analysis in this study were taken from records of the Jocko Valley Division of the Flathead Indian Reservation Irrigation Project. This irrigation division was used for several reasons? (1) there is a recent soil survey available that is essential for the soil indexing method used; (2) this division of the irrigation project covers a small geographic area, which is necessary to minimize differences in weather between tracts of land; (3) there is a large number of Indian operators as well as non-Indian operators, which also permits cross-cultural comparisons in testing the method statistically; and (4) a high percentage of the cropland is in alfalfa hay, giving a crop that is grown under all or most of the levels of management present in the area.

The method is based oh the removal of the weather influence through sampling, and removing the influence of variations in soil by use of the Storie Soil Index.

Each of the physical characteristics of the soil are given an index value on the basis of an "ideal" soil. These values are then used to obtain a productivity index value for the soil itself. From these soil productivity indexes a productivity index for each tract (alfalfa field) in the sample is obtained. The productivity index is then used to subtract out the soil influence on yield, with the remainder representing the influence of the management input.

Using the indexed yields, statistical tests are made to determine whether this method reveals significant differences in the management input among, as well as within, different groups of operators.

The results of these tests show that the method developed to determine an operator’s comparative level of management does, in fact, reveal significant differences within as well as between the groups studied.

# A METHOD OF MEASURING THE COMPARATIVE GENERAL LEVEL OF MANAGEMENT FOR FARM OPERATORS ON THE JOCKO VALLEY DIVISION OF THE FLATHEAD IRRIGATION PROJECT

by

CARL EDMUND OLSON

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Chairman, Examining Committee

Dean, Graduate Division

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Any errors or omissions in this study are the responsibility of the author.

TABLE OF CONTENTS

## LIST OF TABLES

LIST OF TABLES
(continued)

## LIST OF FIGURES

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## PART I

## INTRODUCTION

### Problem Situation

The level of managerial input of the individual farm operation is important in farm budget analysis. The budget tells the operator which of the enterprises considered are best suited for his particular operation and thus enables him to attain his goal more efficiently. Budgeting, as presently used, sets the level of management by specifying what practices are needed to attain a certain level of production. If the level of management input can be related to yields obtained with some degree of confidence, it will be possible to make better budget estimates for the individual farm operator.

Farm management, or management as used in farm budget analysis, may basically be defined as "the ways and means of organizing land, labor and capital and the application of technical knowledge and skills in order that the farm may yield the maximum net return" consistent with the goals of the family farm.[1/] In most farm management research the level of management is assumed constant. The assumption has been justified and explained in several ways. Johnson[2/] gives two cases in support of this assumption.

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1/ C. W. Forster, Farm Organization and Management, New York, Prentice-Hall, Inc., 1946, p. 27.

2/ Glenn L. Johnson, "Problems in Studying Resource Productivity and Size of Business Arising From Managerial Process," Resource Productivity, Returns to Scale, and Farm Size, Edited by Earl O. Heady, Glenn L. Johnson and Lowell S. Hardin, Ames, Iowa, Iowa State College Press, 1956, pp. 16-23.

First, the sample used in the study may be drawn in such a manner that only one level of management is present. In the second case the sample is drawn in such a manner that the managerial input is normally and randomly distributed and the input will "average out" to some uniform level.3/ This "average" level of management is then used to represent all management used in the study. In both cases it is recognized that the management input varies, but great care is taken to hold it constant.

Tramel and Hildreth4/ have a different reason for assuming the level of management to be approximately the same for different farm operators. This is attributed to better education of farm operators. Also, more effective dissemination of agricultural information has increased the extent to which new farming practices are adopted. They argue that this has helped reduce variation in management.5/

In the case presented by Tramel and Hildreth for assuming management constant, it would appear that the managerial ability of an individual would greatly influence the rate at which he will adopt new technologies. Higher managerial ability should result in higher output (or yield). If this is the case, then there would appear to be a direct relationship between yield and management input.

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3/ Ibid., pp. 20-21.

4/ Thomas E. Tramel and R. J. Hildreth, "Relative Role of Survey and Experiment in Farm Management," Journal of Farm Economics, Vol. XXXIX, No. 5, December, 1957, pp. 1445-1451.

5/ Ibid., p. 1451.

In these systems of dealing with the management input, this input is held constant and not included as a variable. If management is not a variable in the production process, why then are there variations in yield on adjoining farms with similar soil, weather and climatic conditions?

Production theory tells us that management is one of the four factors of production. These four factors are land, labor, capital and management. In the actual budgeting process land, labor and capital are used as variables for the enterprises considered. This is reasonable as these factors can be shifted from one enterprise to another without too much difficulty. Management is handled differently. In actual budgeting the management input is assumed constant between enterprises as well as between farm operations. This does not seem reasonable. The idea that there is no managerial difference between farmers is wrong; 6/ there are differences. If one can determine the degree to which managerial ability does vary, he will be better able to estimate the general level of management of a particular operator and its effect on yield.

## Research Problem

If management is to be included as an input in the production process, how much does it contribute to the level of yield attained?

Management, as it will be used in this study, is defined not only as the ability to combine inputs, but also the ability to obtain and control

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6/ Don Kanel, "Discussion: Relative Roles of Survey and Experiment in Farm Management Research," Journal of Farm Economics, Vol. XXXIX, No. 5, December, 1957, pp. 1451-1454.

inputs. The ability to obtain and control inputs reflects not only the wealth, income and credit position of an individual operator, but also the constraints which may be imposed on him by his education, his culture, and the area in which he lives.

Since management is constrained by both institutions and learning, it is suspected that there may be variations in the general level of management within as well as between different cultural groups. This study is to determine whether there are measurable differences and whether the adapted methods are sufficient to reveal these differences in a meaningful way.

Yield is influenced by three main inputs: management, soil characteristics and weather conditions. By "netting out" the effects of soil and weather on yield, the residual yield can be attributed to the management input. Included in the management input are such things as type of seed used, rate of seeding, use of fertilizers, use of proper machines in the proper manner and timeliness of the operation.

## Hypotheses

This study will be conducted under two general hypotheses relating to the measurability of management. They are, (1) there are measurable differences in the levels of management between individuals in a cultural or tenure group, and (2) there are measurable differences in the level of management between cultural and tenure groups as a whole. Thus, if the levels of management are significantly different, these hypotheses will not be rejected by the statistical tests to be used.

## Objectives

There are two objectives of this study. First, an attempt will be made to develop a method for measuring comparatively the general level of management of different groups (both cultural and tenure) of farm operators in a given area. Second, this will be an attempt to determine whether such a method can produce estimates that will be of use in establishing levels of yields for different operators in farm budgeting.

# PART II

## DEVELOPMENT OF THE METHOD

### Sampling

For this study an area is needed in which there are different cultural groups of farmers, such as Indian and non-Indian farmers, and different tenure positions of the operators. The area to be considered should have a crop which is grown on most farms. Also, a reasonably accurate soil survey is needed of the area.

The first condition suggests going to an Indian reservation where Indians are actively engaged in farming. Records and past experience indicate that the Indian farmer is not as good a manager as the non-Indian operator in the same area, in keeping with the definition of management used in this study, or he is using less productive land or a combination of the two. In reviewing data from the various Indian reservation projects in Montana, it was found that there are very few Indians actively farming on these projects. Of the divisions of the Flathead Indian Reservation Irrigation Project, the Jocko Valley Division has the greatest number of Indian operators.

The preliminary survey of the 1961 crop reports shows 43 tracts with irrigated alfalfa farmed by Indians in the Jocko Valley Division. This compares with 23 in the Mission Valley Division and only a handful in the Camas Division. The Jocko Valley Division crop report shows 125 tracts of irrigated alfalfa farmed by non-Indian operators. Of the 125 tracts, 32 are farmed by renters and 93 are farmed by owner operators. This Division appears to be the most acceptable in terms of relative size of the sample available from each of the cultural and tenure groups. Having sufficient samples from the different cultural groups, among which there are suspected differences in management input, it is necessary to see whether the method to be used is sufficient to reveal these differences.

In keeping with the objective of measuring management by using relative yields, the yield of only one crop should be used. This crop should be one that is of major importance and reflects in its yield the management input. For these reasons alfalfa hay was selected to be the crop used in this study. Approximately 35 percent of all the irrigated crop land in the Jocko Valley Division is in alfalfa (Table I), indicating that it is a major crop and that it should demonstrate the range of management levels present. Other divisions of the Flathead Indian Reservation Irrigation Project have approximately the same percentage of irrigated alfalfa, but there are not sufficient Indian operators to make the necessary statistical tests.

The method to be developed requires a soil indexing method to eliminate soil variation. Most of the Indian reservations have had soil surveys made by the United States Department of Agriculture or the Bureau of Indian Affairs or, in some cases, both organizations. The Jocko Valley Division has such a survey. The original survey was made in 1929 by the United States Department of Agriculture and a revision or second survey was made in the late 1950's by the Bureau of Indian Affairs.

TABLE I. USE OF CROPLAND IN FLATHEAD IRRIGATION PROJECT DIVISIONS, 1960*

| Item | Jocko Valley | | Camas | | Mission Valley | | Total Project | |
|---|---|---|---|---|---|---|---|---|
| | Acres | Percent | Acres | Percent | Acres | Percent | Acres | Percent |
| Forage | | | | | | | | |
| Alfalfa | 3636.1 | 35.41 | 3734.8 | 35.59 | 22168.6 | 25.99 | 29539.5 | 27.85 |
| Grass Hay | 1355.4 | 13.20 | | | 5484.1 | 6.43 | 6839.5 | 6.45 |
| Annual Pasture | 3889.0 | 37.87 | 3115.1 | 29.69 | 31874.9 | 37.37 | 38879.0 | 36.66 |
| Silage | 25.0 | 0.24 | 5.0 | 0.05 | 358.9 | 0.43 | 388.9 | 0.37 |
| Other Forage | 152.8 | 1.49 | 2868.5 | 27.34 | 8498.8 | 9.96 | 11520.1 | 10.86 |
| Total | 9058.3 | 88.21 | 9723.4 | 92.67 | 68385.3 | 80.18 | 87167.0 | 82.19 |
| Grains | | | | | | | | |
| Barley | 359.0 | 3.50 | 368.4 | 3.51 | 5296.0 | 6.21 | 6023.4 | 5.68 |
| Oats | 296.0 | 2.88 | 175.4 | 1.67 | 4286.6 | 5.03 | 4758.0 | 4.48 |
| Wheat | 71.5 | 0.70 | 152.5 | 1.45 | 5176.7 | 6.07 | 5400.7 | 5.09 |
| Other | | | | | 46.0 | 0.05 | 46.0 | 0.04 |
| Total | 726.5 | 7.08 | 696.3 | 6.63 | 14805.3 | 17.36 | 16228.1 | 15.29 |
| Other Uses | | | | | | | | |
| Fruits | 5.7 | 0.06 | | | 110.4 | 0.13 | 116.1 | 0.11 |
| Garden | 41.9 | 0.41 | 1.2 | 0.01 | 138.0 | 0.16 | 181.1 | 0.17 |
| Potatoes | | | | | 794.4 | 0.93 | 794.4 | 0.75 |
| Sugar Beets | 32.5 | 0.32 | | | 491.8 | 0.58 | 524.3 | 0.49 |
| Seed Crops | | | | | | | | |
| Soil Bank | 282.3 | 2.75 | 65.2 | 0.62 | 411.1 | 0.47 | 758.6 | 0.72 |
| Misc. | | | | | | | | |
| Irrigated, not cropped | 120.4 | 1.17 | 7.0 | 0.07 | 166.5 | 0.19 | 293.9 | 0.28 |
| Total | 482.8 | 4.71 | 77.4 | 0.70 | 2112.2 | 2.46 | 2668.4 | 2.52 |
| Total | 10267.6 | 100.00 | 10493.1 | 100.00 | 85302.8 | 100.00 | 106063.8 | 100.00 |

*From Agency Crop Report

Another factor to be considered is the size of the area covered by the project under study. The smaller the area in which the sample is located, the less will be the variation in weather over the area. The Jocko Valley Division is the smallest of the three main divisions in the Flathead project.

These factors make the Jocko Valley Division the area most suited for this study. Also, there are complete crop reports available from which data can be obtained.

The Jocko Valley Division is nearly four miles wide southeast of Arlee, but at Ravalli it narrows to a canyon. It widens again near the junction of the Jocko River and the Flathead River. Its western part is in Sanders County and its southern part extends about three miles into Missoula County. The balance of the Division is in Lake County.[7/]

The elevation of the main part of the Jocko Valley Division is approximately 3,000 feet at the base of the mountains to 2,500 feet along the Flathead River near Dixon. The highest elevation is in the southeastern part of the Division while the lowest is in the northwestern end. The fall in elevation from south to north should, to some extent, make climatic conditions more uniform over the Division. As to formal climatic records, there are none for any point in the Jocko Valley. The nearest reporting

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7/ William DeYoung and R. C. Roberts, Soil Survey of the Lower Flathead Valley Area, Montana, United States Department of Agriculture, Series 1929, Number 22.

station is St. Ignatius. There the growing season is 125 days.[8/] This figure should be fairly representative as Arlee, which is approximately the middle of the Division, is at nearly the same elevation as St. Ignatius. Most of the Division is at an elevation within 100 feet of Arlee, so it is felt the growing season for this Division should be about 122-125 days. The annual precipitation at St. Ignatius is 15.13 inches.[9/] Arlee and the majority of the Jocko Valley Division will have approximately this amount also.

Certain restraints are placed on the sample as it was obtained in order to remove any possibility that factors, not necessarily related to management itself, will not influence the results of the study. The main restraints are total irrigated acres operated by the individual operator and the age of the alfalfa stand.

The size limitation is used on both minimum and maximum acreage of irrigated land that an operator must farm to be included in the sample. Size may be a function of management. High level management will "normally" result in high profit with a large operation. But the level of management may also be a function of size; a large unit may force the operator to reduce the intensity and variety of management practices (and levels).

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8/ United States Department of Agriculture, Climate and Man, 1941 Yearbook of Agriculture, Washington, D. C., United States Government Printing Office, 1941, p. 956.

9/ Ibid.

It is felt that an operator cannot handle much over 320 irrigated acres and still do an adequate job of farming. When the irrigated acreage is too small the operator may tend to overlook the full potential of this resource and will not devote the management effort that the tract warrants, particularly if this tract is only a part of the total operation. With this in mind, 60 irrigated acres were set for the minimum acreage an operator must farm in order to be included in the sample.

The alfalfa stands used in this study must be at least two years old; that is, 1961 is at least the second year that hay has been harvested from the tract. There are two reasons for not including the first year's alfalfa crop. First, the alfalfa may be grown with a nurse crop, such as barley or oats, the first year. In this case the hay crop that is harvested, if any is harvested at all, is quite small and not representative of the yield of a "normal" alfalfa crop. This is partly due to the drain on available nutrients by the growing nurse crop. The second reason for not including first year alfalfa stands is that the first year's crop even when not grown with a nurse crop is considerably smaller in total yield than the second and third year crops from the same stands.[10/]

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10/ W. E. Larson, S.N. Brooks, T.S. Aasheim, and A.H. Post, Irrigated Crop Rotations at the Huntley Branch Station, Montana Agriculture Experiment Station, Bulletin 535, Bozeman, Montana, January, 1958, p. 49.
In comparing the mean yields of the first year the alfalfa was grown with the second and third years, the following results were obtained:

1st. year---4.09 Tons/Acre
2nd. year---4.46 Tons/Acre
3rd. year---4.42 Tons/Acre

There are no restraints on the maximum age an alfalfa stand may be in order to be included in the sample. It is recognized that alfalfa yields decline as the age of the stand increases if no reseeding, fertilizing or any other type of renovating practices are used. If the alfalfa is properly rotated and maintained, the yield should remain higher than if it is not. In determining a level of management, practices which show an apparent lack of management should not be eliminated from the sample. When a tract has been in alfalfa for too many years, this would demonstrate a lack of "good" management practices. Conversely, when a tract shows alfalfa for only a few years, such as three, four or five years, this is an indication of acceptable rotation and satisfactory management practices.

By complying with these sampling restraints, factors which are indications of part-time farming or large-scale farming are removed from the sample so that only family-sized farms are included. These restraints will also exclude tracts of alfalfa with low yields which will unjustifiably influence the final result. As stated above, these tracts are the first year crop and alfalfa grown with a nurse crop.

The actual sample used in this study was taken from the crop reports of 1961 of the Flathead Irrigation Project on the Flathead Indian Reservation. The cultural and tenure groups were based upon Indian or non-Indian operators, and non-Indian renters or non-Indian owner-operators. As it was felt that non-Indian operators are better managers than Indian operators, and owner-operators are believed (by some) to be better managers than renters, the total sample will be broken into these groups for analysis.

The number of observations in the sample used was reduced from the number in the preliminary survey by the sampling restraints. The Indian cultural group has 21 tracts and the non-Indian cultural group has 60 tracts. In the non-Indian renter group there are 23 tracts and in the non-Indian owner-operator group there are 37 tracts. The total sample has 81 tracts.

## Climate Index

In the introduction it was pointed out that the managerial effect on yields might be considered the residual after the effects of climate and soil variations have been removed. The problem arises as to how the climatic and soil variation can be removed from some given set of yields and the residual effect obtained.

Several methods have been developed for removing climatic and weather variations from a series of yields. These methods, such as the one Stallings [11] has developed, measure the influence of weather on crops grown on experimental plots by holding as many factors constant as possible from year to year. They assume that most of the variation in yield is due directly to variation in weather after trend has been removed to account for increases or decreases in the fertility level of the soil. From these data indexes are developed to show how weather has influenced yield over time.

In this study, the influence of weather over a period of years is not necessarily needed. We are attempting to measure the influence of

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11/ James L. Stallings, "Weather Indexes," Journal of Farm Economics, Vol. XXXII, p. 180-186.

management and not the influence of weather. What is needed is to remove the influence of weather among all tracts in the sample for one crop year. This is done by taking the sample from a small area (the Jocko Valley Division) and using alfalfa yields from the 1961 crop report of the Division.[12/]

It is assumed that for one year the weather will be uniform over a small area, such as the Jocko Valley Division, and yields from different tracts will not be influenced by weather variation.

## Soil Productivity Index

The soil indexing method used is a technique developed by R. E. Storie of California. This method is based on soil characteristics that govern the land's potential utilization and productive capacity. It is independent of other physical (climatic) or economic (including managerial ability, as defined in this paper) factors that might determine the desirability of growing certain plants in a given location.[13/]

The area under study was indexed according to the original method in the early 1940's by the Agronomy Department, Montana Agricultural Experiment Station in cooperation with the Soil Survey Division of the Bureau

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12/ Taken from the unpublished 1961 crop report of Flathead Indian Reservation Irrigation Project, St. Ignatius, Montana.

13/ R. Earl Storie, Revision of the Soil-Rating Chart, California Agriculture Experiment Station, Berkley, California, December, 1959.

of Plant Industry.[14/] These data were obtained from the Plant and Soil Science Department of Montana State College.

In determining the percentage values of the various factors considered, a knowledge of soils in general, and the soils under consideration in particular, is needed. Soil scientists are the most logical people to do this type of study. They are able to fix the necessary soil measures with the greatest accuracy.

The Storie indexing or rating chart assigns a value, in terms of an "ideal" soil, to: (1) the character of the physical profile, called "Factor A"; (2) the surface texture, "Factor B"; and (3) slope, "Factor C". In addition to these three characteristics, irrigability and erosiveness are considered, as are freedom from alkali and poor drainage. To determine the index value of the particular soil, the percentage of the ideal soil for each of the six factors considered are multiplied together (Equation 1). Each of the factors in the equation have equal weight.

Equation 1[15/]

Index Value of Soil = Factor A x Factor B x Factor C x Fertility x Irrigability and Erosiveness x Freedom from Alkali and Poor Drainage

This method was used as all the soils are rated against the "ideal" (100 percent index) soil and there is no direct comparison of soil types

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14/ Taken from unpublished soil report, Department of Plant and Soil Science, Montana State College, Bozeman, Montana.

15/ R. Earl Storie, *op. cit.*

against each other. Using the soil indexes, the productivity index for a tract of land can then be found.

Productivity Index of the Tract

The productivity index of each tract is a weighted index made up of the productivity index of each soil within the individual tract. The first step in obtaining the tract productivity index rating is to compute the index rating of soils within that tract.

As mentioned previously, the Jocko Valley Division was surveyed and indexed in the 1940's. The results of this study by the soils personnel at Montana State College is shown in Table II. These indexed values of soil are used in computing the productivity index.

The weighted productivity index of a tract is computed by multiplying the indexed value of each soil in the tract by the acres of that soil in the tract. These values are added, and the result divided by the total acres in the tract (Equation 2).

Equation 2 16/

$$\text{Productivity Index of Tract} = \frac{\text{Soil Index Value x Acres of Soil Type}}{\text{Total Acres in Tract}}$$

Some soils are much more productive than others. As a result, one operator may be obtaining high yields from very productive land, and compare much more favorably than another operator who has lower yields, but

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16/ Ibid.

TABLE II. SOIL TYPES AND SOIL INDEXING OF THE SOILS IN THE JOCKO DIVISION OF THE FLATHEAD IRRIGATION PROJECT.*

| Soil Type | Factor A | Factor B | Factor C | Freedom from Alkali & Poor Drainage | Irrigability & Erosiveness | Fertility | Index Value of Soil |
|---|---|---|---|---|---|---|---|
| | % | % | % | % | % | % | % |
| Millville Loam | 95 | 100 | 95 | 100 | 95 | 95 | 90 |
| Moise Fine Sandy Loam, Fine Texture Phase | 90 | 100 | 92 | 100 | 95 | 90 | 82 |
| Millville Gravelly Loam | 85 | 80 | 90 | 100 | 90 | 90 | 61 |
| Trenton Very Fine Sandy Loam | 95 | 100 | 80 | 95 | 95 | 90 | 76 |
| Trenton Stony Loam | 90 | 80 | 87 | 100 | 90 | 85 | 63 |
| Flathead Fine Sandy Loam | 90 | 100 | 85 | 100 | 80 | 90 | 76 |
| Trenton Gravelly Loam | 85 | 80 | 87 | 100 | 90 | 85 | 56 |
| Corvallis Silty Clay Loam, Brown Phase | 60 | 95 | 87 | 100 | 85 | 90 | 50 |
| Flathead Fine Sand | 50 | 70 | 70 | 100 | 60 | 80 | 24 |
| Hyrum Gravelly Loam, Terrace Phase | 65 | 80 | 90 | 100 | 95 | 85 | 47 |
| Hyrum Gravelly Loam | 60 | 80 | 90 | 100 | 95 | 85 | 43 |
| Hyrum Stony Loam | 60 | 70 | 87 | 100 | 85 | 90 | 36 |
| Corvallis Silty Clay Loam | 60 | 90 | 70 | 100 | 60 | 80 | 38 |
| Corvallis Silty Clay Loam, Gravelly Phase | 60 | 80 | 65 | 100 | 66 | 70 | 31 |
| Lonepine Very Fine Sandy Loam, Steep Phase | 90 | 100 | 55 | 100 | 30 | 80 | 49 |
| Post Clay Loam | 60 | 70 | 90 | 100 | 90 | 90 | 38 |

*Source: Unpublished data from Plant and Soil Science Department, Montana State College.

also much poorer land to work with. The productivity index is the basis for indexing yields so as to account for differences in yields that result from such differences in soil productivity.

### Development of the Yield Index

In order to make the statistical test on the yields to accept or reject the hypotheses of this study, all the influences of soil type must be removed. The resulting value is, for purposes of this study, the indexed yield.

The indexed yield is a value which shows what the management, as defined here, will obtain on the ideal soil in the crop year studied. To go from the actual yield to the indexed yield, the actual yield is divided by the productivity index (Equation 3).

Equation 3

$$\text{Indexed Yield of Tract} = \frac{\text{Actual Yield of Tract}}{\text{Productivity Index of Tract}}$$

Table III shows the actual yield in tons per acre from each tract, the soil productivity index of the tract, the indexed yields found by use of Equation 3, and the cultural and tenure position of the operator of the tract.

By using the methods described, soil variations have been removed from each tract and an indexed yield has been obtained. These indexed yields will be used in making the desired statistical tests of the hypotheses of this study.

TABLE III. CULTURAL OR TENURE POSITIONS OF OPERATOR, ACTUAL YIELD, SOIL PRODUCTIVITY INDEX AND INDEXED YIELD OF EACH TRACT IN SAMPLE.

| Group a/ | Actual Yield Tons | Soil Productivity Index | Indexed Yield |
|---|---|---|---|
| I | 0.68 | 59.13 | 1.15 |
| nIoo | 1.03 | 84.75 | 1.22 |
| I | 1.00 | 61.00 | 1.64 |
| I | 1.00 | 61.00 | 1.64 |
| I | 1.00 | 60.95 | 1.64 |
| nIoo | 1.00 | 60.61 | 1.65 |
| nIoo | 1.04 | 61.29 | 1.70 |
| I | 0.77 | 44.74 | 1.72 |
| I | 1.00 | 57.88 | 1.73 |
| nIr | 1.28 | 74.05 | 1.73 |
| nIoo | 1.30 | 70.56 | 1.84 |
| nIoo | 0.80 | 43.00 | 1.86 |
| I | 1.21 | 61.00 | 1.98 |
| I | 1.00 | 50.26 | 1.99 |
| I | 1.00 | 50.24 | 1.99 |
| nIr | 1.00 | 49.08 | 2.04 |
| nIr | 1.00 | 48.50 | 2.06 |
| I | 1.18 | 54.84 | 2.15 |
| nIoo | 1.63 | 73.00 | 2.22 |
| nIr | 1.17 | 52.03 | 2.25 |
| nIr | 1.00 | 44.15 | 2.27 |
| nIr | 1.06 | 45.25 | 2.34 |
| nIoo | 1.03 | 43.12 | 2.39 |
| nIoo | 1.27 | 52.62 | 2.41 |
| nIoo | 1.25 | 50.06 | 2.50 |
| I | 1.59 | 60.88 | 2.61 |
| nIoo | 1.79 | 66.93 | 2.67 |
| nIr | 1.16 | 43.00 | 2.70 |
| nIoo | 1.62 | 58.30 | 2.78 |
| nIoo | 1.50 | 52.00 | 2.89 |
| nIr | 1.30 | 45.03 | 2.89 |
| nIr | 1.25 | 43.00 | 2.91 |
| I | 1.33 | 44.73 | 2.97 |
| nIoo | 1.32 | 44.13 | 2.99 |
| I | 1.71 | 50.07 | 3.00 |
| nIoo | 2.30 | 76.18 | 3.02 |
| I | 1.90 | 62.31 | 3.05 |
| nIoo | 1.50 | 48.88 | 3.07 |
| nIoo | 2.21 | 71.95 | 3.07 |
| nIoo | 1.94 | 63.00 | 3.08 |
| I | 2.00 | 64.81 | 3.09 |
| nIoo | 1.92 | 61.02 | 3.15 |
| nIr | 2.00 | 62.36 | 3.21 |

TABLE III Continued

| Group a/ | Actual Yield Tons | Soil Productivity Index | Indexed Yield |
|---|---|---|---|
| I | 1.80 | 55.58 | 3.24 |
| nIoo | 2.08 | 64.00 | 3.25 |
| nIoo | 1.98 | 60.90 | 3.25 |
| nIr | 1.74 | 53.28 | 3.27 |
| nIoo | 2.00 | 61.00 | 3.28 |
| nIoo | 2.00 | 61.00 | 3.28 |
| nIr | 1.88 | 56.72 | 3.31 |
| nIoo | 2.00 | 60.14 | 3.33 |
| nIoo | 1.43 | 43.00 | 3.33 |
| I | 1.99 | 59.24 | 3.36 |
| I | 1.98 | 57.80 | 3.43 |
| nIoo | 1.50 | 43.00 | 3.49 |
| nIoo | 2.14 | 59.89 | 3.57 |
| I | 1.67 | 46.83 | 3.57 |
| nIr | 2.67 | 74.15 | 3.60 |
| nIoo | 2.00 | 55.17 | 3.63 |
| nIoo | 1.60 | 43.00 | 3.72 |
| nIoo | 1.63 | 43.00 | 3.79 |
| nIr | 3.00 | 77.54 | 3.87 |
| nIr | 1.67 | 43.00 | 3.88 |
| nIr | 1.72 | 43.00 | 4.00 |
| nIoo | 2.00 | 49.53 | 4.04 |
| nIoo | 2.53 | 61.00 | 4.15 |
| nIr | 2.33 | 56.16 | 4.15 |
| nIoo | 2.62 | 62.28 | 4.21 |
| I | 2.00 | 47.46 | 4.21 |
| nIr | 1.80 | 43.47 | 4.32 |
| nIoo | 2.82 | 63.00 | 4.48 |
| I | 1.94 | 42.25 | 4.59 |
| nIr | 2.23 | 47.00 | 4.75 |
| nIr | 2.44 | 51.28 | 4.76 |
| nIr | 3.00 | 63.00 | 4.76 |
| nIr | 2.00 | 41.56 | 4.81 |
| nIr | 2.35 | 65.31 | 5.19 |
| nIoo | 2.83 | 49.00 | 5.78 |
| nIoo | 3.25 | 54.31 | 5.98 |
| nIoo | 3.64 | 65.47 | 6.56 |
| nIoo | 2.86 | 38.00 | 7.53 |

a/ I - Indian Operator, nIr - Non-Indian Renter, nIoo - Non-Indian Owner-Operator

## PART III

### STATISTICAL TESTS

Are the indexed yields, obtained through the procedure just outlined, meaningful as a measure of management input? If so, how can we make comparisons between different groups, both cultural and tenure, to see what influence these factors may have on the management input?

In answer to the first question, the yields observed represent the population as restricted by the constraints placed upon it in this study. Since each of the observed yields are handled and indexed in this same manner, the indexed yields should represent the population based upon the 100 percent or ideal soil. To the extent that variations in climatic conditions and soils have been eliminated, any variation in the indexed yield is due to management, as management is defined in this study. As to what the variations of management input are, the procedure outlined will not give any concrete answers. It is intended only to show whether there are measurable differences in the management input.

The testing procedure used in making the various comparisons is the analysis of variance technique, using the F-test.[17/] This will be used as we are interested in the variance of the means of different groups in the observed sample to determine whether there are statistically significant differences between those means. A brief explanation of the assumptions will be given.

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17/ Frederick E. Croxton and Dudley J. Cowden, Applied General Statistics, New York, Prentice-Hall, Inc., p. 706.

Assumptions Underlying the Analysis of Variance

Before we interpret the analysis of variance technique applied to a set of survey data, certain assumptions must be made explicit. If we desire our data to be capable of rigorous analysis and our conclusions to be accompanied by statements of probability as to the correctness of our inference, such assumptions must be of a mathematical nature. For the sake of definitions, we shall assume that the characteristic being measured is affected by one factor, or rather that we are interested only in estimating the effect of one factor, that is, the effect of the management level on yield. 18/

The assumptions may be clearly summarized in the following way. If we assume that an observation ($X_{ij}$) may be represented by the mathematical model 19/

$$X_{ij} = \mu + a_i + \xi_{ij} \qquad i = 1, \cdots, r \quad j = 1, \cdots, n$$

where $\mu$ and $a_i$ are constants such that $\sum_{i=1}^{r} a_j = 0$ and the $\xi_{ij}$ are independent and normally distributed with mean zero and a common variance $\sigma^2$, then we may validly apply analysis of variance techniques

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18/ Bernard Ostle, Statistics in Research, Ames, Iowa, The Iowa State University Press, 1954, p. 240.

19/ $\mu$ = sample mean
$a_i$ = variance of observation from sample mean
$\xi_{ij}$ = error

to detect and estimate fixed relations among the means of groups of the population under consideration. That is, if the assumptions are satisfied, we may test hypotheses and estimate group effects, with the added feature that we can attach measures of reliability to any inferences to be drawn from our analysis.[20/]

Analysis of Variance Calculating Formulas

The analysis of variance tests made will be working with only two variables, that is, cultural or tenure groupings, and their effects upon yield. In the calculation to obtain the F-ratio, which is the value compared with the F-statistic, three basic equations are used. To find the needed values, first the total sum of squares must be found. The sum of squares between the groups needs to be found, as does the sum of squares within groups. To find these values more easily, the data have been arranged in tables (Appendix Tables I, II, and III).

In these tables, the indexed yields are represented by the $X_i$'s. The sum of the indexed observations are indicated by $\sum_{i=1}^{n} X_i$. This sum ($\sum_{i=1}^{n} X_i$) is shown for each column in the table. Also needed will be the sum of the sum of squared observations. These values are shown for each column and are indicated by $\sum_{i=1}^{n} X_i^2$.

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20/ Ostle, op. cit., pp. 240-241. See Appendix for formal model.

The computing formulas needed for analysis of variance are [21]

$$\text{Total Sum of Squares} = \sum_{i=1}^{n} \sum_{j=1}^{m} X_i^2 - \frac{\left(\sum_{i=1}^{n} \sum_{j=1}^{m} X_i\right)^2}{N}$$

$$\text{Sum of Squares Among Groups} = \sum \frac{\left(\sum_{i=1}^{n} X_i\right)^2}{n_i} - \frac{\left(\sum_{i=1}^{n} \sum_{j=1}^{m} X_i\right)^2}{N}$$

Sum of Squares Within Groups = Total sum of squares - sum of squares among groups.

Analysis of Variance by Thirds of the Population

There are 81 tracts used in this study, that meet the requirements of size and age of stand. This sample of 81 was then divided into three groups (low, medium and high) by level of indexed yield. Each group has 27 observations, or one-third of the tracts in the sample. The indexed yields in the low yield group range from 1.15 tons per acre to 2.67 tons per acre. The indexed yield in the medium yield group range from 2.70 tons per acre to 3.43 tons per acre. In the high yield group the indexed yields range from 3.49 tons per acre to 7.53 tons per acre. Within each indexed yield grouping, there are Indian operators, non-Indian renters and non-Indian owner-operators.

Before any other tests of variance are run, it was decided to see whether there are significant differences between the thirds of the sample. If there are no significant differences between the mean yields of the low,

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21/ Croxton and Cowden, *op. cit.*, pp. 706-711.

medium and high yield groups, there will be no significant differences between any further breakdown of the data.

The following (Table IV) is the analysis of the variance of the means of the indexed yield for the three yield level groups. The basic data used in these calculations are presented in Appendix Table I.

TABLE IV. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS BY THIRDS OF THE SAMPLE.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Among Groups | 2 | 93.94 | 46.97 | 1677.50 | 5% = 3.11<br>1% = 4.88 |
| Within Groups | 78 | 21.93 | 0.28 | | |
| Total | 80 | 115.87 | | | |

*From data presented in Appendix Table I.

Null hypothesis tested: There are no significant differences in the means of the low, medium and high indexed yield groups.

The F-ratio (1,677.50) exceeds the F-critical values at both the 5 percent level (3.11) and the 1 percent level (4.88), and we must reject the hypothesis. That is, we can say there are significant differences between the low, medium and high yield groups in this population. This is expected as the indexed yield groups were established by putting the low 27 indexed yields in the low yield group, the middle 27 indexed yields in the middle yield group, and the high 27 indexed yields in the high yield group.

The next test is to determine whether there are significant differences among mean yields of Indian operators in the three yield levels. That is, are the mean yields of the Indian operators in the low yield group significantly different from the mean yields of Indian operators in the medium and high yield groups, and are the medium yield group Indians significantly different from the low and high yield group Indians?

Table V is the analysis of the variance of the mean yields of the Indian operators in low, medium and high indexed yield groups. The basic data used in these calculations are presented in Appendix Table I.

TABLE V. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF INDIAN OPERATORS IN THE LOW, MEDIUM AND HIGH YIELD GROUPS.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Among Groups | 2 | 15.54 | 7.77 | 64.75 | 5% = 3.55<br>1% = 6.01 |
| Within Groups | 18 | 2.10 | 0.12 | | |
| Total | 20 | 17.64 | | | |

*From data presented in Appendix Table I.

Null hypothesis tested: There are no significant differences in the mean yields of Indian operators in the low, medium and high indexed yield groups.

The results, the F-ratio (64.75) is greater than the F-critical values at both the 5 percent level (3.55) and the 1 percent level (6.01), indicate that the null hypothesis must be rejected. This means that there are significant differences between mean yields of Indians in these three yield groups.

Are there significant differences among the mean yields of the non-Indian operators in the low, medium and high yield groups? Table VI is the analysis of variance making this test. The basic data for these calculations are presented in Appendix Table I.

TABLE VI. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF ALL NON-INDIAN OPERATORS IN THE LOW, MEDIUM AND HIGH YIELD GROUPS.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Among Groups | 2 | 61.31 | 30.66 | 65.23 | 5% = 3.17<br>1% = 5.01 |
| Within Groups | 57 | 27.05 | 0.47 | | |
| Total | 59 | 88.36 | | | |

*From data presented in Appendix Table I.

Null hypothesis tested: There are no significant differences in the mean yields of non-Indian operators in the low, medium and high indexed yield groups.

In this analysis of variance, the F-ratio (65.23) exceeds the F-critical values, at both the 5 percent level (3.17) and the 1 percent level (5.01), and the null hypothesis is rejected. This result indicates that there are significant results among the mean yields of non-Indian operators in the low, medium and high indexed yield groups.

These analysis of variance tests (Tables V and VI) deal with cultural groups. Next, the two tenure groups will be considered. The first group to be tested are the non-Indian renters. Once again the test is to determine whether there are significant differences among the mean yields of the non-Indian renters in the low, medium and high yield groups. Table VII is the analysis of variance making this test. The basic data used in these calculations are presented in Appendix Table I.

TABLE VII. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF NON-INDIAN RENTERS IN THE LOW, MEDIUM AND HIGH YIELD GROUPS.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Among Groups | 2 | 22.63 | 11.32 | 40.43 | 5% = 3.49<br>1% = 5.85 |
| Within Groups | 20 | 5.63 | 0.28 | | |
| Total | 22 | 28.26 | | | |

*From data presented in Appendix Table I.

Null hypothesis tested: There are no significant differences in the mean yields of non-Indian renters in the low, medium and high indexed yield groups.

In this test the F-ratio (40.43) is greater than the F-critical at both the 5 percent level (3.49) and the 1 percent level (5.85). This indicates that the null hypothesis must be rejected and that there are significant differences among the means of the non-Indian renters in the low, medium and high indexed yield groups.

The last test using the low, medium and high yield groups by one-third of total sample is to determine whether the means of non-Indian owner-operators in these yield groups are significantly different. This analysis of variance test is shown in Table VIII. The basic data used in these calculations are presented in Appendix Table I.

TABLE VIII. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF NON-INDIAN OWNER-OPERATORS IN THE LOW, MEDIUM AND HIGH YIELD GROUPS.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Among Groups | 2 | 40.89 | 20.45 | 30.07 | 5% = 3.28<br>1% = 5.29 |
| Within Groups | 34 | 23.27 | 0.68 | | |
| Total | 36 | 64.16 | | | |

*From data presented in Appendix Table I.

Null hypothesis tested: There are no significant differences in the mean yields of non-Indian owner-operators in the low, medium and high indexed yield group.

The tests show that the null hypothesis must be rejected as the F-ratio (30.07) is greater than the F-critical values at both levels used: 5 percent (3.28); 1 percent (5.29). Thus, there are significant differences among the mean yields of non-Indian owner-operators in the low, medium and high indexed yield groups.

The five analysis of variance tests above (Tables IV through VIII) show that there are significant differences among the low, medium and high thirds of the indexed yields of this sample.

## Analysis of Variance by Cultural and Tenure Groups

The question now arises as to the effect that an individual operator's cultural and tenure position may have on the level of managerial input he uses. It is interesting to note the number of Indians (11) in the low yield group (Tables IV and V). This is 53 percent of all the Indian operated tracts included in the sample. These 11 observations make up approximately 41 percent of all the observations in the low indexed yield group. There are 26 percent of the non-Indian renters and 27 percent of the non-Indian owner-operators in this group. These non-Indian renters, six observations in total, are 22 percent of the low group, and the non-Indian owner-operators, seven observations, are 37 percent of the group. Of the total observations in the sample, 25.9 percent (21) of them are Indian. This would indicate that the Indian managerial input is somewhat less than that of the non-Indian renters and owner-operators (Table IX, and Appendix Tables I and II).

Table IX gives the percentages of the cultural and tenure groups that fall into each yield classification (low, medium and high). It also gives the percentages of the yield classification that a particular cultural or tenure group makes up.

The medium yield group includes 50 percent of the non-Indian owner-operator observations, 22 percent of the non-Indian renters observations and 26 percent of the Indian operators (Table IX). In the low and medium indexed yield classifications there are 52 percent

TABLE IX. PERCENT OF A CULTURAL OR TENURE GROUP IN A YIELD LEVEL CLASSIFICATION AND PERCENT OF YIELD LEVEL CLASSIFICATION CONSISTING OF A CULTURAL OR TENURE GROUP.

| | Indian | All Non-Indian Operators | Non-Indian Renters | Non-Indian Owner-Operators |
|---|---|---|---|---|
| Percent of cultural or tenure group falling in low yield classification by thirds of total sample | 41 | 59 | 22 | 37 |
| Percent of cultural or tenure group falling in the medium yield classification by thirds of total sample | 26 | 74 | 22 | 52 |
| Percent of cultural or tenure group falling in the high yield classification by thirds of sample | 11 | 89 | 41 | 48 |
| Percent of low yield classification by thirds of total sample that a cultural or tenure group makes up | 53 | 27 | 26 | 27 |
| Percent of medium yield classification by thirds of total sample that a cultural or tenure group makes up | 33 | 33 | 26 | 38 |
| Percent of high yield classification by thirds of total sample that a cultural or tenure group makes up | 14 | 40 | 48 | 35 |
| Percent of total observations | 26 | 74 | 28 | 46 |

of the non-Indian renter observations, 86 percent of the Indian observations and 65 percent of the non-Indian owner-operator observations. If the managerial input of the three groups are the same, approximately one-third (33 percent) of the observations of the cultural and tenure groups should fall into each yield group.

Table IX indicates this is not the case. The indication is that the Indians use a lower management input than the non-Indian operators (86 percent of the Indian observations are in the low and medium yield groups compared to 60 percent of the non-Indian operators). The non-Indian renter appears to use higher levels of management input as 48 percent of their observations fall in the high yield group compared to 14 percent for the Indians and 35 percent of the non-Indian owner-operators.

Tests will be run on the observed tract's indexed yields in an attempt to determine whether there are significant differences (1) between the two cultural groups, the Indian and the non-Indian operators; and (2) between the tenure groups, the non-Indian renters and owner-operators. Also to be determined is whether there is a significant difference among the three general groups, Indians, non-Indian renters and non-Indian owner-operators. This gives a cross cultural-tenure position analysis of the sample.

The first two comparisons will be made using two different divisions of each group. The first division will be by thirds of the total population using the same yield data as were used in the analysis of the low, medium and high thirds of the sample.[22/]

The second division of the data is made by taking one-third of the cultural or tenure group being considered. The low third of the yields make up the low yield group. The middle third of the yields make up the medium yield group and the high third of the yields make up the high yield group. This division is set up so that comparisons between the high thirds, medium thirds and low thirds of the cultural and tenure groups may be made. There are no yield levels that must be attained in order to be placed in a yield level group. The yield level group that a tract is placed in is based upon its indexed yield attained in relation to the other tracts in the cultural or tenure group. In some cases a tract's yield level grouping may change as the cultural and tenure grouping changes. This occurs with the non-Indian operated tracts in the one-third of cultural or tenure group divisions. Appendix Table III shows this shifting. Looking at the low one-third of all non-Indian operators, the highest indexed yield is 2.89 tons. In looking at the non-Indian renters, the 2.89 yield figure is in the medium yield group. Also the highest two yields in the medium yield group of the non-Indian renters shifts to the high yield group when all non-Indian operators are considered. The reason for the shifting is that the three divisions of non-Indian operators are grouped in order (lowest indexed

22/ Low indexed yield from 1.15 T/A to 2.67 T/A
Medium indexed yield from 2.70 T/A to 3.43 T/A
High indexed yield from 3.49 T/A to 7.53 T/A

yield to highest indexed yields, and the low one-third of the indexed yields become the low yield group). The middle one-third of the indexed yields become the medium yield group. The high one-third of the indexed yields become the high yield group. In several instances the lowest or highest indexed yields of one grouping of the non-Indian operators will fall in a lower or higher yield classification when the grouping of the tracts are shifted (Appendix Table III).

The comparisons just mentioned will be run, first, by thirds of the population division, and then by thirds of the cultural or tenure group.

The first comparison to be made is to see whether there are significant differences between the mean indexed yields of the Indian operator tracts, the non-Indian renter tracts and the non-Indian owner-operator tracts (Table X). The data for these comparisons are presented in Appendix Table II.

TABLE X. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF INDIAN OPERATORS, NON-INDIAN RENTERS AND NON-INDIAN OPERATORS.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Among Groups | 2 | 9.48 | 4.74 | 3.49 | 5% = 3.11<br>1% = 4.88 |
| Within Groups | 78 | 106.39 | 1.36 | | |
| Total | 80 | 115.87 | | | |

*From data presented in Appendix Table II.

Null hypothesis tested: There are no significant differences between the mean indexed yields of the Indian, non-Indian renter and non-Indian owner-operator tracts.

The F-ratio (3.49) exceeds the F-critical at the 5 percent level (3.11) but is smaller than the F-critical at the 1 percent level (4.88). The results mean that the hypothesis must be rejected at the 5 percent level and accepted at the 1 percent level. This means that there are significant differences among the mean indexed yields of the Indian, non-Indian renter and non-Indian owner-operator tracts in this sample.

The problem now is to discover where these differences exist. When they are found between two groups, the groups involved will be divided by the methods outlined and further comparisons will be made.

The next test is to determine if there are significant differences between cultural groups, that is, differences between the Indian farmers and the non-Indian farmers, both renter and owner-operators. The data for this analysis of variance comes from Appendix Table II. The non-Indian renter and non-Indian owner-operator indexed yields have been combined. Table XI shows the calculation of the F-ratio to be used.

TABLE XI. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF THE INDIAN AND NON-INDIAN OPERATORS.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 9.74 | 9.87 | 7.37 | 5% = 3.11<br>1% = 4.88 |
| Within Groups | 79 | 106.13 | 1.34 | | |
| Total | 80 | 115.87 | | | |

*From data presented in Appendix Table II.

Null hypothesis tested: There are no significant differences between the mean yields of the two cultural groups, Indian and non-Indian operators, in the sample.

In this analysis the F-ratio (7.37) is greater than the F-critical values, 5 percent (3.11); 1 percent (4.88). Thus we reject the hypothesis that the non-Indian farmers and the Indian operators have the same mean indexed yield. This tells us that there are differences in managerial input between different cultural groups.

Does this difference between cultural groups show up when the low, medium and high indexed yield thirds are compared? Table XII is the analysis of variance testing the means of the low yield Indian tracts and the low yield non-Indian tracts of alfalfa land. The data used in these calculations are presented in Appendix Table II.

TABLE XII. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF THE INDIAN AND NON-INDIAN OPERATORS IN THE LOW (BY THIRD OF SAMPLE) GROUP.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 0.32 | 0.32 | 2.29 | 5% = 4.21<br>1% = 7.68 |
| Within Groups | 25 | 3.59 | 0.14 | | |
| Total | 26 | 3.91 | | | |

*From data presented in Appendix Table II.

Null hypothesis tested: There are no significant differences between the mean yields of low indexed yields of the two cultural groups, Indians and non-Indian operators, in the sample.

In this test the F-critical values, 4.21 at 5 percent and 7.68 at 1 percent, exceed the F-ratio (2.29) and the null hypothesis is accepted.

Table XIII is the analysis of variance calculations comparing the means of the medium indexed yield Indian and non-Indian operators. The data used in this test are presented in Appendix Table II.

The F-ratio (0.75) is less than the F-critical at both the 5 percent level (4.21) and at the 1 percent level (7.68). Thus the null hypothesis is accepted. That is, there are no significant differences in the mean yields of the Indian and non-Indian operators in the medium yield group.

TABLE XIII. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF THE INDIAN AND NON-INDIAN OPERATORS IN THE MEDIUM (BY THIRD OF SAMPLE) GROUP.*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 0.03 | 0.03 | 0.75 | 5% = 4.21<br>1% = 7.68 |
| Within Groups | 25 | 0.90 | 0.04 | | |
| Total | 26 | 0.93 | | | |

*From data presented in Appendix Table II.

Null hypothesis tested: There are no significant differences in the mean yields of the Indian and non-Indian operators in the medium yield group.

The analysis of variance calculation for comparing the mean yields of the Indian and non-Indian operators in the high yield group are shown in Table XIV. The data for these calculations are presented in Appendix Table II.

TABLE XIV. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF THE INDIAN AND NON INDIAN OPERATORS IN THE HIGH (BY THIRD OF SAMPLE) GROUP*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 0.56 | 0.56 | 0.57 | 5% = 4.21<br>1% = 7.68 |
| Within Groups | 25 | 24.60 | 0.98 | | |
| Total | 26 | 25.16 | | | |

*From data presented in Appendix Table II.

Null hypothesis tested: There are no significant differences between the mean yields of the Indian and non-Indian operators in the high yield group.

The null hypothesis is accepted in the test as the F-ratio (0.57) is less than the F-critical values which were 4.21 at the 5 percent level and 7.68 at the 1 percent level.

In the preceeding analysis of variance tests (Tables XI through XIV), as explained before, the data have been divided by third of sample. This means that the number of observations of a particular cultural or tenure group that fall into a yield level group is determined by the general level of management of the group. If this is the criterion used (a tract must have a specified indexed yield level to be placed in a certain group), then the results of the tests in Tables XI through XIV are to be expected. There should be no significant difference in the mean yields of the different cultural and tenure groups in the low, medium or high yield classifications with this division of the data.

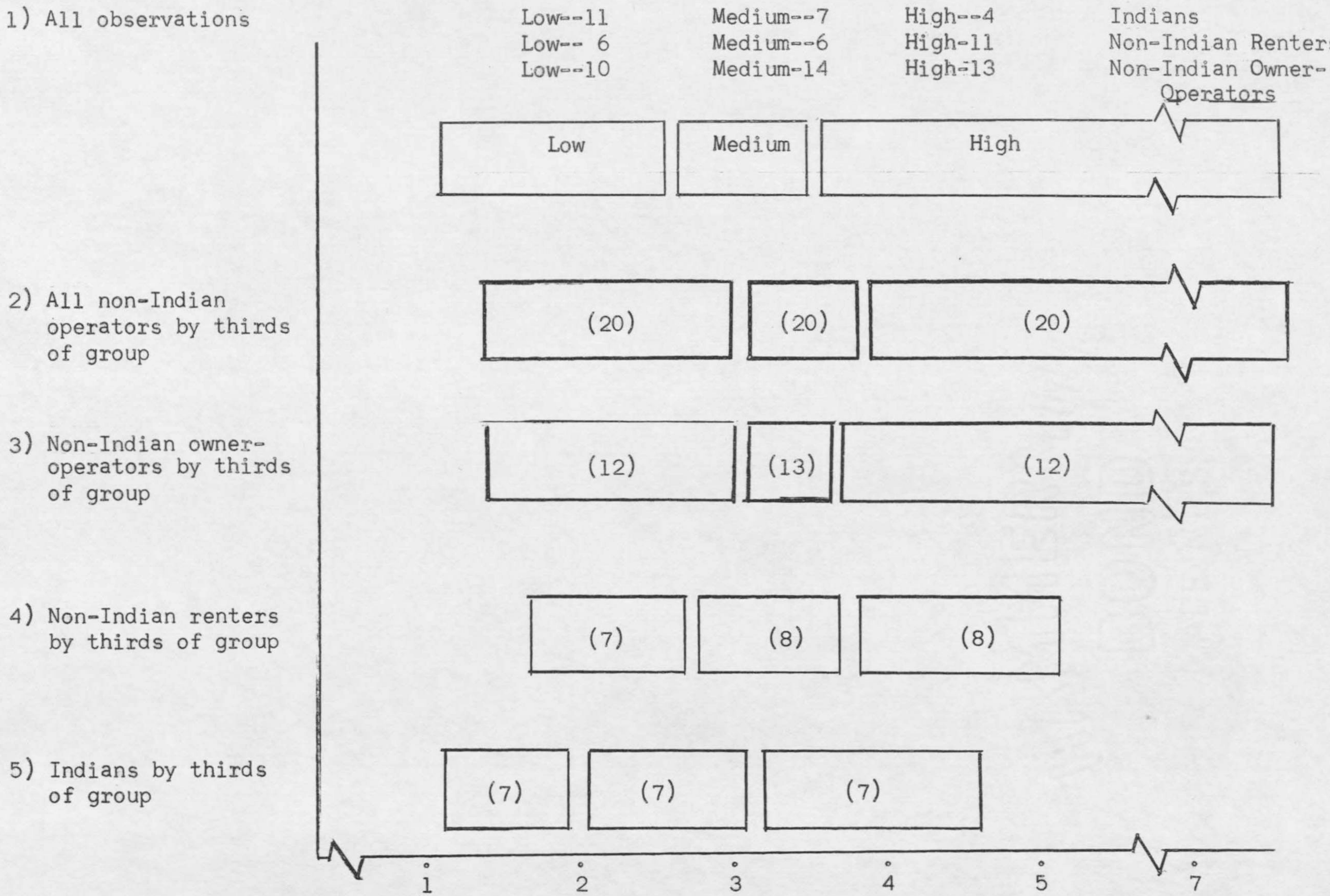


Figure 1. Number of Observations in Yield Groups (Low, Medium and High) for the Two Methods of Dividing the Sample.

If a comparison of the lowest one-third of the Indian and non-Indian operators is to be made, it would seem more logical to use the low one-third of the indexed yields of each group, not the Indian and non-Indian observations falling in the low one-third of sample indexed yields.

Figure 1 shows the division of the data into low, medium and high indexed yield groups by (1) one-third of sample, and (2) one-third of cultural or tenure group. In looking at all the non-Indian operators by one-third of the group, and the Indians by one-third of the group in Figure 1, it is evident that the Indians, as a whole, use a lower level of management input than the non-Indian operators. Table V also pointed this out.

Tests will now be made comparing the means of the indexed yields of the low, medium and high one-third of the Indian operated tracts and the non-Indian operated tracts. Table XV shows the analysis of variance tests comparing the low one-third of the Indian operators and the low one-third of the non-Indian operators. The data used in these calculations are presented in Appendix Table III.

In this analysis the F-ratio (10.12) is greater than the F-critical values, 5 percent level (4.24); 1 percent level (7.77). Thus we reject the null hypotheses. This means there are significant differences between the Indian and non-Indian operators when the low one-thirds of each group are compared.

TABLE XV. ANALYSIS OF VARIANCE OF THE MEANS OF THE LOW ONE-THIRD OF THE INDEXED YIELDS OF THE INDIAN AND NON-INDIAN OPERATORS*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 1.72 | 1.72 | 10.12 | 5% = 4.24<br>1% = 7.77 |
| Within Groups | 25 | 4.35 | 0.17 | | |
| Total | 26 | 6.07 | | | |

*From data presented in Appendix Table III.

Null hypothesis tested: There is no significant difference in the means of the low one-third of the indexed yields of the Indian and non-Indian operators.

The next test made is the analysis of variance of the means of the medium one-third of Indian and non-Indian operators. Table XVI shows these calculations. The data used in these calculations are presented in Appendix Table III.

TABLE XVI. ANALYSIS OF VARIANCE OF THE MEANS OF THE MEDIUM ONE-THIRD OF THE INDEXED YIELDS OF THE INDIAN AND NON-INDIAN OPERATORS*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 2.67 | 2.67 | 29.67 | 5% = 4.24<br>1% = 7.77 |
| Within Groups | 25 | 2.20 | 0.09 | | |
| Total | 26 | 4.87 | | | |

*From data presented in Appendix Table III.

Null hypothesis tested: There is no significant difference in the means of the medium one-third of the indexed yields of the Indian and non-Indian operators.

The F-ratio (29.67) is greater than the F-critical at both the 5 percent level (4.24) and the 1 percent level (7.77). Thus the null hypothesis is rejected, indicating significant differences between the two groups compared.

The last analysis of variance test using the cultural group division will be made comparing the means of the indexed yields of the high one-third of the Indian and non-Indian operators. The calculations for this test are shown in Table XVII. The data used in these calculations are presented in Appendix Table III.

TABLE XVII. ANALYSIS OF VARIANCE OF THE MEANS OF THE HIGH ONE-THIRD OF THE INDEXED YIELDS OF THE INDIAN AND NON-INDIAN OPERATORS*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 6.23 | 6.23 | 7.33 | 5% = 4.24<br>1% = 7.77 |
| Within Groups | 25 | 21.16 | 0.85 | | |
| Total | 26 | 27.39 | | | |

*From data presented in Appendix Table III.

Null hypothesis tested: There are no significant differences in the means of the high one-third of the indexed yields of the Indian and non-Indian operators.

The tests show that at the 5 percent level the null hypothesis is rejected as the F-critical (4.24) is less than the F-ratio (7.33). At the 1 percent level, the null hypothesis is accepted, as the F-critical (7.77) is greater than the F-ratio.

In all three cases the null hypotheses must be rejected at the 5 percent level. That is, there are significant differences between the mean indexed yields of the Indian and non-Indian operators at all three yield levels. This indicates that the poorest third of the Indian operators have a management input less than the poorest third of the non-Indian operators. The middle third of the Indians have lower management input than the middle third of the non-Indian operators. The same relationship holds for the high third of the groups.

This result indicates that, as a group, the Indians are poorer managers than the non-Indian operators. We can say that, in a general budget analysis such as the Bureau of Indian Affairs might run, the Indians should be budgeted with an assumed lower level of management and therefore lower yields than the non-Indian.

The next analysis of variance tests to be made use comparisons between tenure groups. These tests are made to determine if an operator's tenure position has any effect on the management input used by the operator. For this test non-Indian renter operated and non-Indian owner-operated tracts are used. The first test to be made compares the mean yields of all yield levels of non-Indian renters and non-Indian owner-operators in the sample. Table XVIII shows this analysis of variance calculation needed in this comparison of the means of those groups. The data used in these calculations are presented in Appendix Table II.

TABLE XVIII. ANALYSIS OF VARIANCE OF THE MEANS OF THE INDEXED YIELDS OF THE NON-INDIAN RENTERS AND THE NON-INDIAN OWNER OPERATORS*

| Source of Variance | Degrees of Freedom | Sum of Squares | Mean Square | F-Ratio | F-Critical |
|---|---|---|---|---|---|
| Between Groups | 1 | 0.18 | 0.18 | 0.12 | 5% = 4.00<br>1% = 7.08 |
| Within Groups | 58 | 88.18 | 1.52 | | |
| Total | 59 | 88.36 | | | |

*From data presented in Appendix Table II.

Null hypothesis tested: There are no significant differences in the means of the indexed yields of the non-Indian renters and the non-Indian owner-operators.

Here we must accept the hypothesis that there are no differences in the mean yields between non-Indian renters and non-Indian owner-operators. This tells us that the tenure position of the operator has little effect on the management input of the production process. Since there are no significant differences between the means of the indexed yields of all the non-Indian renters and all the non-Indian owner-operators, there will be no significant differences between further division of the groups.

The results of the tests show that there are significant differences between the two cultural groups. Observations show that the Indian uses lower management input than the non-Indian operator. There are significant differences between the low, medium and high thirds of the Indians and non-Indian operators, but when taken as thirds of the population, there are no significant differences between the low, medium and high Indians and non-Indians.

The tenure position of the operators seems to make no difference on the management input of the operator. The tests accept the hypotheses that there are no significant differences between the mean yields of the non-Indian renters and the non-Indian owner-operators.

# PART IV

# SUMMARY AND CONCLUSIONS

## Summary

In a farm budget analysis, it is necessary to use some level of yield for the crops considered in making estimates of future production and farm income. The question arises, what yield levels should be used in the budget and is this yield level attainable with the managerial ability present? This study is an attempt to measure the management input, or managerial ability, of an operator, in quantative terms, by using alfalfa hay yields.

The area used in this study is the Jocko Valley Division of the Flathead Indian Reservation Irrigation Project. This irrigation division was used for several reasons: availability of soil survey, large number of Indian operators, high percentage of crop land in alfalfa hay and irrigated tracts in a relatively small area.

To use alfalfa hay yield as a measure of management, the influence of all factors that are not directly attributable to management are netted out of the yield. This is accomplished by restraints placed on age of alfalfa stand and total irrigated acres farmed, by samples obtained from small areas to remove climatic influences and by the use of the Storie Soil Index to remove soil variation. The yield, after these restraints and operations are used, indicate the level of management input used on a particular tract in this study.

Using the indexed yields, statistical tests are made to determine if this method reveals significant differences in the management input among different groups of operators as well as within the group of operators. The sample is divided into two cultural groups, Indian and non-Indian, and two tenure groups, renter and owner-operator, for these tests.

The first series of tests were to determine whether there are significant differences between low, medium and high thirds of the tracts in the sample. This was done both within and between groups. In all cases significant differences were found.

The second series of tests were to determine whether there are signigicant differences between the cultural groups at the low, medium and high indexed yield levels by thirds of total sample. Here no significant differences were found.

The third series of tests were to determine whether there are significant differences between the cultural groups at the low, medium and high indexed yield levels by thirds of the cultural group. In this series there were found significant differences in all comparisons.

The last series of tests were to determine if there are significant differences between the two tenure groups. The first test shows no significant differences between these two groups and no further division of the group was necessary.

## Conclusions

The results of the statistical tests show that the method developed to determine an operator's comparative level of management input, does, in fact, reveal significant differences within, as well as between, the groups studied. The Indian operators show a lower management input than do the non-Indian operators. The comparison of Indian and non-Indian operators at the low, medium and high indexed yield levels show this to be true.

The comparisons between low, medium and high level of yields by thirds of groups show that a division of this nature can be made and the general level of management of operators be compared in this manner.

The question may be asked as how such a general method of measuring management input may be of any use in a farm budget analysis? This method can be very valuable in this work. The individual farm operator may have the level of his management input determined in this manner. This indexed yield can then be compared with a schedule of indexed yields which represent different levels of management in his area. This schedule should include indexed yield for the different crops grown in an area and the indexed yields can then be used as guides for budgeting different crops. In this way, the method developed can be used in the budget analysis. The yields used will truly represent the management input present and will be attainable.

## PART V

## RECOMMENDATIONS

The method of measuring differences in managerial ability as developed in this study does reveal significant differences in levels of management among farm operators. It provides a rough guide for estimating the level of yields attainable for a farm budget with management given but unspecified as to level.

It is felt that this method can give a much better indicator of managerial ability by considering several additional factors that can be expected to influence the result of an operator's managerial ability. These factors should be obtained by interviewing the farm operators that were included in this study and will aid in determing the <u>why</u> of their yield results.

One important factor that should be studied carefully is the capital position of the operator. This should be considered to determine whether a lack of capital might be part of the cause of lower yield levels.

A shortage of capital may express itself in the amount of land the operator has under his control. He may have too little (or too much) land in relation to his other farm resources, and thereby obtain lower yields as a result.

The operator's capital position may also affect his ability to adopt new technology. If he has too little capital available, the operator may not be able to acquire new machines or other new technological developments in farming, even though he would like to do so and has the ability to handle them.

Further, the capital position of the operator may be influential through the amount and availability of hired labor on the farm. This could be noted especially in the timeliness and adequacy of irrigations, the harvesting of the crop at the proper time, and its removal and storage.

Another area that might be considered (to make the method more specific with regard to causal factors) is the operator's need for and use of the crop selected as the indicator of the level of management. In this study, alfalfa yields were used as that indicator. However, one operator may strive for high alfalfa yields simply because his land and number of livestock force him to pay an extra amount of attention to that crop. On the other hand, a neighbor may have few livestock and little use for roughage other than as a green manure crop in the rotation. Such variations in the need for and use of the crop taken as the indicator of management should be accounted for in the application of the method.

Yields may be influenced to some degree by the goals of the farm operator and his family, by his age and nearness to retirement. These may all act to affect his willingness to "accept" yields that are lower than he is capable of producing with the resources he has available.

Additionally, there are many other factors related to (and possibly stemming from) those enumerated above. Specific identification and study should include such management practices as type and timeliness of field operations, rotations established, fertilizations (both kinds of fertilizers used and their quantities), irrigation water use, quantity and quality of seed, frequency of re-establishing stand, and harvesting methods.

If these factors influencing yields are incorporated into the method, a more accurate and usable measure of management ability and its total influence on yields can be obtained. The yield projections used in farm budgets will thus be more meaningful, since the budgeted yield levels can be tied to specific management practices.

# APPENDIX

# APPENDIX A

## Model for Analysis of Variance*

1. The observations $Y_{ij}$ are (observed values of) random variables distributed about true means (expected values),

   $\xi_i (i=1, \cdots, r)$ , which are fixed constants.

2. The parameters $E_i$ may be expressed as $\xi_i = \mu + a_i$ where

$$\mu = \frac{\sum_{i=1}^{r} \xi_i}{r}$$

$$a = \xi_i - \mu$$

Hence we see that

$$\sum_{i=1}^{r} a_i = 0$$

3. The random variables $Y_{ij}$ have a common variance $\sigma^2$

4. The $Y_{ij}$ are independently distributed in a multivariate normal distribution.

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*Ostle, op. cit., p. 240

APPENDIX B

APPENDIX TABLE I. INDEX YIELD DATA BY INDEXED YIELD LEVELS BASED ON THIRDS OF TOTAL SAMPLE.

| | Low Yield | | | Medium Yield | | | High Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | a/ I | b/ nIr | c/ nIoo | a/ I | b/ nIr | c/ nIoo | a/ I | b/ nIr | c/ nIoo |
| | 1.15 | 1.73 | 1.22 | 2.97 | 2.70 | 2.78 | 3.57 | 3.60 | 3.49 |
| | 1.64 | 2.04 | 1.65 | 3.00 | 2.89 | 2.89 | 4.21 | 3.87 | 3.57 |
| | 1.64 | 2.06 | 1.70 | 3.05 | 2.91 | 2.99 | 4.59 | 3.88 | 3.63 |
| | 1.64 | 2.25 | 1.84 | 3.09 | 3.21 | 3.02 | | 4.00 | 3.72 |
| | 1.72 | 2.27 | 1.86 | 3.24 | 3.27 | 3.07 | | 4.15 | 3.79 |
| | 1.73 | 2.34 | 2.22 | 3.36 | 3.31 | 3.07 | | 4.32 | 4.04 |
| | 1.98 | | 2.39 | 3.43 | | 3.08 | | 4.75 | 4.15 |
| | 1.99 | | 2.41 | | | 3.15 | | 4.76 | 4.21 |
| | 1.99 | | 2.50 | | | 3.25 | | 4.76 | 4.48 |
| | 2.15 | | 2.67 | | | 3.25 | | 4.81 | 5.78 |
| | 2.61 | | | | | 3.28 | | 5.19 | 5.98 |
| | | | | | | 3.28 | | | 6.56 |
| | | | | | | 3.33 | | | 7.53 |
| | | | | | | 3.33 | | | |
| $\sum X_i$ | 20.24 | 12.69 | 20.46 | 22.14 | 18.29 | 43.77 | 12.37 | 48.09 | 60.93 |
| $\sum X_i^2$ | 38.62 | 27.09 | 43.77 | 70.22 | 56.06 | 137.22 | 51.54 | 212.83 | 306.55 |
| $\sum\sum X_i$ | 53.39 | | | 84.20 | | | 121.39 | | |
| $\sum\sum X_i^2$ | 109.48 | | | 263.50 | | | 570.92 | | |
| $\sum\sum\sum X_i$ | 258.98 | | | | | | | | |
| $\sum\sum\sum X_i^2$ | 943.90 | | | | | | | | |

a/ I - Indian
b/ nIr - Non-Indian Renter
c/ nIoo - Non-Indian Owner-Operator

APPENDIX TABLE II: INDEXED YIELD DATA BY CULTURAL AND TENURE GROUPS BASED ON THIRDS OF TOTAL SAMPLE.

| | Indian | | | Non-Indian Renters | | | Non-Indian Owner-Operator | | |
|---|---|---|---|---|---|---|---|---|---|
| | Low | Medium | High | Low | Medium | High | Low | Medium | High |
| | 1.15 | 2.97 | 3.57 | 1.73 | 2.70 | 3.60 | 1.22 | 2.78 | 3.49 |
| | 1.64 | 3.00 | 4.21 | 2.04 | 2.89 | 3.87 | 1.65 | 2.89 | 3.57 |
| | 1.64 | 3.05 | 4.59 | 2.06 | 2.91 | 3.88 | 1.70 | 2.99 | 3.63 |
| | 1.64 | 3.09 | | 2.25 | 3.21 | 4.00 | 1.84 | 3.02 | 3.72 |
| | 1.72 | 3.24 | | 2.27 | 3.27 | 4.15 | 1.86 | 3.07 | 3.79 |
| | 1.73 | 3.36 | | 2.34 | 3.31 | 4.32 | 2.22 | 3.07 | 4.04 |
| | 1.98 | 3.43 | | | | 4.75 | 2.39 | 3.08 | 4.15 |
| | 1.99 | | | | | 4.76 | 2.41 | 3.15 | 4.21 |
| | 1.99 | | | | | 4.76 | 2.50 | 3.25 | 4.48 |
| | 2.15 | | | | | 4.81 | 2.67 | 3.25 | 5.78 |
| | 2.61 | | | | | 5.19 | | 3.28 | 5.98 |
| | | | | | | | | 3.28 | 6.56 |
| | | | | | | | | 3.33 | 7.53 |
| | | | | | | | | 3.33 | |
| $\sum X_i$ | 20.24 | 22.14 | 12.37 | 12.69 | 18.29 | 48.09 | 20.46 | 43.77 | 60.93 |
| $\sum X_i^2$ | 38.62 | 70.22 | 51.54 | 27.09 | 56.06 | 212.83 | 43.77 | 137.22 | 306.55 |
| $\sum\sum X_i$ | 54.75 | | | 79.07 | | | 125.16 | | |
| $\sum\sum X_i^2$ | 160.38 | | | 295.98 | | | 487.54 | | |
| $\sum\sum\sum X_i$ | 258.98 | | | | | | | | |
| $\sum\sum\sum X_i^2$ | 943.90 | | | | | | | | |