AGL:SF/KOR 9
Technical Report 1

SOIL FERTILITY SURVEY

REPUBLIC OF KOREA

RESULTS OF FERTILIZER TRIALS

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION
OF THE UNITED NATIONS ROME, 1972

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Report prepared for
the Government of the Republic of Korea
by
the Food and Agriculture Organization of the United Nations
acting as executing agency for
the United Nations Development Programme

UNITED NATIONS DEVELOPMENT PROGRAMME
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1972

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ABSTRACT

Fertilizer trials formed an important part of a project undertaken by the Government of the Republic of Korea with assistance from the United Nations Development Programme (Special Fund sector) and the Food and Agriculture Organization of the United Nations. The general purpose of the project was to make a soil fertility survey.

From 1963 to 1970 thousands of fertilizer trials were conducted in farmers' fields on all important crops. Some 4 876 trials were conducted mainly on paddy but also on rainfed rice. Other crops such as barley, wheat, maize, potato and forage crops had a total of 1 157 trials conducted on them.

From the considerable amount of data and information that have been collected, a number of important contributions have been made to fertilizer studies in Korea. The original fertility level of the soil, both through soil analysis data and yields of unfertilized plots, has been assessed. The soils have also been classified according to their fertility and productivity and those soils where crop production is limited by factors other than scarcity of nutrients or water have been isolated and recognized. Investigations have also been made on methods of improving problem soils, and generally recommended fertilizer levels have been formulated for the maximum and most economic yield per crop and province.

Through the valuable experience gained and the substantial experimental evidence that has been collected, the profitability of complete balanced fertilization has been clearly indicated. The need for better water management, and for the introduction of high yielding varieties is also clear. The improvement of problem soils has been shown as a viable proposition.

The magnitude of the scope of various crops, so far practically neglected, has been shown to have future relevance for the agriculture of the country. The feasibility of increasing the country's agricultural production by double cropping paddies at present under monoculture has also been made evident.

The Food and Agriculture Organization is greatly indebted to the following organizations which assisted in the implementation of the project by providing information, advice and facilities:

Ministry of Agriculture and Forestry,

Economic Planning Board,

Office of Rural Development,

Suwon Agricultural College,

Agency for International Development.

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GLOSSARY

Administrative Divisions	English Equivalents
Do	Province
Gun	District
Myon	Country, group of townships
Ri	Village, township

Land Measurements

Chung Bo (or Chungbo)	–	area equivalent to 9 917.36 square metres(m^2) or 0.99 hectare (ha)
Tan Bo (or Tanbo)	–	area equivalent to 991.736 m^2 (approx. 0.1 ha)
Pyong	–	area equivalent to 3.3 m^2

1 US$ = 310 Won (W)

Rice Plant Diseases

Akiochi or "autumn decline": slackening growth of previously vigorous plants, characterized by quick death of lower leaves. It is provoked by hydrogen sulphide toxicity to rice plant roots.

Akagare: yellowish, reddish-brown spots on older leaves of rice plants occurring in degraded impoverished soils.

LIST OF ABBREVIATIONS

1. Organization:

MAF	-	Ministry of Agriculture and Forestry, Republic of Korea
NACF	-	National Agricultural and Cooperative Federation
ORD	-	Office of Rural Development

2. Soil and Land Use:

Fertilizers:

Nutrients:	N	-	Nitrogen, N
	P	-	Phosphate, P_2O_5
	K	-	Potash, K_2O
	Si	-	Silica

3. Other:

Mg	-	Magnesium
Mn	-	Manganese
C.E.C.	-	Cation Exchange Capacity
C.D.	-	Critical Difference
C.V.	-	Coefficient of Variance
ha	-	Hectare
kg	-	Kilogramme
No	-	Number of Fertilizer Replications
R	-	Response
S.E.	-	Standard Error of Difference
V/C	-	Value Cost Ratio
Y	-	Yield

PRICES OF COMMODITIES

(end 1969)

	Won/kg	US$ cents/kg
Nitrogen	59.22	17.4
Phosphorus	41.96	12.3
Potash	18.67	5.5
Rice (paddy)	47.68	14.0
Upland rice	29.32	8.6
Barley	29.32	8.6
Wheat	51.57	15.2
Rape	50.50	14.9
Soyabean	35.93	10.6
Italian millet	20.00	8.2
Maize	47.68	14.0
White potato	14.51	4.3
Sweet potato	12.00	3.8

Note: through the report fertilizer levels are given in kg/ha and are expressed in the following way: 100-80-60 (100 kg/ha of nitrogen, 80 kg/ha of phosphorus and 60 kg/ha of potash). Yields and responses are given in ton/ha, unless stated otherwise.

Chapter 1

AGRICULTURE IN KOREA

1.1 INTRODUCTION

Agricultural production in the Republic of Korea has been inadequate to meet the increasing requirements of the country, and the yearly import of food grain recently exceeded 1 million tons. To overcome this problem the Government is endeavouring to achieve self-sufficiency in food by raising yields and opening new areas to agriculture. Until the late fifties, however, no organized programme of agricultural development existed, nor was information on land productivity and capability available, although a considerable amount of research work was being done.

The promising results of fertilizer trials conducted in farmers' fields during 1961 and 1962 made it clear to the Government that the assessment of fertilizer status of the soils of the country and the improvement of methods for increasing crop yields were feasible through expansion on a countrywide scale of these kinds of trial. In 1963, therefore, the Government, with assistance from the United Nations Development Programme (Special Fund Sector) 1/ and the Food and Agriculture Organization of the United Nations, began a soil fertility survey of the country. This internationally assisted project fitted into the active government programme for the development of agriculture, which included other UNDP projects, multilateral and bilateral projects and national schemes.

The main objectives of the Soil Fertility Project were the establishment of a soil fertility survey and the implementation of a soil testing and fertilizer use programme to increase crop yields. It also included investigation and promotion of improved agricultural practices, proper use of insecticides and pesticides, water control measures and the training of counterpart personnel.

A large number of fertilizer trials were performed to assess the fertility status of soils and the attainable yields, and formulate recommendations and these trials are covered in this report. Field experiments were carried out over several years to compensate for the periodic fluctuations of crop productivity and yearly variation in weather conditions. Trials were also conducted in laboratories when more detailed and accurate information was required to answer specific problems: the results of these special investigations are presented and discussed elsewhere 2/.

1/ The United Nations Special Fund and the Expanded Programme of Technical Assistance were merged to form the United Nations Development Programme on 1 January 1966.

2/ See Technical Report 2.

1.2 FARMING

The peninsula of Korea is mountainous and not well suited to agriculture which is mainly confined to the western coastal region, where the extensive lowlands along the lower courses and estuaries of the main rivers are found. Not far from the western coast, as around the river basins, there are rather extensive areas of elevated rolling land.

Both temperate and subtropical climates occur in Korea, diversified by summer breezes from the Pacific and cold winter blizzards from Siberia.

According to 1966 data, only 23 percent of the total land of Korea is cultivated, and of this over 50 percent is under paddy. The remainder is under upland crops. Cold weather in the north shortens the growing season and most of the paddy is single cropped, while in the southern and central regions which have a more favourable climate, more and more paddies are being double cropped. About 62 percent of paddies are adequately irrigated in the remaining area. To obviate to some extent the water shortage which may be critical in dry years, storage of water in bounded fields is a common practice. Upland crops are rainfed and yields vary with precipitation.

Farm householdings number 2.6 million, more than 50 percent of the total 5.1 million. Human labour application is excessive and out of proportion to the output. Investment on animal power and farm machinery is low. Excessive demographic pressure leads to land fragmentation which hinders improvement, lowers productivity and economic return. The only possible way to increase output is to intensify fertilization, plant protection, irrigation and multiple cropping.

About 80 percent of farm households are rice farms. About two thirds of the produce is consumed by the farmer and his family. The rest is sold and accounts for more than half of the farmer's annual income. Areas and percentage of land under various crops are shown in Table 1. The increase in arable and cultivated land and in the percentage of double cropping in the period 1961-67 is shown in Table 2.

1.3 IRRIGATION

Adequate and reliable water supply is a prerequisite for stable efficient agriculture production as paddy is the predominant type of farming. As already mentioned, at the end of 1967, only 62 percent of paddy land, which covers 52 percent of the total arable land was efficiently irrigated. Small and large reservoirs providing more than 70 percent of water for all irrigation, are the most important sources.

Shortage of irrigation water is one of the most serious barriers to the further agricultural development of the country. Several irrigation projects, to utilize underground water, to construct breakwaters and small dams along major and minor river estuaries, and the drainage of some coastal areas and river basins are being carried out. Table 3 shows the targets in hectares (ha) of the Four Year Water Resources Development Plan.

1.4 LAND IMPROVEMENT

Negative physiochemical soil characteristics, widespread over sizeable portions of arable land, are seriously limiting the agricultural production of Korea. There are large areas of acid soils where acidity has been created or further increased by prolonged application of heavy rates of ammonium sulphate, which only a large-scale liming programme over several years may be able to improve. Other areas have been turned almost unproductive by excessive irrigation, lack of drainage and continuous rice farming. The configuration of the land is also an obstacle, but recently some 400 000 ha of slope land located in the catchment areas of the ten large rivers have been identified as convertible into farmland.

Chapter 2

IMPLEMENTATION OF FERTILIZER RATES TRIALS

2.1 SELECTION OF EXPERIMENTAL SITES, SOIL SAMPLING AND ANALYSIS

Provinces were grouped into climatologically homogeneous areas, two to seven per province. Random selection of group, of villages within each group and of farmer fields in which experiments were to be conducted, was made each year. In each site only one replicate, or trial, was laid out.

Soil samples were collected from all experimental fields and analysed at the Central Laboratory at Sowon. However, once the nine provincial soil laboratories were established, routine analyses were performed there and only soil samples from special research experimental sites were analysed at the Central Laboratory. In this way, much time was saved and the results were easily accessible to extension staff and farmers as the laboratories were located in the buildings of the Office of Rural Development (ORD) provincial branches.

2.2 OBJECTIVES OF THE INVESTIGATION

The investigation took the form of fertilizer trials whose design varied according to the information sought. Response of various crops, and within each crop of different varieties, to increasing rates of fertilizers was studied. The best mode of fertilizer application and the best time, in the form of split application of nitrogen (N) only, or N and potash (K) at various stages of plant growth was decided. Application of amendments, such as lime or silicate, and minor nutrients, to various upland crops and paddy within a variety of environmental conditions, was also of concern. Moreover, the interaction between two or more of these factors and the use of improved agricultural practices such as plant population, time of sowing or transplanting, depth of ploughing, plant protection measures and adequate water control were also studied.

2.3 WORK PROGRAMME

Before each cropping season, the entire work plan was prepared at the project headquarters in cooperation with counterpart staff. Background and purpose of the trials were discussed in detail, and the number and type of trials agreed upon.

Report cards were prepared and distributed to all field staff to record the layout of treatments and blocks of the experimental field, the data on crop, variety, soil type, sowing and harvesting dates etc. Detailed information on plant growth, occurrence of pests and diseases, pH values and soil analysis data were recorded in a corresponding agronomic record card.

2.4 EXPERIMENTAL DESIGNS

During winter 1963/64 the few experiments conducted had a 3^3 factorial design 1/. The 27 plots were divided into three blocks each of nine plots plus control due to the fact that each block was laid out in a different site. In subsequent winters only two blocks of six treatments plus control each were laid out. During the first summer, 1964, a three blocks design with eight treatments per block was used on rice to determine the response curves for N, phosphate (P) and K. This design, however, was found unsuitable for local conditions and not flexible enough for the various kinds of information required. Consequently since summer 1965 all trials on rice had the complete 3^3 factorial design, replicated once per experimental site. Such design was found very effective in supplying full information. In spite of its complexity the losses due to incorrect execution were insignificant.

2.5 RANGE OF CROPS

Besides rice, which being the most important crop in the country received most attention, experiments were conducted on many other crops. Among the cereals, wheat has recently begun to gain importance, replacing barley in some areas. Barley is grown in upland areas mainly under rainfed conditions and exposed to winter blizzards, spring pest and disease attacks and summer droughts. Response to fertilizer and to improved water and farm management practices was therefore much more noticeable than on rice, which is grown under highly developed management.

Millet and potato received some attention as they are very important cash crops. Experiments were also carried out on maize, soyabean, sweet potato and fodder crops.

2.6 REPORTING, PROCESSING AND ANALYSIS OF EXPERIMENTAL RESULTS

The report cards, once completed with all relevant data, were forwarded to the statistic division of the project for elaboration and processing. Findings have been stratified first according to province, group, district and village. Afterwards, when soil analysis data became available, they were also stratified according to soil type and characteristics.

The data were analysed with the standard method and summarized in tables showing the mean value of response with their standard errors.

Response curves and surfaces have been calculated for all types of experiments including the 3^3 factorial design. It has been found that the estimates of optimum fertilizer rates obtained from a quadratic response surface fitted to the experimental results of a 3^3 design were realistic.

2.7 ECONOMIC ANALYSIS

The profitability of fertilizer use depends mainly on the increase in yield and/or in quality, the crops'price, the cost of the fertilizers, the additional

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1/ Three treatments each at three levels.

expenditure for their application, harvesting and marketing a larger crop, the value of the straw and the value of the residual effect of the fertilizers applied. The net profit has been calculated by multiplying the increase in yield, or the difference between the yields of treated and untreated plots, for the crop's price. It is in fact considered that the other factors may off-set each other, in the assumption that the peasant farmer used approximately the same amount of labour. In Korea, where alternative employment for farm human labour is practically unavailable and where 50 percent of the agriculture is at subsistance level, this assumption does not seem unrealistic. The findings of the economic analysis have been included in the tables of experimental results. Market prices of both crops and fertilizers have been used to calculate the value of the yield increases, the cost of treatments and the resulting value cost (V/C) ratios. In the absence of response curves or surfaces, the optimum fertilizer levels will be indicated by the highest V/C ratio and the corresponding high profit. In fact, while yields and gross profits tend to rise, though at a slowing pace, until a certain point, the V/C ratios tend to decrease.

The V/C ratio may also be used as an indication of the profitability of one crop versus another one.

Chapter 3

RESULTS OF FERTILIZER RATES TRIALS 1/

3.1 PADDY

The position of rice in the agriculture of the country is predominant and practically all available land is used to grow it. The use of fertilizers (mainly N), compost and insecticides on paddy rice, is commonly practised.

In the northern parts of the country, larger responses to fertilizers than in the south were recorded, but the yields were 10-15 percent lower due to the shorter growing season and uncertain weather conditions. The country-wise average yield of fertilized plots was 37 percent higher than the yield of unfertilized plots.

Substantial yield increases were obtained with higher levels of N, but the rate of the increase declined sharply when P and K were not applied as well. However, complete N P K application did not give the highest return per unit of investment in spite of giving the largest yield increase.

Response to fertilizers seemed to be more affected by differences in climatic conditions than by nature of the soil; productivity depended largely on management practices and availability of irrigation water. N is almost always and everywhere the limiting factor to the satisfactory production of rice. Most local varieties did not benefit from heavy application of N. Only a few high yielding varieties took full advantage of it.

3.2 UPLAND RICE

Mainly grown in the Cheju island under rainfed conditions, upland rice yields less than paddy. The average yield of fertilized plots was almost 120 percent higher than that of unfertilized plots but, contrary to what had been observed for paddy, rainfed rice response to N was inferior than that to P and K. Response to N increased with top dressing. The most effective application was to split about 60 percent of the total N into two equal doses between 15 days after transplanting and ear formation stage.

The return per unit of investment was higher than 600 percent making the use of fertilizers highly profitable.

1/ For detailed results of trials, see Appendix 1. A Table of Contents is included for easy cross referencing.

3.3 BARLEY

The extremely low average yields without fertilizers, about 1 ton/ha in the north and 1.5 ton/ha in the central and southern regions, give an indication of the low standard of management for this crop.

Response was high to P and K in the north, and to N in the south. A positive interaction among nutrients was observed. In fact, the total response was further increased with N P K application. In areas with higher rainfall, higher rates of N proved effective, while in those areas with lower rainfall the response to P was higher. Use of P seemed to increase the resistance of the crop to both drought and cold. Since most of the soils in which barley is grown have pH values lower than six, the effect of liming was substantial. Application of 4 tons/ha increased the yield by about 55 percent. Its effect was strongly influenced by moisture of soil and method of application. With band applications along the furrows increases of 60 percent were obtained. From the application of the country-wise recommended level of 100-75-55 kilogrammes per hectare (kg/ha), an average yield of 3.35 tons/ha could be expected, that is about 45 percent increase over the country average yield. The Suwon varieties, with the exception of Suwon 6, were highly responsive to fertilizers.

3.4 WHEAT

Farmers are encouraged to grow wheat and the area under this crop is expanding each year. Average yields without fertilizers vary between 1.8 to 1.0 ton/ha from south to north.

Yield increases to the order of 90 percent in the centre and south and almost 200 percent in the north have been obtained with adequate fertilization. The largest response was that to N. Also P and K were very effective in the north. The response to the additional 25 kg/ha of N from 75 to 100 was higher than from 50 to 75. Similarly, the response to 20 additional kg/ha of K was higher from 60 to 80 than from 40 to 60.

From experimental evidence it is clear that wheat could yield more than 4 tons/ha with adequate fertilizer application in the south, where its cultivation is highly profitable.

3.5 RAPE SEED

Response of rape to fertilizer was substantial, in the order of N, P, K. Application of Boron increased the yields by 10 percent everywhere but in the Cheju island. Fertilizer use proved to be very profitable, giving a return per unit of investment higher than 400 percent.

3.6 SOYABEAN

Only very small amounts of fertilizers had been applied to this crop. As expected from a leguminosa, responses to P and K were higher than to N. In spite of the crop's resistance to acidity, very low soil pH values may affect the yields. Increases of 20 percent were obtained with liming alone which proved to be of utmost importance for the improvement of the crop. Also P and K may have considerable effect although similar results can be achieved from the residual effect of heavy fertilization to the previous crop.

3.7 MILLET

This crop is mostly grown in the uplands of the south under rainfed conditions. Average yield without fertilizer is in the order of 2 tons/ha. Best response to N was obtained with 60 kg/ha with evidence of additional response to increasing levels.

Best yield and highest gross profit were obtained with a balanced and complete formula of 100-80-80 due to positive interaction among nutrients.

3.8 MAIZE

Yields increased from 1.8 ton/ha without fertilizers up to 5.8 tons/ha with adequate and balanced applications. Responses to N and P were high and similar, that to K rather smaller.

Optimum level was 150-125-100 and proved very profitable as returns of 500 percent per unit of investments were recorded.

3.9 WHITE POTATO

With adequate fertilizer applications similar yields were obtained both in uplands and lowlands. The average yield without fertilizers was only 9 tons/ha and increases of the order of 120 percent were realized.

With the application of 120-90-150 a gross profit of 190 000 won (US$ 613) per hectare was obtained.

3.10 SWEET POTATO

This crop is grown mainly in the uplands under rainfed conditions and has wide variations on yields, per province and year. The average responses to 1 kg/ha of N, P and K at the levels 80-90-210 was respectively 99, 93, 37 kg of yield. Unit responses were even larger in the Cheju island, where the crop is widely cultivated. The yields on newly reclaimed soils were substantially lower than in older soils. Sweet potato has proved to be one of the most profitable crops among those under investigation. In fact yields could be raised from 16 tons/ha control to 30 tons/ha with use of fertilizers.

3.11 FORAGE CROPS

These crops which are the basis for the development of a livestock industry deserve more attention. The very low control yields and the encouraging experimental results obtained indicate that with proper management great improvements could be obtained which may even produce better yields than in many developed countries.

In the south, with favourable soil conditions, the dry matter production of Italian Rye Grass can reach 12.0 tons/ha. Good average yields of Oats were also obtained mainly in the central region. Orchard Grass also yielded very well in the central region and Cheju island. Red Clover yields were erratic mainly due to low moisture and the elevated acidity of newly reclaimed soils. These conditions affected also the production of Alfalfa and Ladino Clover.

Chapter 4

INFLUENCE OF FACTORS OTHER THAN FERTILIZER ON RICE PRODUCTION

On the basis of original soil fertility status, as determined by yield of unfertilized plots, Korean paddy fields have been divided into three classes or levels of productivity: Low, with yields between 2.5 - 3.5 tons/ha of paddy; Medium, with yields between 3.5 to 4.5 tons/ha; High, with yields from 4.5 to 5.5 tons/ha. Their distribution is shown in Figure 1. Paddy yields obtainable in Korea are are much lower than those of Japan, in spite of wide use of fair amounts of fertilizers in the recent past. This may be due to the adverse influence of several factors such as unfavourable climatic conditions during the plant growth, inadequate water supply at critical stages, problems concerning soils and improper fertilization, usually excessive in nitrogen.

4.1 CLIMATIC CONDITIONS

Hours of sunshine and temperature recorded during rice growing season in Japan are compared with those occurring in the northern and southern parts of Korea, respectively in Figures 2 and 3. As the yearly rainfall of about 1 100 millimetres (mm) is mainly concentrated in July and August, the drought in April, May-June may delay or altogether cancel the transplanting operations in the rainfed areas in the northern region, which accounts for more than 17 percent of the total area under rice. Moreover, during July-August the production of effective tillers and the panicle formation may be seriously affected by the high temperature and heavy rainfall with little sunshine mainly in the northern region where, during this period, the sun seldom shines. On the other hand, low temperature and abundant sunshine during September and October are very favourable conditions for the ripening of the grain unless, as in the northern region, temperature values become too low. These growth patterns are also shown in Figures 2 and 3.

4.2 INADEQUATE WATER SUPPLY

The yields obtainable in rainfed and in partially irrigated areas are much lower than those of properly irrigated paddy fields. Table 5 shows yields and area of paddies according to irrigation facilities.

4.3 SOIL CHARACTERISTICS

Agricultural soils of Korea are primarily derived from igneous rocks such as granite and gneiss and various sedimentary materials. Their texture varies between clay loam and sandy loam. Soils are highly weathered, have very low organic matter content as well as cation exchange capacity and are generally deficient in P, K, Silica (Si), Magnesium (Mg) and Manganese (Mn). These soils have little capability of absorption and storage of the nutrients supplied through fertilization. Moreover, under the influence of the unfavourable climatic conditions seen above, rice plant growth is initially vigorous but slackens afterwards. Chemical characteristics of Korean paddy soils are summarized in Table 6.

4.4 IMPROPER USE OF FERTILIZERS

Experimental evidence made clear that the government-recommended rate of application to paddy, 91-31-20 kg/ha, is very low in P and K. Comparison of relative amounts of nutrients applied to paddy and average yields of Korea against those of Japan in Figures 4 and 5 confirms this statement.

4.5 REGIONAL VARIATIONS IN LENGTH OF GROWING PERIOD

The total length or duration of the rice plant growing period is influenced by several factors such as variety, climate and time of transplanting which can be performed either at an early or late date. Also, the respective length of vegetative and reproductive growths and that of each one of the various growing stages, can vary accordingly. Table 7 shows the regional and varietal variations in the duration of the growing period due to early and late transplanting.

4.6 REGIONAL DIFFERENCES IN DRY MATTER PRODUCTION

Figure 6 shows the regional differences in the dry matter production of rice plants. Generally low during vegetative growing period, it increases during reproductive growth. The increase is very low in the northern area, maximum in the central area where it rises from values similar to those of the northern area, to values similar to those of the southern area.

4.7 REGIONAL DIFFERENCES IN SOIL FERTILITY LEVELS

The relationship between the original soil fertility level of a soil and its productivity is made evident in Figure 7. There the nutrient levels of unfertilized plots, expressed in kilogrammes per hectare, are stratified per region and nutrient and compared with the corresponding yield in tons per hectare. The country average of the three main nutrients contents is 71-50-102 kg/ha 1/, with minimum values in the north. These are highest in the south. The correlation coefficient between nutrient level and yield has been found: for N, 0.778; for P, 0.664 and for K: 0.566.

1/ Total N was determined by Kjeldahe method; available P by Lancaster extractant; exchangeable K and other cations by N-ammonium acetate leaching method.

4.8 CHEMICAL CHANGES IN FLOODED SOILS

The NH_4 - N content, follows the pattern characteristic in flooded soil. Initially high, it decreases sharply until panicle initiation stage when it is only 20 percent of the original. Afterwards it increases slightly and remains constant. Values are very small in soils with low productivity and in unfertilized plots, but significantly higher in fertilized plots (see Figure 8).

Iron reduction takes place in flooded soil due to anaerobic metabolism of bacteria. It becomes very soluble and its concentration may reach values of toxicity which can be avoided by liming, drainage and cautious application of organic matter. Figure 9 shows that Fe^{++} content is very high and widely varying in normal soils, while it is small and constant in soils with high productivity.

Redox potential is influenced by organic matter, Fe, Mn, drainage and temperature. Figure 10 shows the variations in Redox potential according to the date of transplanting. Only with early transplanting is the value at panicle initiation stage still high enough to prevent root rot, a disease closely associated with soil reduction. The conditions occurring with late or normal transplanting do not seem favourable to rice plants.

4.9 NUTRIENTS UP-TAKE AND CONTENT IN PLANT TOP AT VARIOUS STAGES OF GROWTH

The content of N increases until effective tillering stage and gradually decreases afterwards. Values found in plants grown in poor soils are much lower than in those grown in normal soils, though the pattern is the same (see Figure 11). There is a relationship between N uptake and yield. No high yield can be expected if N content at harvesting time is lower than 1.75 percent. In Figure 12 the values of N absorption are given. These are high in the south, low in the north, with a country average of 99 kg/ha, which is rather large. On the other hand, the utilization rate is small, being only 29 percent (see Figure 13). The quantities of P absorbed are smaller than N, but follow the same regional trend (see Figure 14). It is worth mentioning that Korean soils contain fair P amounts. The rate of K absorption is the highest one. Korean soils are well provided with potash, and irrigation water can supply from 20 to 40 kg/ha of K_2O.

Chapter 5

RECOMMENDATIONS

5.1 RICE

5.1.1 Recommended Fertilizer Levels According to Soil

The rate recommended by the Government, 91-31-20 kg/ha, is based on products availability and has proved to be unbalanced and excessive in N in respect to P and K. This has been proved by field experimentation results. Despite the presence of fair amounts of these two nutrients (P and K) in the soils and the low rate of absorption of phosphates, the continuous use of high rates of nitrogen leads to a serious decline in production as Figure 15 shows. In the light of experimental results, economic returns and rate of utilization of fertilizer nutrients, a general recommendation of 100-45-60 kg/ha can be formulated. The optimal levels will vary of course according to the soil. These have been stratified per province and soil series in Table 8.

5.1.2 Improved Cultural Practices

Early transplanting is recommended for the northern region and the Chung Chong Nam province of the central region so that plants may find more suitable climatic conditions during growth. Occurrence of strip or dwarf disease limits the use of this practice in the central and southern areas.

Direct seeding can be recommended in the rainfed or poorly irrigated areas.

Application of compost or straw in addition to chemicals is necessary to maintain fair fertility level. Only about half of the paddy area receives green manure or compost, rice straw being usually used for other purposes. Further investigation is needed to assess quantities and time of application of organic matter and the interactions, if any, with fertilizer rates.

Deep ploughing with upturn of subsoil is recommended mainly in those soils which have a deep topsoil or a subsoil in which the nutrients, leached down from topsoil, have been accumulated.

The so called midsummer drainage, or the practice of suspending irrigation and draining the water from the fields 30-40 days before heading period, is recommended. In such a way, roots can be oxigenized and toxic materials removed.

5.1.3 Application of Silicate

Silica enhances in the soil the availability of P to plants; in the plant, resistance to lodging and diseases, and the assimilation functions through improvement of photosynthetic activities of leaves and the oxidation power of roots. It appears, from experimental and analytical results, that a minimum of 120 p.p.m. SiO_2 are required for proper plant development and therefore 94.4 percent of soils in Korea are deficient in silica, as shown in Figure 16. Application of silica gave some 12-14 percent yield increases in normal soils and larger in soils with low productivity. In Figure 17 the recommended quantities and regional effects of wollanstonite ($Ca\ Si\ O_2$) are given, in the presence of different levels of N.

5.1.4 Best Time for Fertilizer Application

Split application of N and K proved effective. Nitrogen in particular gave the best results when split in the following way:

50 percent as basal dressing;
25 percent as top dressing 15 days after transplanting; and
25 percent at ear formation stage.

In the south further splitting of the last top dressing as follows proved effective:

50 percent as basal dressing;
25 percent 15 days after transplanting;
12.5 percent at ear formation stage; and
12.5 percent at heading time.

The effect of split N application is up to 180 kg/ha paddy, which is an increase of 4 percent.

However, the best time for N application varies with locality. In Chulla Puk best yields were obtained from plots which received all N at an early stage of growth, while in the rest of the country extremely delayed top dressing at panicle initiation stage gave positive effect. Generally, it can be said that in the north N has to be applied early, in the south, the later the better. Further investigation is however still needed on this subject.

5.1.5 Use of Amendments and Micro-Nutrients

Crop responses to additional quantities of fertilizers, measured in terms of additional yield increases, begin to become insignificant from a certain level of nutrients onward. Results of a large number of trials however demonstrated that a further yield increase of 10 percent is still possible with the application of micro-nutrients or amendments. Iron enriched composts, manganese, wollanstonite, which is a cheap source of lime and silica abundant in the country, have been found to produce significant increases in paddy yields. In fact, increases in the order of 0.5 ton/ha have been obtained with such applications in permeable sandy soils, heavy clay, old marine soils, leached soils and soils with a high watertable. Enriched composts and wollanstonite, together with drainage and high ridges cultivation proved effective also in preventing Akiochi and Akagare diseases 1/. The effect of high ridges and closer planting space has been measured on 0.30 ton/ha.

Selection of short stemmed and disease resistant varieties is recommended.

1/ See Glossary.

5.2 OTHER CROPS

(For more detailed information on these crops see Appendix 1).

5.2.1 Barley

Barley is the second food crop and is planted both in winter and spring, either in uplands or in rotation with rice. Due to its low market price, chemical fertilizer application is not a common practice. A large number of experimental results indicate that high responses and fair yields are obtainable, with countrywise average 110-80-50 kg/ha of nutrients, and yield 3.37 tons/ha. Liming gave significant increases in yield, evidently not only because of its effect on raising the soil pH, but also because it supplies calcium and magnesium to the crop. Application of compost is also recommended. Optimum fertilizer levels and corresponding expected yields are given, per soil series, in Table 9.

5.2.2 Wheat

Wheat response to fertilizers is fairly high. Because of the greater amount of land used and increasing importance of the crop, many experiments have been conducted. The average recommended level is 100-80-60 kg/ha nutrients and in Table 10 the optimum levels are distributed per soil series.

5.2.3 Soyabean

The response of this crop to fertilizer is low and so are the benefits. In clay loam soils derived from granite, 40-80-60 kg/ha of nutrients is recommended. In soils derived from alluvial deposits or sedimentary rocks 40-40-60 kg/ha of nutrients is recommended.

5.2.4 Maize

This crop responds well to fertilizers and 150-125-110 kg/ha is recommended.

5.2.5 Millet

On the basis of economic consideration, the level of 60-80-80 kg/ha is recommended, although best yields have been obtained with 100-80-60 kg/ha.

5.2.6 Rape Seed

Levels varying from 90-140-60 to 90-185-80 are recommended.

5.2.7 Sweet Potato

In normal upland soil 80-90-120 kg/ha is recommended. In newly reclaimed soil 100-90-120 kg/ha is recommended.

5.2.8 Potato

In normal upland soil 100-30-60 kg/ha in lowland in rotation with rice 140-90-60 kg/ha is recommended. The recommended levels for the provinces are given in Table 11.

Table 1

DISTRIBUTION OF CULTIVATED LAND AMONG VARIOUS CROPS (1966)

Crop	Area (ha)	Percentage
Grain crops	3 115 890	89.5
Vegetables	154 154	4.4
Mulberry	61 692	1.7
Fruits	45 190	1.3
Tobacco	36 726	1.1
Other crops	68 175	2.0
Total	3 481 827	100.0

Table 2

UTILIZATION OF CULTIVATED LAND (1961-67)

Year	Total arable land (in 1 000 ha)	Cultivated land (in 1 000 ha)	Percentage of double cropping
1961	2 049	3 047	149
1962	2 080	3 135	151
1963	2 097	3 193	152
1964	2 189	3 389	155
1965	2 275	3 588	158
1966	2 312	3 482	151
1967	2 331	3 541	152

Table 3

TARGETS OF THE WATER RESOURCES DEVELOPMENT PLAN (1968-71)

Year	Area undergoing water regulation (in 1 000 ha)
1968	25 000
1969	208 000
1970	127 000
1971	75 000
Total	435 000

Table 4

STORAGE CAPACITY OF FERTILIZER WAREHOUSES (1964-67)

Year	Distribution points	Number of warehouses	Storing capacity (tons)
1964	1 116	2 241	338.661
1965	2 345	2 712	385.308
1966	2 486	2 953	400 254
1967	2 707	3 417	455 545

Table 5

DIFFERENCES IN PADDY YIELDS ACCORDING TO IRRIGATION FACILITIES

	Total cultivated area	Land improvement association	Properly irrigated	Partially irrigated	Rainfed
Area	1 191 358.3	277 278.3	418 688.1	288 575	206 794.4
Yield (ton/ha)	2.44	2.74	2.60	2.29	1.95
Percentage of total cultivated land				24.2	17.3

Table 6

CHEMICAL CHARACTERISTICS OF KOREAN PADDY SOILS

	High production paddy soil	Normal paddy soil	Low production paddy soil	Average
pH (H_2O)	5.3	5.4	5.3	5.37
Organic matter	2.0	-	2.27	0.23
Total nitrogen	0.18	-	0.18	0.18
C.E.C.	13.5	11.8	11.5	11.7
Exchangeable Ca	5.7	4.8	3.99	4.2
" Mg	2.0	1.32	1.32	1.32
" K	0.3	0.27	0.25	0.26
" Na	0.49	0.32	0.35	0.33
" H	4.6	5.30	4.9	5.18
P_2O_5 (ppm)	59	57	53	55.8
Mn "	42		36	36.1
Soluble SiO3	1.544		935	946.8
Active iron	1.6		9.09	0.91
Yields in ton/ha	4.5	3.7	2.3	3.75

Table 7

VARIATION IN THE LENGTH OF THE GROWING PERIOD OF RICE

Province	Variety Medium maturing	Transplanting date	Growing period, from transplanting to harvest (days)	Vegetative growth, from transplanting to panicle initiation (days)	Reproductive growth, from panicle initiation to harvest (days)
Kang Won	Jim Heuns	25 May	133	53	80
Suwon	"	5 June	116	47	69
Chulla Nam	Nong Lim 6	25 June	113	35	78
	Early maturing				
Kang Won	Suwon 82	25 May	99	32	67
Suwon	"	3 June	94	30	64

The influence of varietal characterisics and transplanting date on length of growth may play a very important role in better fitting the crop requirements to climatic conditions, and in finding the most suitable time for fertilizer application.

Table 8

RECOMMENDED FERTILIZER LEVELS FOR RICE PER SOIL SERIES

Kyonggi Do

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing of nitrogen 1/ 1	2	3	4	5
1	Apa	100-60-40	3	4.60	-	-	-	-	-
1	Rxa	100-60-40	4	4.57	-	-	-	-	-
1	Apb	120-30-40	5	6.57	-	-	-	-	-
1	AFb	100-30-80	8	5.15	50	0	0	50	0
1	Anb	120-60-40	3	3.45	-	-	-	-	-
2	Apa	100-60-40	3	5.66	50	0	0	50	0
2	Apa	100-30-40	4	4.29	-	-	-	-	-
2	Rxa	120-60-80	4	4.37	40	30		15	15
2	AFb	120-60-80	8	4.93	-	-	-	-	-
2	Fma	100-30-80	5	5.43	40	30	0	30	0
2	Fmb	100-60-80	3	5.57	40	30	0	30	0
2	Fmb	120-30-40	3	6.08	-	-	-	-	-
2	Fmc	100-60-40	2	5.08	-	-	-	-	-
2	Raa	100-60-40	6	5.75	-	-	-	-	-
2	Raa	100-60-80	6	5.82	-	-	-	-	-
2	Raa	120-30-40	1	7.67	-	-	-	-	-
3	Apa	100-60-40	8	5.25	40	30	0	15	15
3	Apa	100-60-40	12	5.76	(50	0	50	0	0
					(40	30	0	15	15
3	Rxa	100-60-80	16	5.17	-	-	-	-	-
3	AFb	100-60-80	3	4.81	-	-	-	-	-
3	Apc	100-60-80	3	4.23	-	-	-	-	-
4	Apa	120-60-80	13	5.17	40	0	0	30	30
4	Rxa	120-30-40	4	5.79	50	0	50	0	0
4	AFb	120-30-40	1	5.49	-	-	-	-	-
4	Raa	120-30-40	4	4.83	40	30	30	0	0
					40	30	0	30	0
5	Apa	100-60-40	2	5.83	-	-	-	-	-
5	Apa	100-60-40	16	5.08	40	30	0	30	0
5	Rxa	100-60-80	1	6.28	-	-	-	-	-
5	Apb	100-30-40	2	4.76	50	0	0	50	0
5	Fma	100-60-40	11	5.87	40	30	0	30	30
					40	0	0	30	30
5	Fma	120-60-80	10	6.04	40	30	0	0	30
5	Fmb	120-60-80	8	5.78	(40	30	0	30	0
					(40	0	0	30	30
5	Fmd	100-60-80	1	6.31	-	-	-	-	-
5	Fmd	120-60-40	8	5.69	-	-	-	-	-
5	Fmd	100-60-80	1	6.42	-	-	-	-	-
5	Fmd	100-60-40	4	5.28	40	30	0	30	0
5	Fmd	100-60-80	4	5.24	-	-	-	-	-
5	Ana	120-60-40	1	5.68	40	30	0	30	0

1/ 1. Basic dressing; 2. 15 days after transplanting; 3. 10 days after transplanting; 4. Panicle initiation stage; 5. Heading period.

Table 8 cont......

Kangwon Do

Cluster	Soil Series	Fertilizer rate – kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
1	Apb	120–30–80	2	4.97	–	–	–	–	–
1	Apb	120–60–40	2	4.92	–	–	–	–	–
1	Rva				50	0	50	0	0
2	Apb	100–60–40	1	5.37	–	–	–	–	–
2	AFa	100–30–40	1	4.66	–	–	–	–	–
2	AFa	100–60–40	1	4.84	–	–	–	–	–
2	AFb	100–60–80	1	6.49	–	–	–	–	–
2	AFd	100–60–80	2	4.97	–	–	–	–	–
2	RVa	100–60–80	12	3.50	–	–	–	–	–
3	Apa	100–30–40	4	3.44	40	30	0	15	15
3	AFb	100–60–80	9	3.90	(40	0	0	30	30
					(0	40	0	30	30
3	AFb	100–60–80	15	5.34	–	–	–	–	–
3	Ana	100–60–40	5	4.70	(60	40	0	0	0
					(0	40	0	30	30
3	Anb	100–60–80	4	3.47	60	40	0	0	0
3	Fma	100–60–80	2	3.97	–	–	–	–	–
3	Fmb	100–60–80	3	3.85	–	–	–	–	–
3	Rxa	100–60–40	11	4.15	50	50	0	0	0
4	Apa	120–60–40	12	4.24	(40	30	0	30	0
					(50	0	0	50	0
					(40	30	30	0	0
					(10	30	0	30	0
4	Apb	100–60–40	5	5.70	–	–	–	–	–
4	AFa	100–60–40	8	4.46	0	40	0	30	30
4	AFb	100–30–40	18	4.52	0	40	0	30	30
					0	40	0	30	30
4	AFb	100–30–80	18	4.54	–	–	–	–	–
4	AFb	100–60–40	18	4.50	–	–	–	–	–
4	AFd	120–60–80	1	6.14	–	–	–	–	–
4	Rab	100–60–80	4	5.65	40	30	0	30	0
5	Apa	120–30–40	1	4.65	–	–	–	–	–
5	Apa	100–60–80	1	4.50	–	–	–	–	–
5	AFa	100–60–40	3	4.50	–	–	–	–	–
5	AFb	100–30–40	1	5.38	–	–	–	–	–
Chungchong Puk Do									
1	Apb	120–30–40	6	4.86	50	0	0	50	0
1	AFb	120–30–40	4	5.20	–	–	–	–	–
1	Rxa	120–60–80	3	6.74	–	–	–	–	–
1	Ana	120–30–40	4	6.18	–	–	–	–	–
2	Apa	120–30–40	3	5.18	–	–	–	–	–
2	Apa	120–30–80	3	5.34	–	–	–	–	–
2	Apb	120–30–40	2	5.25	(40	30	0	30	0
					(40	30	0	15	15
2	AFb	120–60–40	4	6.05	(40	30	0	30	0
					(40	30	0	15	15
2	Rxa	120–30–80	6	4.52	–	–	–	–	–
2	Rxa	120–60–40	6	4.57	–	–	–	–	–
2	Raa	120–30–40	2	5.98	–	–	–	–	–

Table 8 cont....

Chungchong Puk Do

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
2	Rab	120-30-40	2	5.99	40	30	0	30	0
2	Apa	120-60-80	8	4.69	40	30	0	30	0
2	Apa	100-60-80	8	4.31	-	-	-	-	-
3	Apa	120-30-40	4	3.98	40	30	0	30	0
3	AFb	100-60-80	2	4.44	-	-	-	-	-
3	Apa	100-60-80	3	3.99	-	-	-	-	-
3	Apa	100-60-80	8	4.60	-	-	-	-	-
3	Apb	120-30-40	8	4.52	40	30	0	15	15
4	Apa	120-60-80	4	4.32	40	0	0	30	30
4	Apb	100-60-80	2	4.53	-	-	-	-	-
4	Apb	120-30-80	2	4.64	-	-	-	-	-
4	AFb	120-30-40	1	5.82	40	30	0	15	15
4	AFb	120-60-40	1	5.87	-	-	-	-	-
4	Apd	120-60-80	3	6.03	-	-	-	-	-
4	Rab	100-60-80	3	3.96	-	-	-	-	-
4	AFb	100-60-80	3	4.43	-	-	-	-	-
4	Apa	120-30-80	4	4.00	40	30	0	30	0
4	Apa	120-60-40	4	3.90	-	-	-	-	-
4	Anb	120-60-80	4	5.80	40	30	0	30	0
4	Rab	120-30-40	4	5.47	-	-	-	-	-
Chungchong Nam Do									
1	Apc	100-60-40	3	5.21	-	-	-	-	-
1	Apb	80-30-40	3	3.64	-	-	-	-	-
1	Apd	100-80-40	6	4.77	-	-	-	-	-
1	Apa	100-60-80	9	5.01	-	-	-	-	-
1	Apa	120-60-40	8	6.05	50	50	0	0	0
1	Fma	100-60-80	8	6.03	50	0	0	50	0
2	Apa	100-30-50	8	5.04	40	30	0	15	15
2	Apa	100-60-80	8	5.03	-	-	-	-	-
2	Apb	100-60-80	4	5.67	40	30	0	15	15
3	Apa	100-60-80	6	5.77	-	-	-	-	-
3	Apb	120-30-40	3	5.82	-	-	-	-	-
3	Ana	120-30-40	3	6.54	-	-	-	-	-
3	Ana	100-60-80	3	6.19	-	-	-	-	-
3	Fma	100-30-40	4	5.28	-	-	-	-	-
3	Fma	100-30-80	3	5.08	-	-	-	-	-
3	Fma	100-60-80	3	5.01	-	-	-	-	-
3	Rxa	120-30-40	3	6.80	-	-	-	-	-
4	Apa	100-30-40	6	5.55	(40 (60 (40	30 0 30	0 0 0	15 40 15	 0 15
4	Apa	100-80-40	6	5.44	-	-	-	-	-
4	Apa	100-60-80	6	5.52	-	-	-	-	-
4	Apb	120-30-40	4	5.70	0	40	0	30	30
4	Apc	100-80-40	2	5.84	60	0	0	40	0
4	Apd	100-60-40	2	6.10	-	-	-	-	-
4	AFb	100-60-40	4	5.50	40	0	0	30	30
4	AFb	100-60-80	4	5.29	40	30	30	0	0

Table 8 cont....

Chungchong Nam Do cont....

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
4	Apa	120-60-80	8	5.83	-	-	-	-	-
4	Apa	120-60-40	8	5.90	-	-	-	-	-
4	AFb	120-30-40	4	5.48	-	-	-	-	-
4	AFb	80-30-60	4	5.23	-	-	-	-	-
5	Apa	100-60-80	5	5.21	40	30	0	15	15
5	Apb	100-60-40	4	4.85	(40	30	0	30	0
					(0	40	0	30	30
5	Apb	100-60-80	4	4.84	-	-	-	-	-
5	Apb	120-30-80	4	5.01	-	-	-	-	-
5	Ana	100-30-40	4	6.23	40	30	0	30	0
6	Ana	120-30-40	4	6.34	(40	30	0	30	0
					(0	40	0	30	30
6	AFa	100-60-40	8	5.01	40	30	30	0	0
5	AFb	120-60-80	2	5.02	40	30	0	30	0
5	Rab	100-30-80	3	5.56	-	-	-	-	-
5	Rab	80-30-40	3	5.22	-	-	-	-	-
5	Rxa	100-30-40	1	6.46	-	-	-	-	-
5	Rxa	120- 0-80	1	5.00	-	-	-	-	-
5	Rxa	100-60-80	1	6.32	-	-	-	-	-
6	Rab	100-60-40	1	5.42	-	-	-	-	-
6	Raa	100-60-80	3	5.14	-	-	-	-	-
6	Fma	100-60-80	12	5.03	-	-	-	-	-
6	Apa	100-60-40	13	4.83	-	-	-	-	-
6	Fma	100-60-80	12	5.60	40	30	0	15	15

Kyongsang Puk Do

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
1	Apb	100-30-40	12	5.79	40	30	0	30	0
1	Apb	100-60-40	12	5.75	(-	-	-	-	-
1	AFb				(0	40	0	30	30
2	Apa	100-60-40	8	6.28	40	30	0	30	0
2	AFb	120-30-40	3	5.79	-	-	-	-	-
2	Fma	120-60-40	1	6.06	-	-	-	-	-
2	Fmb	100-60-40	3	5.22	-	-	-	-	-
3	Apa	100-60- 0	2	5.48	-	-	-	-	-
					(50	0	50	0	0
3	Apa	120-60-40	6	4.88	(40	30	0	15	15
					(40	30	0	30	0
					(40	30	0	30	0
3	Apa	100-60-80	56	5.19	(40	30	0	15	15
					(40	30	0	15	15
					(40	30	0	15	15
3	Apa	120-30-80	56	5.31	(0	40	0	30	30
					(40	30	0	15	15
3	Apb	100-60-40	1	5.44	(40	30	0	15	15
					(0	40	0	30	30
3	Apb	100-60-30	8	4.11	(40	30	0	0	30
					(40	30	0	15	15

Table 8 cont....

Kyongsang Puk Do cont....

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
3	Apc	120-30-40	6	5.70	40	30	0	30	0
3	Ana	100-30-40	4	4.88	40	30	0	15	15
3	AFb	120-30-40	2	3.58	(50	50	0	0	0
					(40	30	0	15	15
3	AFb	100-60-40	51	4.54	(40	30	30	0	0
					(40	30	30	0	0
					(40	30	0	30	0
					(40	30	0	0	30
3	Raa	120-60-80	4	6.83	(40	30	0	30	0
					(40	30	0	15	15
3	Rxa	100-60-80	5	6.01	(50	0	0	50	0
					(40	30	0	30	0
3	Msa	120-30-80	3	6.94	-	-	-	-	-
3	AFa				40	30	0	30	0
4	Apa	120- 0-40	8	5.82	0	40	0	30	30
4	Apb	100-60-40	16	6.15	(40	30	0	15	15
					(40	30	0	15	15
4	Apb	100-60-80	16	6.12	(40	30	30	0	0
					(40	30	0	0	30
					(40	60	0	0	0
					(40	30	30	0	0
4	Apc	100- 0-80	20	5.35	40	30	0	30	0
4	Apc	100-30-40	20	5.38	-	-	-	-	-
4	Apc	100-60- 0	20	5.25	-	-	-	-	-
4	Apc	100-30-80	2	5.49	-	-	-	-	-
4	Apg	100-30-80	1	5.11	-	-	-	-	-
4	Ana	100-60-80	3	6.99	-	-	-	-	-
4	Anb	120-60-80	6	6.44	-	-	-	-	-
4	AFa	100-30-40	1	5.84	40	30	0	30	0
4	AFa	100 30-80	8	4.07	-	-	-	-	-
4	AFb	120-30-40	1	6.77	-	-	-	-	-
5	Apa				50	0	50	0	0
Kyongsang Nam Do									
1	Apa	100-60-80	11		(40	30	0	30	0
					(40	30	0	15	15
					(40	30	0	0	30
1	Apc	100-60-80	4	5.52	40	30	0	15	15
1	Ana	100-60-80	2	6.30	40	30	0	0	30
1	Ana	80-30-80	4	5.15	-	-	-	-	-
1	Anb	100-60-40	4	5.97	-	-	-	-	-
1	Anb	100-60-80	4	5.85	-	-	-	-	-
1	AFd	100-60-40	2	5.60	-	-	-	-	-
1	AFd	100-60-80	2	5.64	-	-	-	-	-
1	Mab	100-60-40	1	6.41	-	-	-	-	-
1	Rxa	100-60-80	4	6.26	-	-	-	-	-
1	Rmc				50	50	0	0	0
2	AFa				40	30	0	30	0

Table 8 cont....

Kyongsang Nam Do cont....

Cluster	Soil Series	Fertilizer rate – kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
2	Apa								
2	Apa	100–60–40	9	5.54	0	40	0	30	30
2	Apa	100–60–80	26	5.45	40	30	30	0	0
2	Apb	100–60–80	3	4.71	–	–	–	–	–
2	Apc	100–60–80	3	6.01	–	–	–	–	–
2	Ana	100–30–40	8	5.69	40	30	0	30	0
2	Ana	100–60–40	8	5.67	–	–	–	–	–
2	Anb	100–30–40	4	5.59	40	30	0	30	0
					40	0	0	30	30
2	Anb	100–30–80	4	5.64	–	–	–	–	–
2	AFb	120–30–80	4	4.55	40	0	0	30	30
3	Apc	120–30–40	1	5.65	–	–	–	–	–
3	Apb	120–30–80	2	5.50	–	–	–	–	–
3	Apg	100–60–80	4	4.92	40	30	0	30	0
3	Anc	120–60–40	1	5.70	–	–	–	–	–
3	AFb	100–60–40	4	4.90	–	–	–	–	–
3	AFb	100–60–80	4	4.90	–	–	–	–	–
3	AFb	120–30–80	5	5.09	–	–	–	–	–
3	AFd	100–60–40	2	5.20	–	–	–	–	–
3	Fma	100–30–40	26	4.79	40	30	0	30	0
3	Fma	100–60–80	26	4.79	(0	40	0	30	30
					(40	0	0	30	30
3	Fmb	100–60–80	11	4.90	–	–	–	–	–
3	Fmd	100–60–40	8	5.22	(40	0	0	30	30
					(40	30	0	15	15
3	Fmk	80–60–40	8	3.28	0	40	0	30	30
3	Fmk	100–30–40	8	3.18	–	–	–	–	–
3	Raa	100–30–40	4	4.69	(40	30	0	30	0
					(40	30	0	15	15
3	Rac	100–60–40	4	6.66	0	40	0	30	30
4	Apa	100–60–80	10	5.84	–	–	–	–	–
4	Apa	100–30–80	8	5.85	–	–	–	–	–
4	Apa	100–60–40	8	5.81	–	–	–	–	–
4	Apb	120–60–80	2	8.78	–	–	–	–	–
4	Ana	100–60–40	1	5.88	–	–	–	–	–
4	AFb	100–60–40	1	5.84	–	–	–	–	–
4	Rea	100–60–40	3	5.75	–	–	–	–	–
5	Apa	100–60–40	7	5.97	–	–	–	–	–
5	Apc	100–60–80	4	5.72	40	30	0	15	15
5	Apb	100–60–40	2	5.64	40	30	0	30	0
5	Apb	100–60–80	9	5.56	40	30	0	15	15
5	Ana	100–30–40	12	5.10	50	50	0	0	0
5	Ana	100–60–40	12	5.18	–	–	–	–	–
5	Apg	100–30–40	4	5.51	40	0	0	30	30
5	Apd	100–60–40	1	5.44	–	–	–	–	–
5	Apd	100–60–80	1	5.46	–	–	–	–	–
5	Anb	100–60–80	4	5.67	(40	30	0	30	0
					(40	30	0	15	15
5	AFd	100–60–40	2	5.15	–	–	–	–	–
5	Fma	100–30–40	5	4.72	–	–	–	–	–

Table 8 cont....

Kyongsang Nam Do cont....

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing				
					1	2	3	4	5
5	Fma	100-30-40	5	4.79	-	-	-	-	-
5	Rxa	100-60-80	11	4.98	0	40	0	30	30
5	Fmd	120-60-40	1	6.44	-	-	-	-	-
5	Rac	100-60-80	4	6.19	-	-	-	-	-
6	Ana	120-60-40	4	6.43	0	40	0	30	30
6	Anb	100-30-80	3	6.64	-	-	-	-	-
6	Anb	100-60-40	3	6.50	-	-	-	-	-
6	AFb	100-60-80	6	5.11	-	-	-	-	-
6	AFc	120-60-40	1	6.84	-	-	-	-	-
6	Fma	120-30-80	5	6.15	-	-	-	-	-
6	Fmb	120-60-40	1	6.50	-	-	-	-	-
6	Fmc	100-30-80	4	5.54	0	40	0	30	30
Chulla Puk Do									
1	Apa	100-60-40	10	4.78	40	30	0	30	0
1	Apa	100-60-80	10	4.74	50	50	0	0	0
1	Apa	120-60-80	24	5.52	(50	0	50	0	0
					(60	0	0	40	0
1	Apa	120-60-40	24	5.43	40	30	30	0	0
1	Apb	100-60-40	4	5.22	40	30	0	15	15
1	Apb	120-30-40	4	5.27	-	-	-	-	-
1	Apc	120-30-40	2	6.18	50	0	50	0	0
1	Rab	100-60-80	2	5.39	-	-	-	-	-
1	Fma	100-60-80	17	4.62	(40	0	0	30	30
					(50	0	50	0	0
1	Fma	120-30-40	46	5.15	60	40	0	0	0
1	Fma	120-60-80	4	5.33	40	30	0	15	15
1	Rxa	100-60-80	1	5.14	(	-	-	-	-
1	Fmb				(60	40	0	0	0
2	Apb	100-60-80	2	5.58	-	-	-	-	-
2	Apc	100-60-80	5	5.92	-	-	-	-	-
2	Rab	100-60-40	1	5.86	-	-	-	-	-
2	Rab	100-60-80	1	5.36	-	-	-	-	-
2	Ana	100-60-40	3	5.67	50	50	0	0	0
2	Ana	100-60-80	4	5.60	-	-	-	-	-
2	Anb	100-60-40	4	6.18	50	50	0	0	0
2	Anb	120-60-40	4	6.04	-	-	-	-	-
2	Rxa				50	0	50	0	0
3	Apc	100-30-80	3	5.76	-	-	-	-	-
3	Ana	120-60-40	3	5.75	-	-	-	-	-
3	Anb	100-30-80	3	4.88	-	-	-	-	-
4	Apa	120-30-40	7	4.73	60	40	0	0	0
4	Apa	120-30-40	7	4.76	40	30	30	0	0
4	Apc	100-60-40	3	5.76	-	-	-	-	-
4	Apc	100-60-80	3	5.42	-	-	-	-	-
4	Apd	100-60-80	1	6.48	-	-	-	-	-
4	Ana	120-60-80	4	6.44	60	40	0	0	0
4	Anb	120-30-40	3	5.12	-	-	-	-	-
4	AFb	100-60-80	2	5.80	-	-	-	-	-

Table 8 cont....

Chulla Puk Do cont....

Cluster	Soil Series	Fertilizer rate - kg/ha	Rep.	Yield t/ha	Top dressing 1	2	3	4	5
4	AFb	120-60-40	3	4.89	-	-	-	-	-
4	Rxa	100-60-80	7	5.68	-	-	-	-	-
4	Rxa	120-60-40	6	5.39	-	-	-	-	-
4	Rea	120-30-40	1	5.33	-	-	-	-	-
Chulla Nam Do									
1	Apa	100-60-80	15	5.01	(50	50	0	0	0
					(50	0	0	50	0
1	Apb	100-60-80	2	5.79	50	50	0	0	0
1	Apb	100-60-80	15	4.84	40	30	0	0	0
1	Apc	120-30-40	8	5.61	40	0	0	30	30
1	Apc	120-30-80	8	5.42	-	-	-	-	-
1	Apg	100-60-40	4	4.65	40	30	30	0	0
1	Apg	100-60-80	4	4.64	-	-	-	-	-
1	AFb	100-30-40	5	4.70	40	30	0	15	15
1	Ana	100-60-80	6	5.32	40	30	0	15	15
1	Anb	100-60-80	3	6.33	40	30	0	30	0
1	Anb	120-30-40	16	5.25	-	-	-	-	-
1	Fma	100-30-40	8	4.79	40	0	0	30	30
1	Fmc	100-30-40	4	6.03	40	30	0	15	15
2	Apa	120-60-40	12	5.13	40	30	0	30	0
3	Apa	100-60-40	39	4.87	(40	30	0	15	15
					(40	30	0	30	0
					(40	0	0	30	30
2	Fma	100-30-40	3	5.24	-	-	-	-	-
2	Fmd	120-60-40	6	6.06	-	-	-	-	-
3	Apb	100-30-40	12	5.19	(40	30	0	30	0
					(40	30	0	0	30
					(40	30	0	15	15
3	AFb	100-30-40	8	5.00	(40	30	0	0	30
					(40	30	0	15	15
3	AFb	120-30-40	8	5.12	-	-	-	-	-
3	Fma	100-60-80	4	5.73	(50	0	0	50	0
					(60	40	0	0	0
3	Fna	100-60-80	4	3.92	-	-	-	-	-
4	Apb	100-60-80	4	4.78	-	-	-	-	-
5	Apb	100-30-80	2	4.29	-	-	-	-	-
5	Apc	100-60-80	5	4.97	50	0	0	50	0
5	AFd	120-30-40	1	5.05	-	-	-	-	-
5	Anb	100-60-40	3	6.04	50	50	0	0	0
5	Fma	100-60-40	6	4.48	40	30	0	30	0
5	Fmd	100-30-80	5	3.99	-	-	-	-	-
5	Fmd	100-60-80	5	3.80	-	-	-	-	-

Table 9

RECOMMENDED FERTILIZER LEVELS FOR BARLEY, PER SOIL SERIES, IN KG/HA OF NUTRIENTS (1964/65 - 1967/68)

Soil Series	N	P	K	Expected Yield (ton/ha)
Baeg San	130	100	80	4.72
Ban Cheon	130	80	80	3.62
Bang Gi	130	100	40	3.80
Ban Ho	70	100	40	1.99
Ban San	110	90	80	3.33
Bong Gye	120	60	60	4.26
Bong Ryang	90	60	80	3.09
Chang Pyeong	100	60	40	3.12
Dae Gu	90	60	60	4.63
Dal Cheoen	120	60	40	3.10
Gag Hwa	100	50	60	3.64
Gwang San	80	60	60	3.38
Hag Seong	70	100	40	3.15
Ho Gye	120	80	80	3.60
Ho Nam	70	80	80	3.06
Hwa Bong	90	60	60	3.24
Hwa Dong	120	40	20	2.39
Hwang Yong	120	90	40	4.02
I Hyeon	120	60	40	3.84
I Weon	90	60	60	4.11
Jang Weon	120	60	60	3.65
Jeon Nam	120	60	40	2.74
Nag Dong	110	70	60	2.94
Sa Chon	120	80	80	3.51
Sam Gag	120	60	40	2.69
Seong San	90	70	60	4.04
Seog Gye	100	75	40	3.82
Si Rye	100	60	40	5.44
Song Jeong	120	90	40	3.60
Su Bug	120	60	60	3.38
Tae Hwa	120	60	40	3.88
To Gye	110	100	50	2.81
Tong Cheon	90	50	40	2.20
Yong Ju	120	80	70	3.33
Average	110	80	50	3.37

Table 10

RECOMMENDED FERTILIZER LEVELS FOR WHEAT PER SOIL SERIES, IN KG/HA OF NUTRIENTS

Soil Series	N	P	K
Ban Cheon	118	96	60
Bon Ryang	142	100	56
Dal Cheon	105	100	20
Deog San	113	75	60
Gag Hwa	116	85	60
Gwang San	130	86	60
Ho Gye	124	78	60
Ho Nam	97	87	40
Jeong Nam	119	50	40
Jeon Nam	100	78	40
Nag Dong	107	100	40
Shin Heung	123	100	40
Sin Jeong	70	50	30
Si Rye	70	121	0
Tae Wha	94	45	75
Tong Cheon	140	140	60
Yong Ji	130	100	80
Average	100	80	60

Recommendations per districts are shown in the Appendix.

Table 11

RECOMMENDED FERTILIZER LEVELS FOR POTATO, PER PROVINCE, IN KG/HA OF NUTRIENTS

Province	N	P	K
Kyong gi	100	90	200
Chung puk	40	45	100
Chung num	40	45	100-200
Chulla puk	100	90	100
Chullanum	75	45	100
Kyong puk	100	45	100-200
Kyong num	40	45	200
Cheju	40-70	45	100
Average	90	90	100

- PADDY YIELDS WITHOUT FERTILIZERS (1964-1968) -

FIG. 1

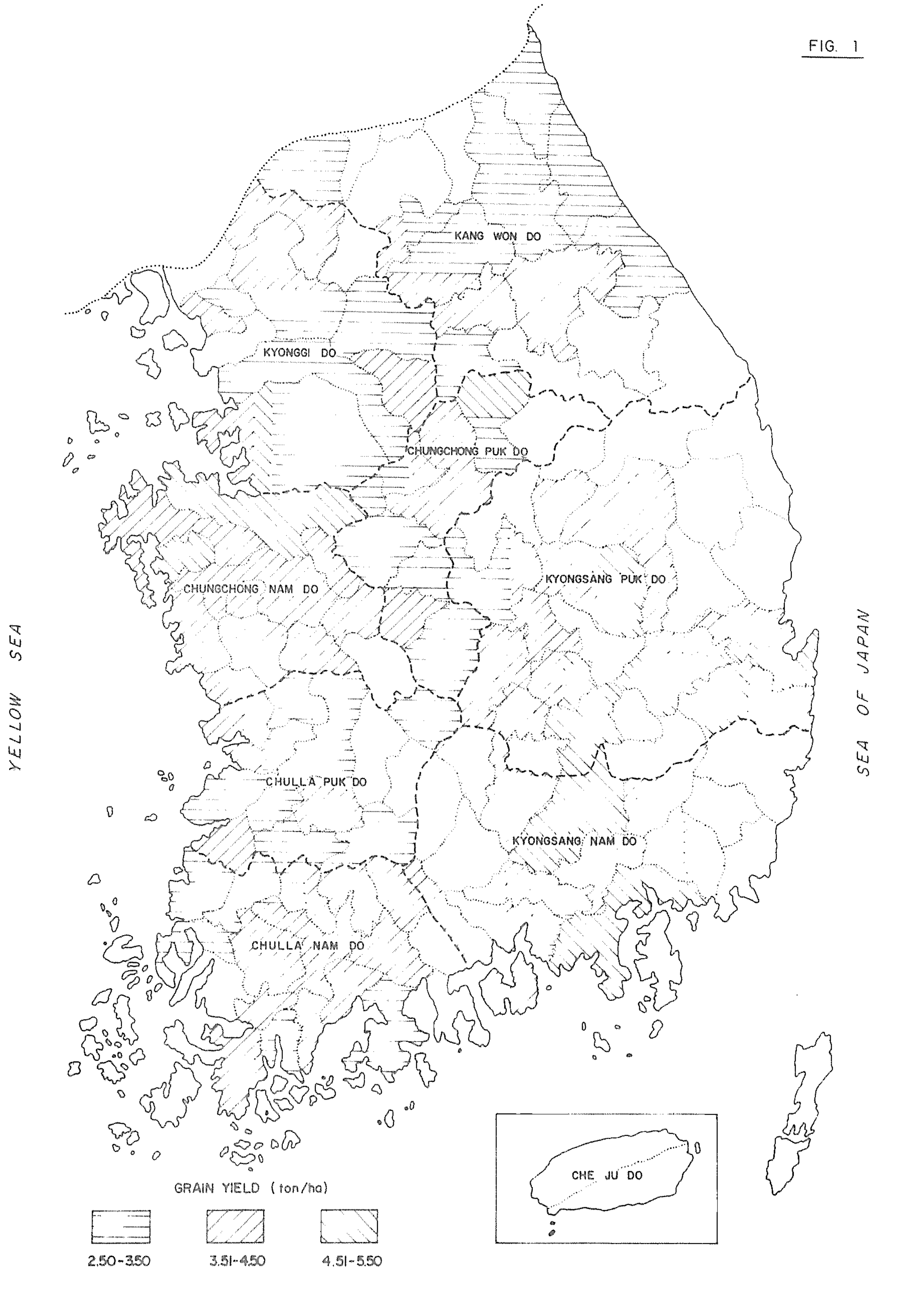


FIG. 2

HOURS OF SUNSHINE AND TEMPERATURES
DURING RICE GROWING SEASON IN THE NORTH (SUWON)

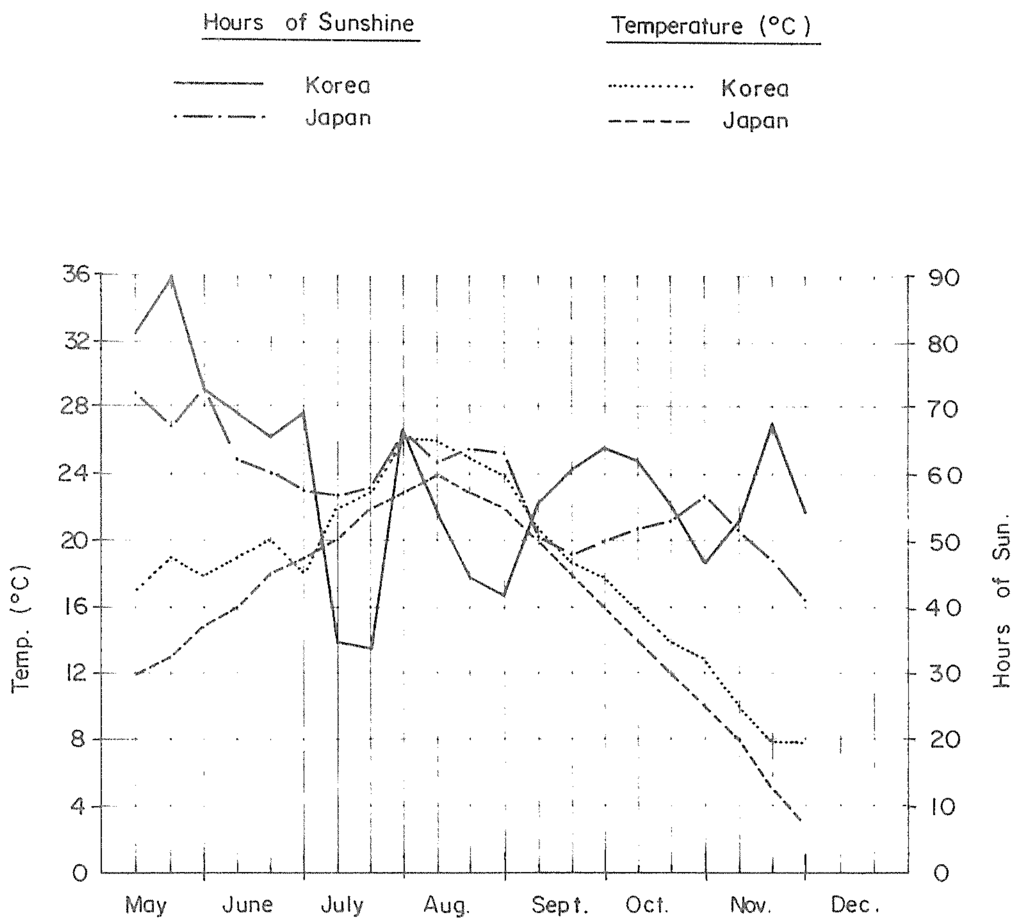


FIG. 3

HOURS OF SUNSHINE AND TEMPERATURES

DURING RICE GROWING SEASON IN THE SOUTH (KWANG SU)

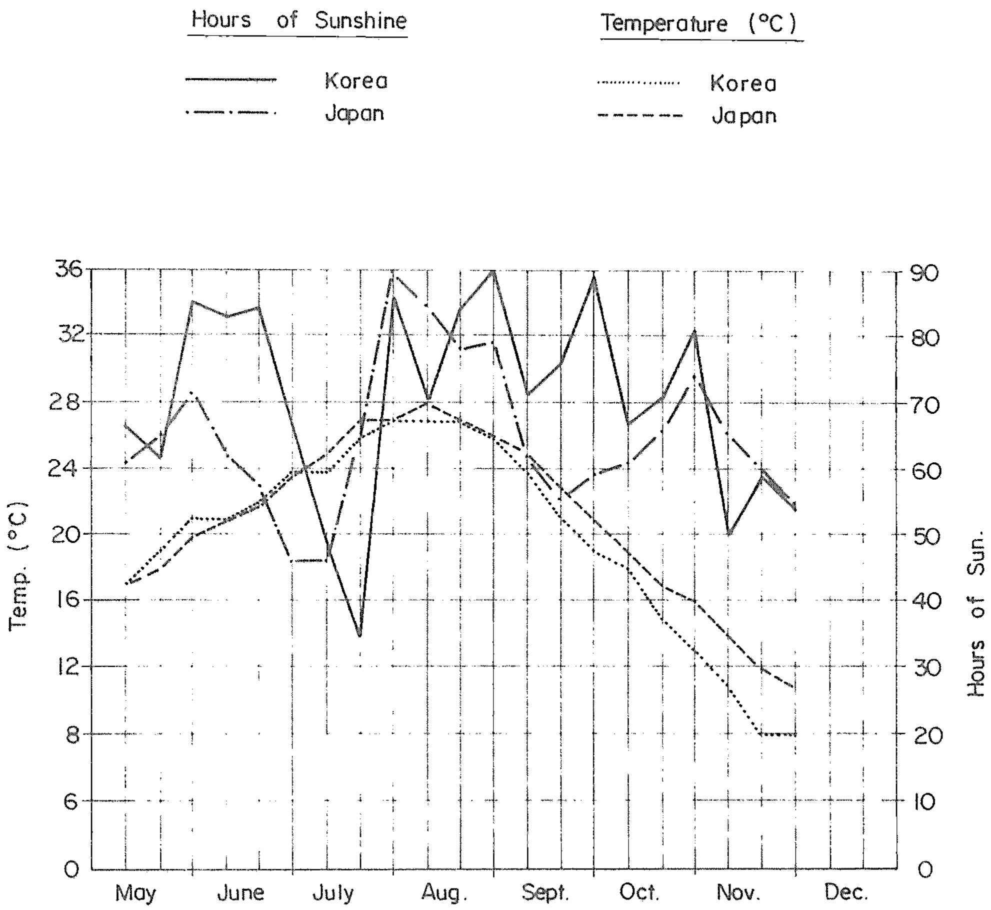


FIG. 4

COMPARISON OF PADDY YIELDS IN JAPAN AND KOREA

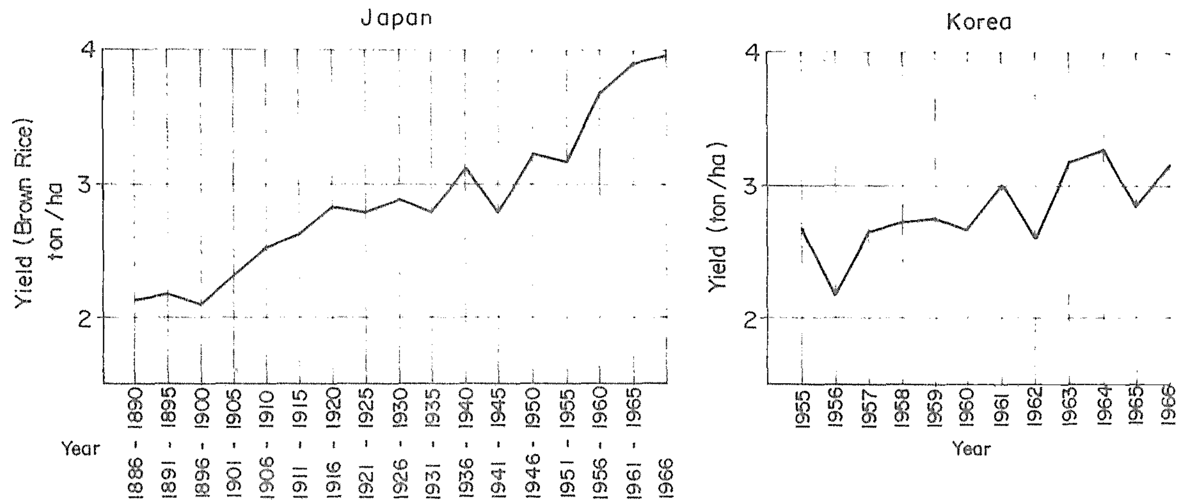


FIG. 5

COMPARISON OF FERTILIZER CONSUMPTION FOR RICE IN JAPAN AND KOREA

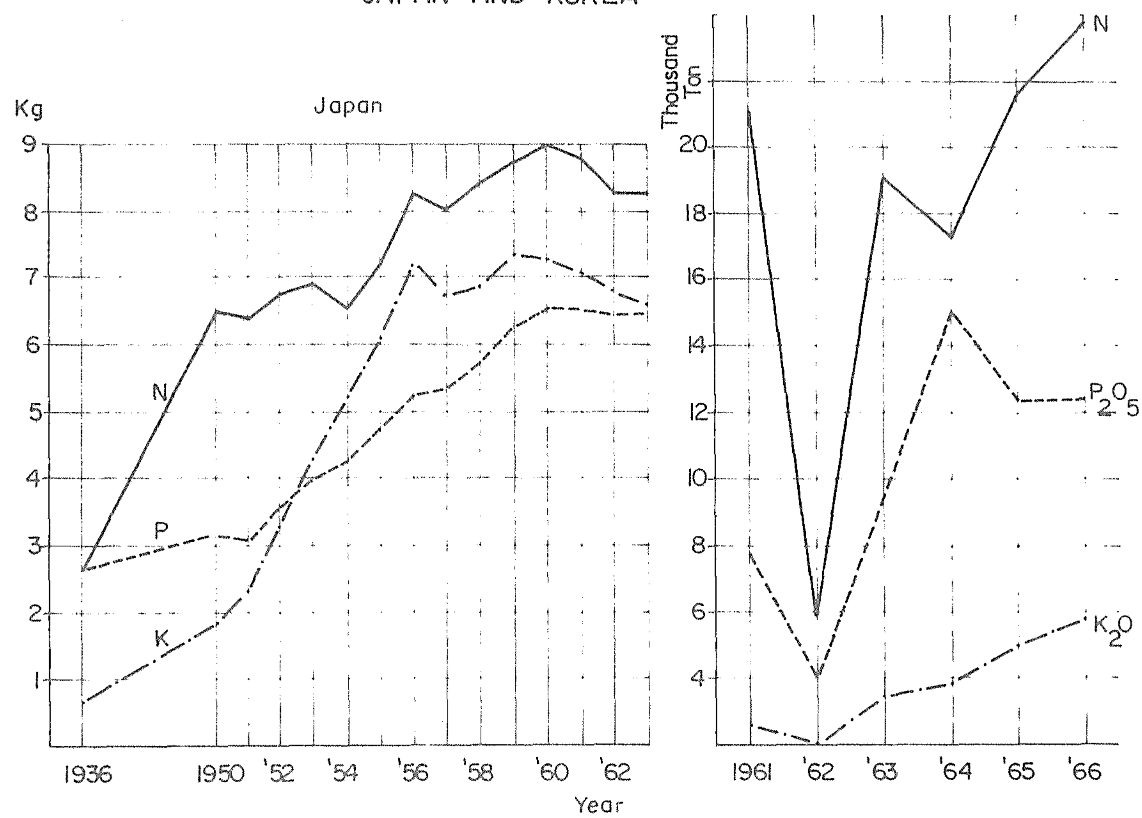
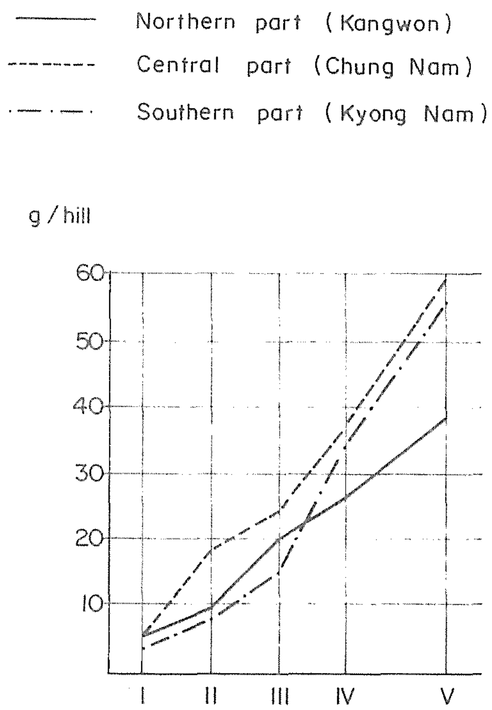


FIG. 6

REGIONAL DIFFERENCE IN DRY MATTER PRODUCTION OF RICE PLANT



STAGES OF SAMPLING

I	20 days after transplanting (Effective tillering stage)
II	30 days after transplanting (Maximum tillering stage)
III	Panicle initiation stage
IV	Heading period
V	Harvesting period

NUTRIENTS LEVEL AND PRODUCTIVITY OF UNFERTILIZED FIELD BY REGIONS AND NUTRIENTS

FIG. 7

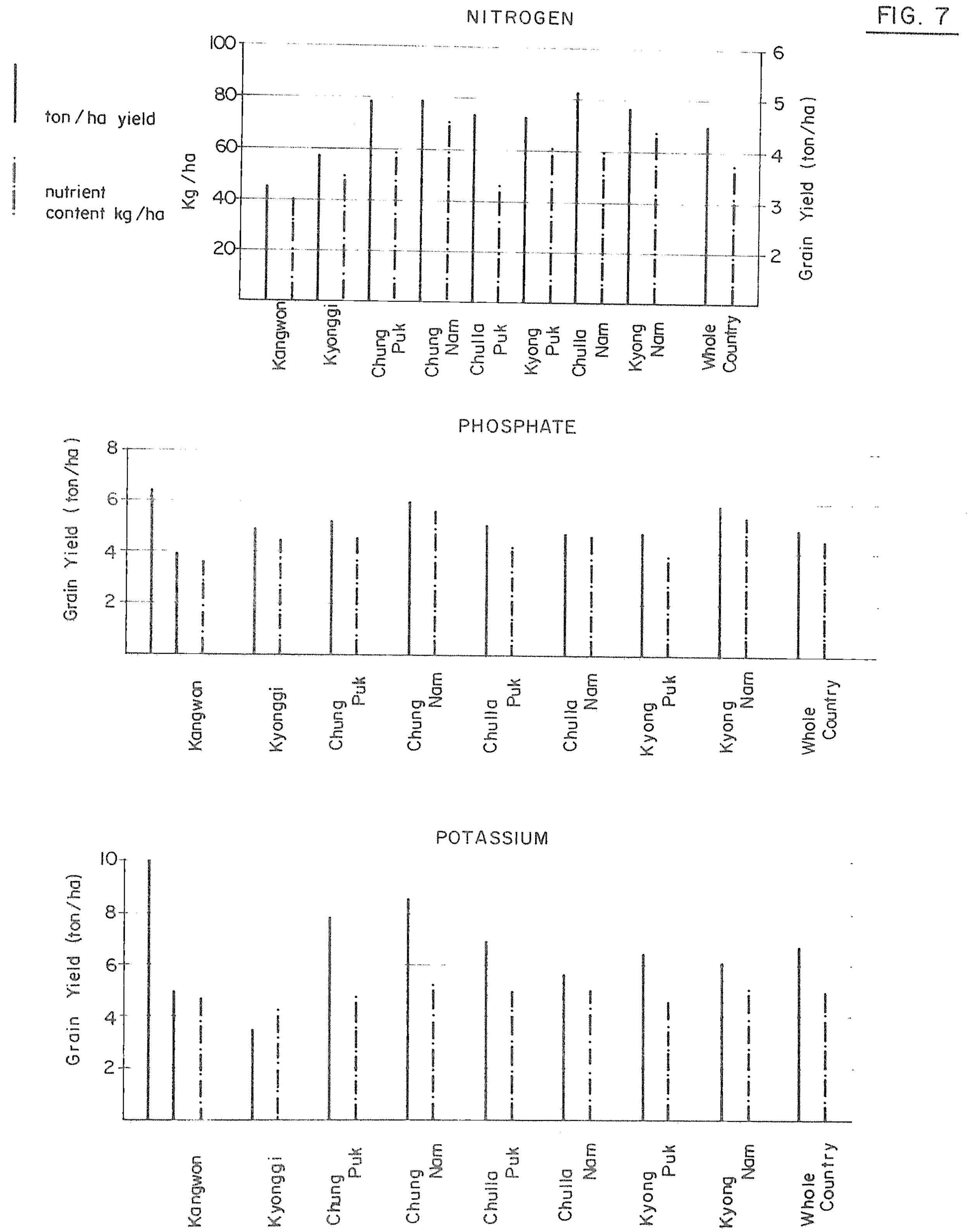


FIG. 8a

CHANGE IN NH_4-N IN SOIL DURING GROWTH PERIOD OF RICE UNDER NO FERTILIZER CONDITION

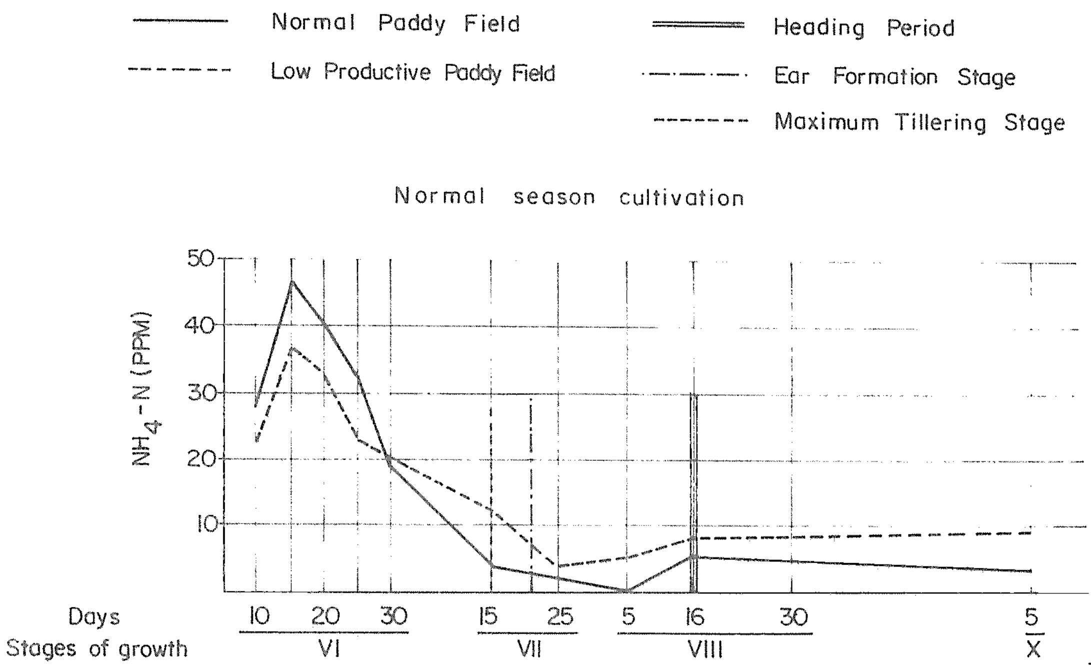


FIG. 8b

CHANGE IN NH_4-N IN SOIL DURING GROWTH PERIOD OF RICE UNDER FERTILIZER CONDITION

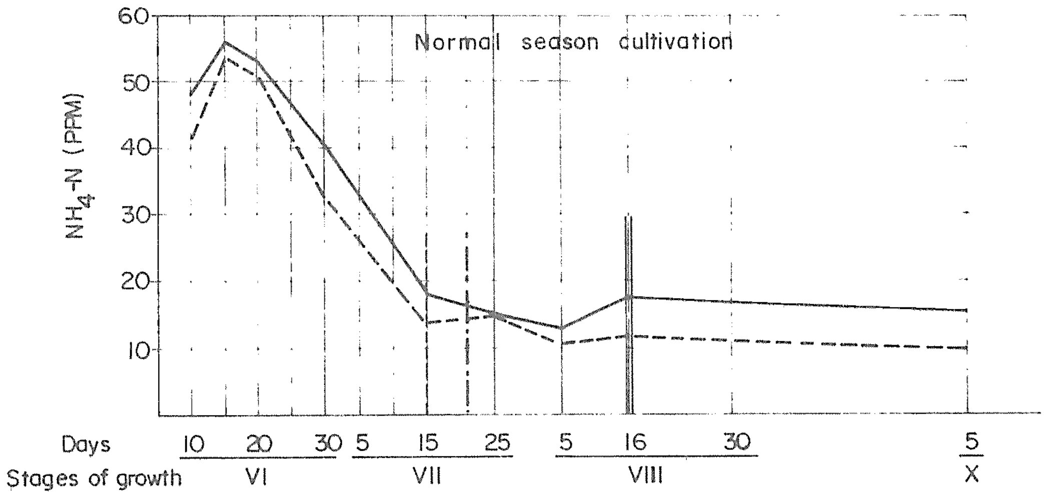


FIG. 9

CHANGES IN FE^{++} CONTENT IN VARIOUS SOILS FLOODED DURING RICE GROWTH

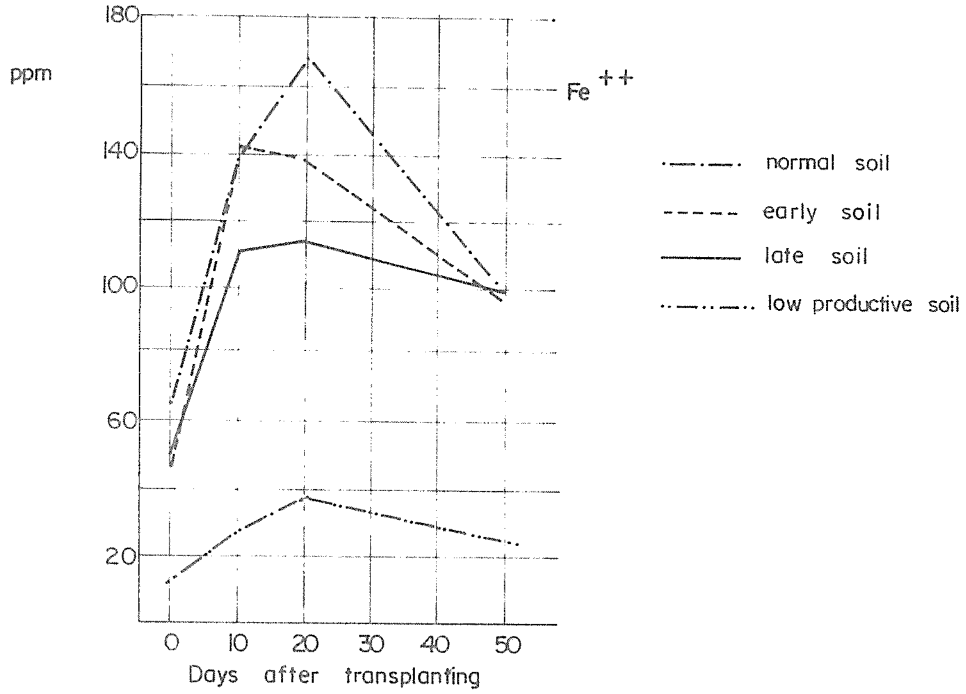


FIG. 10

CHANGES IN THE REDOX POTENTIAL(E.H) IN SOIL ACCORDING TO TRANSPLANTING DATE OF PADDY

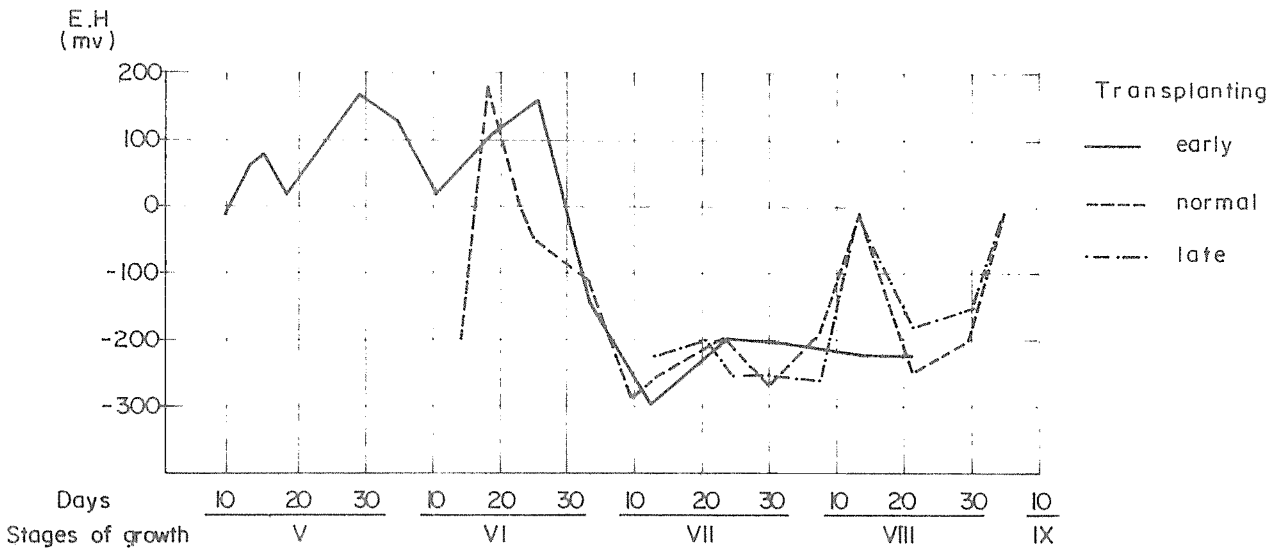


FIG. 11

REGIONAL DIFFERENCES IN NITROGEN CONTENT OF RICE PLANT AT PANICLE INITIATION STAGE AND HEADING PERIOD

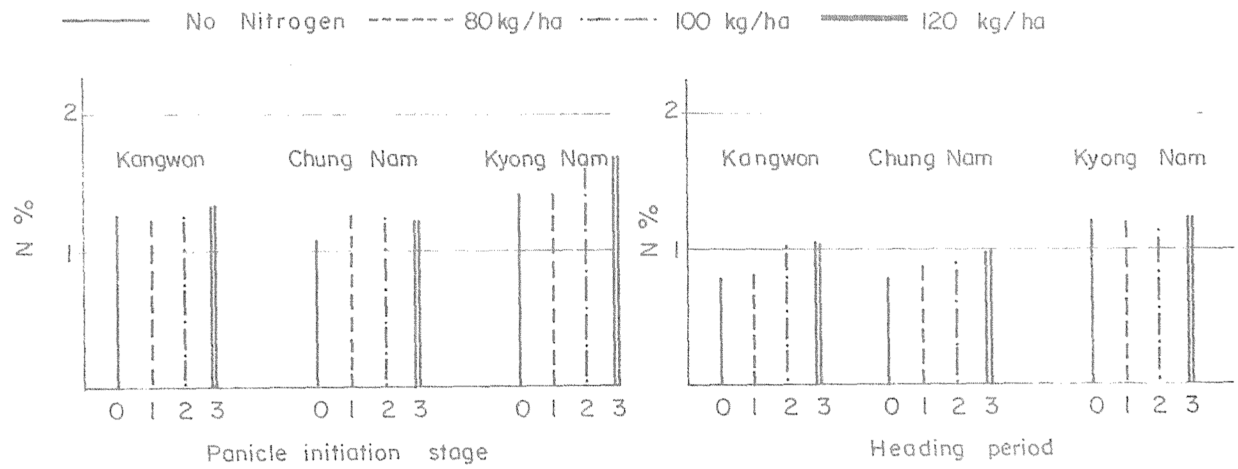


FIG. 12

REGIONAL DIFFERENCES IN TOTAL AMOUNT OF NITROGEN ABSORBED BY RICE AT HARVESTING TIME

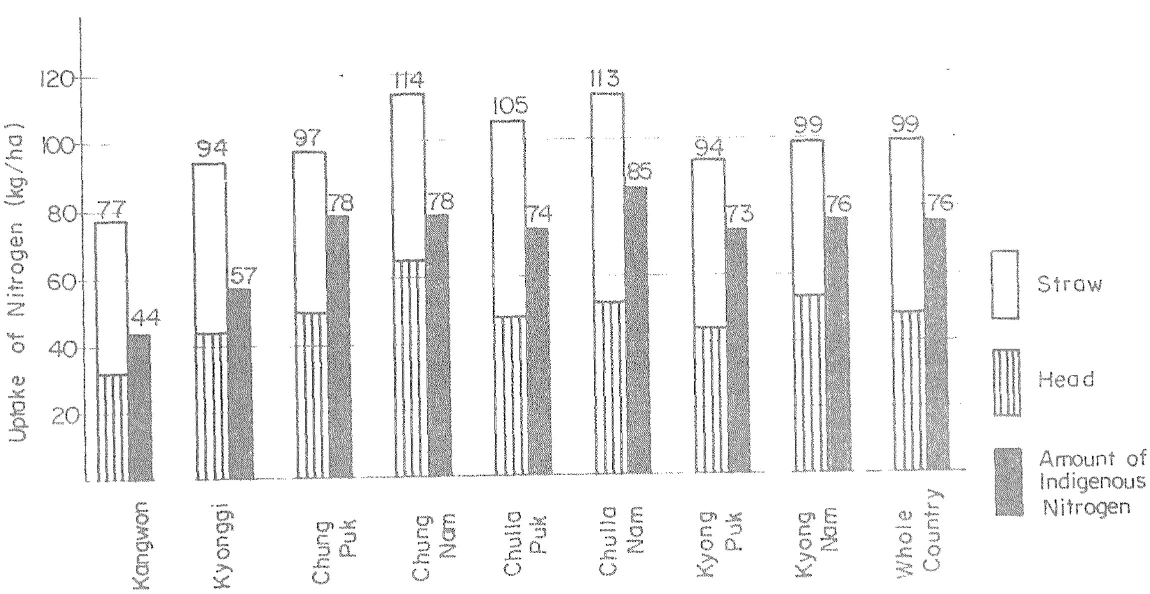


FIG. 13

REGIONAL DIFFERENCES IN RATE OF RICE NITROGEN UTILIZATION AT THE LEVEL OF 100 kg./ha NITROGEN (1967)

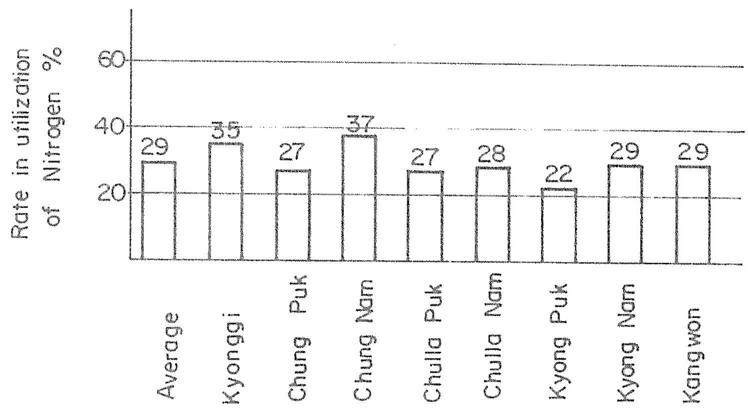
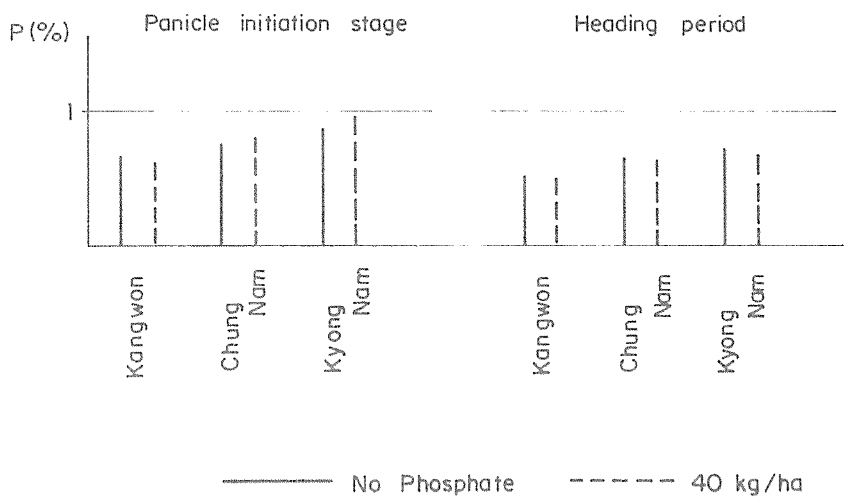


FIG. 14

REGIONAL DIFFERENCES IN PHOSPHATE CONTENT OF RICE PLANT AT PANICLE INITIATION STAGE AND HEADING PERIOD



EFFECT OF PHOSPHATE ON PADDY YIELD IN PRESENCE OF N AND K
SHIGA AGRICULTURAL EXPERIMENT STATION

FIG. 15

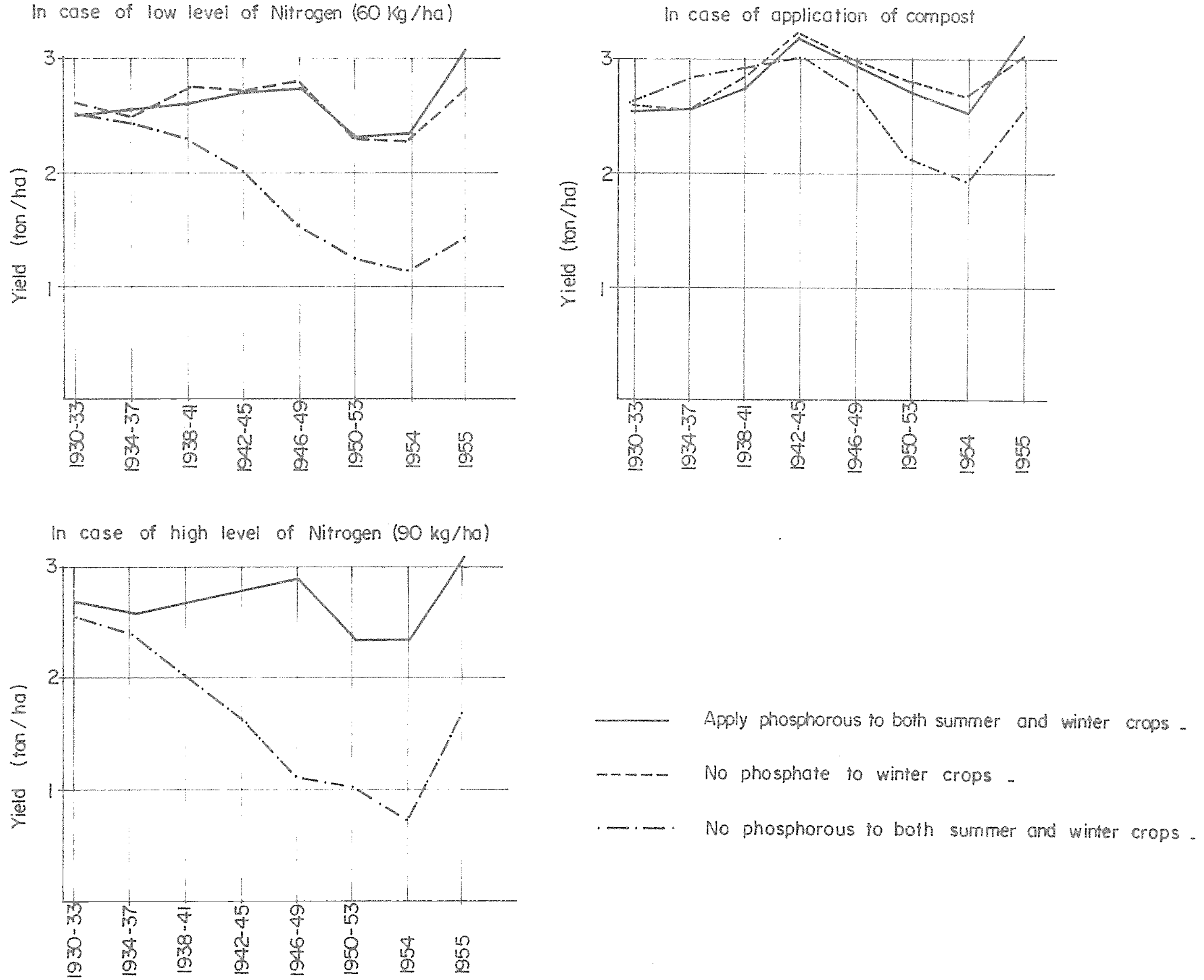
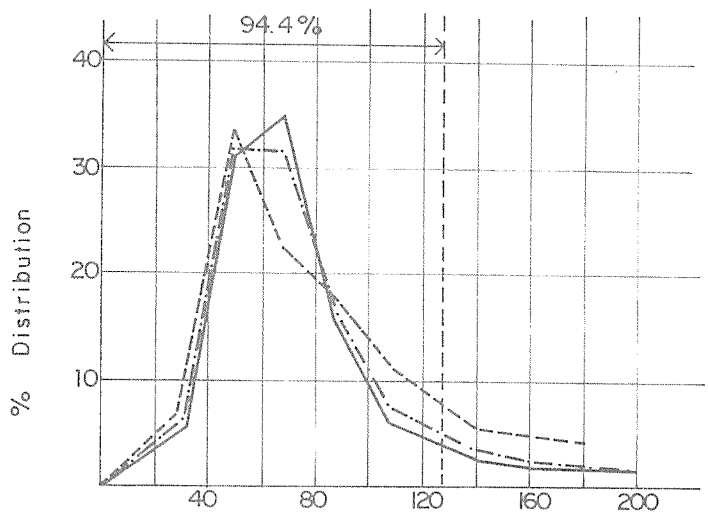


FIG. 16

- AVAILABLE SiO_2 PPM IN SOILS OF KOREA -



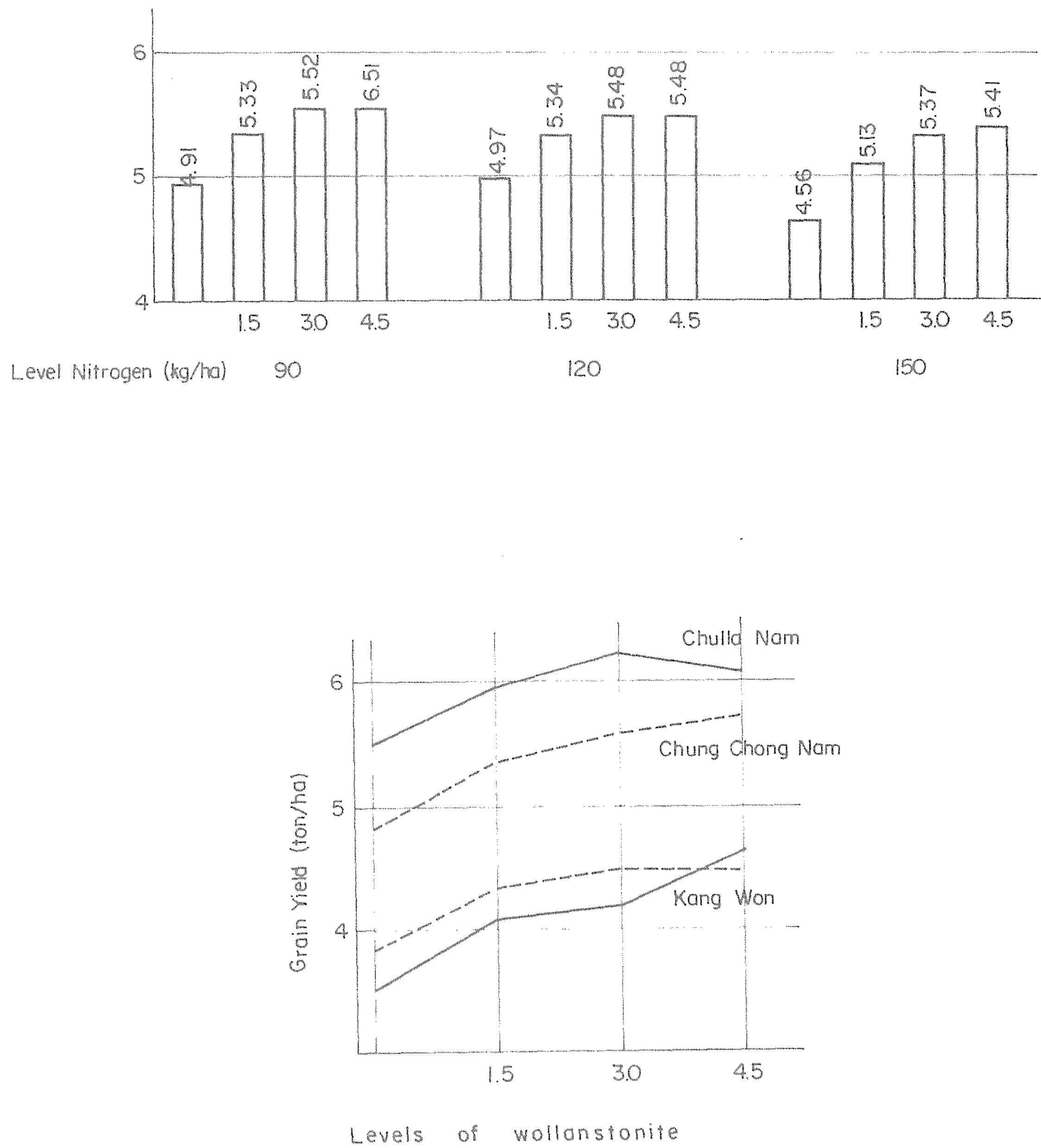
———— NPK Rates Trial (262)

- - - - - - Low Productive Area (105)

·—·—·—· Upland and Paddy Field (367)

FIG. 17

EFFECT OF WOLLANSTONITE ON RICE YIELD IN THE PRESENCE OF DIFFERENT LEVELS OF NITROGEN (1967)



Appendix 1

DETAILED RESULTS OF FERTILIZER TRIALS
ON VARIOUS CROPS

TABLE OF CONTENTS

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GENERAL

The experimental results have been stratified according to regions, provinces, varieties, soil groups and series. The experiments were repeated for six years in order to observe the effects of the varying weather conditions on the crop responses to fertilizer. Greatest emphasis was given to the response to N in the presence of P and K, in order to formulate economic recommendations to farmers on optimum fertilizer use. In addition to the study of the variability in the responses through the analysis of variance, response curves and surfaces were also traced.

Treatments were chosen taking into account also the promotional aspect. Farmers, in fact, could appreciate the promising results of the experiments which were conducted in their own fields.

1. PADDY

1.1 Geographical Differences in Yields and Responses to Fertilizers

Due to geographical differences in grain yields and responses to fertilizers, Korea was divided in three climatological areas: north, centre and south. The north has low mean temperatures during late spring and early autumn; the centre is a little warmer and drier; the south is relatively warm in spring and autumn but temperate in summer.

In the north the growing season of rice, almost always belonging to long duration varieties, is reduced. As a consequence (see Table 1), in the north the average control yield is 3.13 tons/ha, against 3.82 and 3.96 tons/ha respectively in the centre and south.

With a standard application 120-45-60 kg/ha yields increased about 43 percent in the north, 30 percent in the centre and south.

Of the total response to fertilizers, the response to 120 kg/ha of N alone was 86 percent in the north, 88 percent in the centre and south. It was in fact, on the average, more than 1 ton/ha with a very high economic return. This may explain the practice of local farmers who use N alone.

The responses to P and K appeared to be rather consistent in the centre and south, when higher levels of N were applied. In the north, these responses tended to decrease with increasing levels of N, even though the magnitude of the responses remained considerably larger than in the centre and in the south. Application of 40 kg/ha of P and 60 kg/ha of K together with 120 kg/ha of N gave an increase of 140 kg/ha of yield in the south and 190 kg/ha in the north.

Tables 1 and 2 show the responses of rice to different levels of N with and without P and K in the three regions.

1.2 Response of Different Rice Varieties to Fertilizers

Although responses to N differed with varieties and locality, it can be said that most of the rice varieties commonly grown in Korea are not very responsive to N, and thus cannot be defined as high yielding. Most common varieties are: Nang Lim 6 and 25, Pal Kweng, Jin Heung and Pal dal. Among these only Nang Lim 6 and Pal Kweng are found to be relatively consistent in their responses to fertilizers. The increase over control, average of several years, due to 120 kg/ha of N with adequate amounts of P and K, was about 30 percent. With higher N levels, the number of panicles and that of spikelets per panicle still increased giving increasing yields. In the other varieties, excess of N provoked reduction on the 1 000 grain weight, as well as diseases and lodging.

This low response to N might be due to soil characteristics. Most of paddy soils in Korea are derived from granite and have low cation exchange capacity and organic matter content.

In order to improve the production of the available recommended varieties other measures can be adopted such as:

i) application of balanced fertilizer rates according to soil;
ii) establishment of cultural practices aiming at the higher production of effective tiller during early stages of growth;
iii) proper timing of fertilizer application to maintain adequate nutrients supply to plant during reproductive stage of growth and to increase the efficiency of N;
iv) improvement of low productive soils with lime, wollastonite, composts and micro-nutrients application; and
v) appropriate water management.

The locally practised density of planting (72 hill per pyong, 30 x 15 centimetres(cm)) proved to be the best. In fact, only in the Kyonygi Province was a significant increase in yield obtained with increased density of planting (see Table 4).

1.3 Response of Rice to Fertilizer in Different Soil Groups

Paddy land in Korea was classified into 13 soil groups recognized by a soil survey. Of these, nine are well represented and together account for more than 96 percent of the area under rice. Soil groups and their characteristics are listed in Table 5, and the responses to N, P and K have been stratified in Table 6. From the observation of the two tables it appears that in all soil groups there was a significant response to the 20 additional kilogrammes of N from 80-100 kg/ha with the exception of the acid sulphate soils of group FmK. Experiments with amendments such as lime and wollanstonite gave considerable increases in yield. The addition of 20 kg of N from 100 to 120 kg/ha gave results only in the Afa, Apb and Apb groups. Largest responses were recorded in the Rac and Rxa groups. In the latter, rice response to P was the highest. Rice response to K was positive but smaller than that of N and P, except that in the north, application of increasing levels of K increased the unit response to P (see Table 11). Similarly, increasing levels of P increased the unit response to K.

The nature of the rice response to fertilizers in different soil groups was studied through response surfaces fitted to the respective data (see Table 7). The observation of the response surfaces in the three main regions indicated the existence of positive interactions between N and P as well as between P and K (see Table 8). However, the magnitude of the interactions was not significant.

1.4 Response of Rice to Fertilizers in Different Soil Series

Paddy land was further subdivided in some one hundred soil series.

Experiments were conducted on about 40 of them, including the twelve most common ones, which account for nearly 64 percent of the total area. The percentage of total area they respectively occupy is given, among other data, in Table 9.

Generally, response to N was consistent and similar, although the magnitude of the responses varied considerably with the locations and the year.

Remarkable differences among responses in different places could be observed only occasionally for N, but more frequently for P and K.

When the highest response was that to 80 kg/ha of N, no significant responses were recorded with increasing application of P and K. Where higher N levels gave increasing yields, relatively large and consistent responses to P and K were obtained.

1.5 Economics of Fertilizer Use on Rice

The results in Table 10 show that as an average for Korea the unit response to the additional 20 kg/ha of N from 100 to 120 increased when also adequate amounts of P and K were applied. This proved that the largest yield increases are obtained with a complete, balanced application. It may be worth noting that not always lower V/C ratios corresponded to high fertilizer rates. Yearly results are detailed in Table 10. The fertilizer levels underlined gave the highest return for unit of investment.

1.6 Optimum Fertilizer Levels per Province, Region and Soil Group

For the formulation of sound plans for fertilizer distribution, the knowledge of the optimum N, P and K levels per province has great practical importance. Response surface equations (see Table 11), fitted to the data averaged over the period 1965-69, were used to calculate the optimum levels given in Table 12. Only in two provinces, Chulla Puk and Chulla Nam did the optimum N level exceed the 120 kg/ha, being, in fact, 140-88-55. Over the rest of the country, optimum average fertilizer level was 120-60-70 kg/ha.

The optimum levels given per province in Table 12 were combined together: for regional evaluation in Table 13, and for soil groupings in Table 14. From the observation of the tables it appears that the requirements of N and P are slightly higher in the north than in the centre and south. Differences, however, are small.

In all cases the use of the optimum rates of N, P and K results in a considerably higher economic benefit than N alone as mainly used by farmers at present. The additional gains are shown in Tables 15, 16 and 17.

2. UPLAND RICE

Upland rice is mainly grown under rainfed conditions in the Cheju island. Compared to lowland paddy, yields and responses are much smaller. However, substantial responses to N, P and K were obtained (see Tables 18 and 19), and there is evidence of a positive interaction among nutrients. With the use of fertilizers, the yield can be raised from 1.07 to 2.4 tons/ha. The optimum level 100-60-40 kg/ha gave gross profits between 45 000 and 50 000 Won (between $145 and $161) with a V/C ratio over six.

At the time of application of N it had a remarkable influence (see Table 20). By splitting the N application into 40 percent as basal dressing, 30 percent as top dressing 15 days after transplanting and 30 percent at ear formation stage, yield increases of up to 20 percent higher than with the local practice of half at transplanting and half after 15 days, were obtained.

3. BARLEY

3.1 Geographical Differences in Yields and Responses to Fertilizers

The yields of control plots of barley, average of the period 1964-69, were stratified per region in Table 21 and per province in Table 22. They are in the north about 1 ton/ha with large annual variations due to temperature, drought and poor productive soils. In the centre and south the yields were less fluctuating and at least 1.5 ton/ha. The response to N was larger in the south, those to P and K were larger in the north (see Tables 23 and 24 and Figures 1, 2 and 3).

No additional response to increasing levels of N from 60 to 80 kg/ha was recorded in any region, but in the centre and south, significant yield increases were obtained by increasing N level from 90 to 120 kg/ha.

Positive interaction among nutrients, mainly between P and K in the north was evident. Yields were always smaller in the north than in the south.

For planning the fertilizer distribution scheme, the responses of barley to fertilization have been stratified in a provincial basis in Tables 25, 26, 27, 28 and 29.

Substantial yield increases were obtained by increasing P levels from 80 to 100 kg/ha with the exception of Chung Chang Puk province where best results were obtained with 50 kg/ha of P. Application of K gave similar results.

3.2 Response of Different Varieties of Barley to Fertilizers

Out of the 12 most common varieties, experiments were conducted during four years on seven (see Table 30), which were found to be fairly responsive to fertilizers and rather stable in production. The Suwon varieties, with the exception of Suwon 6, were the most responsive and gave the highest yields. The Boek-dong end Non sankwa varieties, also responded very well, and Bang ja was very stable and responsive.

On the average, these varieties would give a yield increase of 120 percent over control with an application of 120-75-60. Suwon 18 and 31 gave average yields very close to 4 tons/ha. Other varieties gave smaller and erratic responses (see Tables 30, 31, 32, 33 and 34).

3.3 Response of Barley to Fertilizers in Different Soil Series

The yields of control and fertilized plots are shown in Tables 35, 36 and 37. Average control yields were below 2 tons/ha; with adequate fertilization well above 3 tons/ha. Over the years, yields varied within the same series. This was probably due to weather conditions and the highly variable nature of upland soils.

Response curves were fitted to the experimental data in order to elaborate optimum fertilizer levels in different soil series (see Tables 38 and 39). With the application of the countrywise optimum level 105-70-55, a yield of 3.37 tons/ha could be expected, with a yield increase of 45 percent over the present control average (see Table 40).

3.4 Economics of Fertilizer Use on Barley

The economic analysis of the data showed that largest gross profits can be obtained in the north and centre with a 90-60-60 level (see Table 40). The use of the optimum level 105-70-55 proved to be highly profitable with a V/C ratio over five (see Tables 39 and 40).

3.5 Response of Barley to Liming

Soils on which barley is grown are generally acidic with pH lower than six. Liming proved very effective and in some places permitted the crop growth, which otherwise would have been impossible. Application of 6 tons/ha of lime increased the yield by about 55 percent. No definite relation was found between chemical soil characteristics and response to liming, which seemed to depend rather on status of moisture and method of application. In fact, with band application to the row before sowing, increases of 60 percent were obtained. Best rates of application varied between 4 and 6.5 tons/ha. Results of trials conducted in three provinces with different quantities of lime are given in Table 41.

4. WHEAT

4.1 Geographical Differences in Yields and Responses to Fertilizers

The area under wheat is increasing each year due to its profitability and government encouragement (see Table 42). It is usually grown as upland crop under rainfed conditions and yields are subject to regional as well as yearly fluctuations. Control yields in the centre and south can be 100 percent higher than those in the north (see Figure 4 and Table 43).

Responses of the order of 200 percent of control yield in the north and of 90 percent in the centre and south were obtained with application of optimum N levels which were respectively 100 and 130 kg/ha. In the centre and south a yield increase over control of 1.84 and 1.94 ton/ha could be expected.

4.2 Economics of Fertilizer Use on Wheat

Table 44 shows that P and K were also very effective mainly in the north, and optimum levels were respectively 100 - 80 in the north, 100 - 40 in the centre and 75 - 40 in the south. The positive interactions among nutrients made their application at higher levels still profitable (see Tables 45, 46 and 47). Best results were obtained, as already stated with higher P and K levels in the north.

4.3 Response of Different Varieties of Wheat to Fertilizers

Among the varieties of wheat commonly grown in the country, Yong Gwang and Nong Lim Ho appeared to be the most responsive to increasing levels of fertilizers. In all varieties but Yuk Sang 3, response to P was smaller than to N. Response to K was in general small and uncertain (see Table 48). All varieties showed similar potential, however they yielded more when grown in the south.

4.4 Response of Wheat to Fertilizers in Different Soil Series

Wheat responded generally better to N in most soil series at the level of 100 rather than at 70 kg/ha. The increase in yield due to additional 30 kg/ha, from 100 to 130, although smaller, was still profitable. Response to P followed the same pattern while response to K was very small (see Table 49). Optimum levels per soil series are given in Table 50. However, the responses were so erratic that the need for further investigation is strongly felt.

4.5 Response of Wheat to Fertilizer in Different Provinces

For distribution planning purposes the provincial responses were studied. Table 51 shows that in the southern provinces the crop might be very profitable. In fact, responses exceeding 2 tons with a total yield over the 4 tons/ha were obtained. In the north, although the responses were of the same order, total yields averaged only 3.5 tons/ha.

5. RAPE SEED

5.1 Geographical Differences in Yields and Responses to Fertilizers

This oilseed crop is gaining in importance and now extends from the Cheju island into the mainland southern provinces. Table 52 shows that average control yield is generally below 1 ton/ha but 2 tons/ha can be reached with fertilization. Yearly response variations are rather large. The crop responds better to N than to P and K. The unit response to 90 kg of N in the presence of 140 P and 60 K was about 12 kg of rape seed per kilogramme of N.

The unit response to P at the level of 185 kg/ha was six, to K at 80 kg/ha it was three (see Table 52).

5.2 Economics of Fertilizer Use on Rape

When applied at relatively high levels fertilizers were highly profitable with returns of over 400 percent. Largest profits were obtained with high P levels (see Table 53). The most promising fertilizer levels were 90-185-60, 70-185-80 and 70-185-60.

5.3 Rape Response to Boron Application

Experiments on the effectiveness of Boron application to rape were carried out in Chulla Puk and Chulla Nam provinces and in the Cheju island. In the last mentioned, the response was insignificant, while in Chulla Puk and Chulla Nam 20 kg/ha of Boron in the presence of 120-100-90 further increased the yield by about 100 percent (see Table 54).

6. SOYABEAN

Mainly grown as cash summer crop in the uplands, soyabean is cultivated over about 300 000 ha of land. The yearly production is about 200 000 tons of beans. Fertilization is seldom practised and is then generally limited to the use of compost. In spite of its elevated resistance to soil acidity, yields may be affected by low pH.

6.1 Soyabean Response to Fertilizer

Liming increased the yields by 20 percent, but the liming efficiency decreased with N P K application (see Table 55).

Soyabean response to fertilizer was erratic, however, as expected, generally better to P than to N. Response to liming was higher than to both N and P, probably because soil acidity limits the formation of the bacterial nodules in the root. Liming proved effective also in controlling the micro-nutrients deficiency symtoms which appeared under dry weather conditions.

6.2 Economics of Fertilizer Use on Soyabean

As shown in Tables 56, 57 and 58, use of fertilizers was economic but, even in the most favourable years, gross profits were small. This prevented farmers from increasing N P K levels on the crop, since liming was more economic. The same results of a direct application of P and K can be achieved through the residual effects of the fertilizers applied to the previous crop, e.g. barley.

7. ITALIAN MILLET

This crop requires warm weather and the cultivation is therefore limited to the well drained, fertile soils of the south which are rich in organic matter. Yields were subject to wide variations according to soil and climatic conditions.

7.1 Response of Millet to Fertilizer

Table 59 shows that high responses to N were obtained with the 60 kg/ha level, while responses to P and K were insignificant. However, complete and balanced fertilizer application at the level 100-80-80 gave the highest response. Due to the practice of applying fair amounts of compost to the crop, response to chemical fertilizers was limited on Cheju island to about 30 percent over control.

7.2 Economics of Fertilizer Use on Millet

Fertilizer application to millet proved highly economic with returns in some cases being above 700 percent (see Table 60). The countrywise average was however somewhat smaller. With the recommended application of 100-80-80 returns of 387 percent can be expected. It is also possible to decrease the P and K levels without affecting excessively the production or the profit (see Table 61).

8. MAIZE

This crop, although recently introduced, is expanding at a fast pace, particularly on the uplands and on the newly reclaimed soils of the foothills. It is mainly used as feed for the growing poultry industry. Yields fluctuate according to weather conditions. Control yields are very low, with an average of only 1.77 ton/ha.

8.1 Maize Response to Fertilizer

Responses to N and P were similar and higher than to K. There was no evidence of interaction among nutrients. With adequate fertilization, increases of the order of 220 percent of a total yield of 5.6 tons/ha were possible (see Tables 62 and 63).

8.2 Economics of Fertilizer Use on Maize

With the optimum level of 150-125-110, returns of about 500 percent were obtained making fertilizer use on maize very profitable.

9. WHITE POTATO

This crop is mainly grown in the provinces of Kyong Sang Puk and Kangwon and to some extent also in Kyong Sang Nam province. While in the north it is grown mainly in the uplands, in the south the crop is grown also in rotation with paddy. The area is expanding each year.

9.1 Response of Potato to Fertilizer

The country's average control yield is about 9 tons/ha, being higher in the uplands than in paddy fields. However, with fertilizer application, the total yields tend to equalize around 20 tons/ha with a yield increase of about 120 percent (see Table 64).

9.2 Economics of Fertilizer on Potato

With the application of the optimum level of 120-90-150, returns in the order of 1 500 percent can be obtained, thus making fertilization extremely profitable (see Table 65). Wide areas at present under less economic crops in the northern uplands could be used for potato farming to the great economic advantage of the local farmers.

10. SWEET POTATO

This crop is also mainly grown in uplands under rainfed conditions. The average control yield is 16 tons/ha and varies between provinces and years according to weather conditions.

10.1 Response of Sweet Potato to Fertilizer

The responses to all three nutrients were very large, mainly to N and P, which increased with increasing levels of application (see Tables 66 to 71). At the level 80-90-210 the average unit responses were respectively 99, 93 and 37 per N, P and K. Highest responses were recorded on the Cheju island where, at the same level, unit response became 144, 130 and 50 respectively. In the southern provinces, where control yields were higher, the magnitude of the responses was smaller.

10.2 Sweet Potato Response to Fertilizer in Newly Reclaimed and Older Upland Soils

Both yields and responses were lower in newly reclaimed soils than in older soils (see Table 72, 75 and 76). It was in fact necessary to increase the levels of application of N and P to obtain from newly reclaimed soils yields comparable to those of the other soils.

10.3 Economics of Fertilizer Use on Sweet Potato

Among all crops under experimentation, sweet potato gave the highest returns. Gross profits were also very large (see Tables 73 to 76). With the application of the recommended level, yield increases in the order of 6 tons/ha, corresponding to returns above 900 percent, can be expected.

11. FORAGE CROPS

A large number of experiments were carried out on several forage crops such as Italian rye grass, ladino and red clover, alfalfa, oats and orchard grass, to identify the areas most suitable for their farming. The growing of these crops is strongly encouraged by the Government in view of the expansion of the livestock industry. Experimental results, in terms of dry matter production, indicate that some areas are more suitable than others.

11.1 Italian Rye Grass

The results in Table 77 show that, while in the north the dry matter production was only 5 tons/ha, in the south it was above 10 tons/ha. Yields were extremely affected by weather conditions, mainly by the amount and distribution of precipitation.

11.2 Ladino Clover

This clover requires somewhat better soil than the common white clover, therefore, in the newly reclaimed soils where the experiments were performed, yields were very low. Also response to fertilizer was disappointing, being barely noticeable as regards N, while being nil to P and K (see Table 78).

11.3 Alfalfa

Dry hot climate and deep, fairly productive, well drained, nonexcessively alkaline soils were found to favour the growth of alfalfa. Newly reclaimed soils on which experiments were located proved unsuitable. Yields were generally low and only in the Kyong Sang Puk province reached the 5 tons/ha (see Table 79) The crop responded well to application of N, with a unit response of 135. Responses to P and K were negligible.

11.4 Oats

The cultivation of this crop is very limited and practised only in the central and northern provinces. The grain is used for fodder, and the straw for litter, mainly for cattle and hogs. Results in Table 80 show that in the central provinces yields of 15 tons/ha can be achieved while in the warmer south yields are very low. Response to fertilizers was maximum at levels of 200-40-30.

11.5 Orchard Grass

This forage crop proved suitable to almost all kinds of soils and resistant to drought. In some cases even four cuttings were possible and the dry matter production rose from 3 to 13 tons/ha.

High responses to N were obtained by raising the level from 150 to 300 kg/ha. Smaller but significant responses were also obtained by increasing the levels of P from 150 to 200 and those of K from 200 to 300 kg/ha (see Table 81).

In the northern part of the Cheju island, where weather conditions are more moderate than in the mainland, the yields were 50 percent higher. The highest dry matter production was achieved with the rate of 300-200-400 kg/ha.

11.6 Red Clover

Most suitable areas for red clover farming were those with abundant rainfall and moderate temperatures both in winter and summer. It can be grown successfully in all soils in which maize can grow, that is mainly on rather heavy, well drained, deep productive soil, rich in lime and organic matter. Soil moisture conditions are also very important. Imported seed did not give satisfactory yields, probably due to lack of acclimatization. Yields varied very greatly between places with the highest yields being recorded in Chung Chong Nam province (see Table 82).

However, the experimentation on forage crops has been carried out only during one year and the results need further confirmation.

Table 1

RESPONSE OF RICE TO N, P AND K PER REGION

Region	Levels of P and K	Control (kg/ha)	N (kg/ha)		
			80	100	120
North	No P and K	3.13	3.92 1/	4.19	4.29
	45 P + 60 K		4.23	4.44	4.48
	Response to P + K		0.31	0.25	0.19
Centre	No P and K	3.82	4.57	4.80	4.80
	45 P + 60 K		4.68	4.87	4.94
	Response to P + K		0.11	0.07	0.14
South	No P and K	3.96	4.74	4.94	5.00
	45 P + 60 K		4.88	5.07	5.14
	Response to P + K		0.14	0.13	0.14

1/ Ton/ha.

Table 2

UNIT RESPONSE OF RICE AT VARIOUS LEVELS OF N, P AND K, PER REGION

N (kg/ha)	P (kg/ha)	K (kg/ha)	North (kg)	Centre (kg)	South (kg)
80	-	0	5.586	1.906	2.754
80	-	40	4.893	1.948	2.794
80	-	80	4.200	2.018	2.834
100	-	0	5.363	1.826	2.554
100	-	40	4.670	1.882	2.594
100	-	80	3.977	1.938	2.634
120	-	0	5.140	1.746	2.354
120	-	40	4.447	1.802	2.394
120	-	80	3.754	1.858	2.434
80	0	-	2.295	0.775	1.539
80	30	-	1.775	0.817	1.569
80	60	-	1.255	0.859	1.599
100	0	-	2.065	0.875	1.639
100	30	-	1.545	0.917	1.669
100	60	-	1.025	0.959	1.699
120	0	-	1.835	0.975	1.739
120	30	-	1.315	1.017	1.769
120	60	-	0.795	1.059	1.799
-	-	0	44.765	36.695	33.274
-	-	40	44.305	36.905	33.483
-	-	80	43.845	37.115	33.692
-	30	0	44.429	36.569	32.983
-	30	40	43.969	36.779	33.192
-	30	80	43.509	36.989	33.400
-	60	0	44.093	36.443	32.692
-	60	40	43.633	36.653	32.901
-	60	80	43.173	36.863	33.109

Relative cost of nutrients in terms of rice:

1 kg N = 1.24 kg rice
1 kg P = 0.88 kg rice
1 kg K = 0.39 kg rice

Table 3

YIELD AND RESPONSE OF RICE VARIETIES TO N, P AND K

Variety	Year	No 1/	Yield control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E. 2/
					100	120		30	60		40	80	
				80	80	80	0	0	0	0	0	0	
			(Y) 3/	(Y)	(R) 4/	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Paldal	1965	26	3.43	4.24	0.15	0.28	4.43	-0.10	-0.05	4.33	0.08	0.08	0.033
	1966	53	3.23	4.20	0.25	0.17	4.29	0.04	0.10	4.30	0.03	0.08	0.018
	1967	6	3.32	4.27	0.07	0.29	4.25	0.23	0.18	4.36	0.10	-0.02	0.099
	1968	1	3.29	4.03	0.12	0.10	4.16	0.03	-0.20	4.09	0.06	-0.02	0.079
Average		86	3.30	4.22	0.20	0.21	4.33	0.01	0.06	4.31	0.05	0.07	0.029
Jin Heung	1965	24	3.98	5.51	0.45	0.87	5.82	0.17	0.23	5.91	0.04	0.09	0.039
	1966	41	2.28	3.79	0.06	0.08	3.61	0.30	0.38	3.75	0.11	0.16	0.030
	1967	24	3.10	4.44	0.31	0.57	4.52	0.15	0.21	4.56	0.10	0.14	0.008
	1968	38	3.36	4.60	0.22	0.19	4.76	0.02	0.08	4.77	0.04	0.03	0.006
	1969	20	3.25	4.75	0.25	0.51	4.87	0.14	0.25	4.85	0.16	0.30	0.010
Average		147	3.25	4.52	0.23	0.37	4.58	0.16	0.23	4.65	0.08	0.13	0.019
Nong Lim 6	1965	36	4.37	5.19	0.12	0.22	5.31	-0.01	-0.01	5.29	-0.02	0.05	0.032
	1965	99	3.95	4.50	0.35	0.44	4.84	0.00	0.02	4.83	0.01	0.03	0.017
	1966	78	3.79	4.75	0.19	0.36	4.88	0.06	0.09	4.92	0.04	0.00	0.025
	1966	42	4.27	5.27	0.07	-0.01	5.27	0.01	0.07	5.26	0.04	0.06	0.018
	1967	4	3.29	4.49	0.30	0.31	4.63	0.11	0.09	4.60	0.17	0.11	0.061
	1967	36	3.94	4.89	0.19	0.30	4.99	0.07	0.12	5.00	0.06	0.10	0.040
	1967	36	4.34	5.57	0.13	0.13	5.63	0.03	0.04	5.61	0.08	0.06	0.027
	1968	16	2.99	4.50	0.39	0.64	4.61	0.30	0.40	4.79	0.07	0.09	0.034
	1968	32	3.05	3.93	0.25	0.31	4.05	0.09	0.11	4.09	0.02	0.05	0.020
	1968	56	3.31	4.42	0.01	-0.04	4.37	0.06	0.07	4.41	0.00	0.01	0.023
	1969	84	3.68	4.18	0.37	0.52	4.36	0.14	0.22	4.46	0.02	0.04	0.022
Average		519	3.80	4.65	0.22	0.30	4.79	0.06	0.09	4.82	0.03	0.04	0.024

1/ Number of replications.

2/ Standard error of difference.

3/ Yield in ton/ha.

4/ Response in ton/ha.

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Table 3 (Cont'd)

Variety	Year	No 1/	Yield control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E. 2/
					100	120		30	60		40	80	
				80	80	80	0	0	0	0	0	0	
			(Y) 3/	(Y)	(R) 4/	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Pal Kweng	1965	99	3.93	4.64	0.25	0.45	4.84	0.03	0.07	4.85	0.01	0.04	0.014
	1966	42	3.68	4.51	0.50	0.91	4.83	0.16	0.29	4.92	0.07	0.11	0.014
	1966	77	4.48	5.26	0.29	0.47	5.46	0.08	0.09	5.48	0.04	0.06	0.013
	1966	24	4.62	5.43	0.16	0.09	5.45	0.11	0.09	5.42	0.13	0.16	0.025
	1967	24	3.21	4.35	0.41	0.67	4.52	0.23	0.34	4.67	0.06	0.06	0.025
	1967	59	3.82	4.55	0.07	0.01	4.54	0.04	0.08	4.56	0.03	0.01	0.030
	1967	16	4.31	5.10	0.14	0.04	5.10	0.06	0.13	5.08	0.14	0.09	0.023
	1968	4	2.94	4.26	0.79	0.96	4.66	0.08	0.46	4.88	-0.05	-0.06	0.068
	1968	64	3.64	4.60	0.17	0.13	4.67	0.02	0.07	4.68	0.04	0.02	0.028
	1969	80	3.94	4.71	0.15	0.19	4.76	0.08	0.11	4.80	0.04	0.03	0.041
Average		489	3.95	4.76	0.23	0.34	4.88	0.07	0.12	4.92	0.04	0.05	0.023
Jae Kun	1966	12	3.51	4.68	-0.02	-0.06	4.67	-0.03	-0.03	4.67	-0.03	-0.03	0.025
	1967	12	3.92	4.66	0.15	0.34	4.86	0.01	-0.12	4.85	-0.02	-0.06	0.037
	1967	1	3.42	4.06	-0.11	-0.18	4.07	-0.30	-0.02	4.13	-0.05	-0.46	0.208
	1968	16	2.75	4.01	0.23	0.52	4.29	-0.07	-0.02	4.22	0.06	0.05	0.052
	1969	24	3.33	4.20	0.07	0.00	4.14	0.12	0.13	4.22	0.02	-0.01	0.012
Average		65	3.33	4.33	0.10	0.16	4.40	0.02	0.02	4.42	0.01	-0.02	0.032
Nong Lim 25	1966	30	4.30	5.22	0.06	0.03	5.25	-0.01	0.02	5.24	-0.02	0.06	0.030
	1968	24	3.92	5.08	0.03	-0.10	5.06	0.01	-0.02	4.98	0.10	0.12	0.010
	1969	30	-	4.34	0.15	-0.02	4.37	0.03	0.01	4.37	0.00	0.04	0.032
Average		84	4.13	4.87	0.08	-0.03	4.88	0.01	0.00	4.85	0.02	0.07	0.025
Shin 2 Ho	1966	12	2.44	3.04	0.28	0.45	3.20	0.10	0.15	3.10	0.16	0.38	0.054
	1969	12	3.74	5.40	-0.05	-0.15	5.31	0.01	0.06	5.32	0.04	0.00	0.060
Average		24	3.09	4.22	0.12	0.15	4.26	0.06	0.10	4.21	0.10	0.19	0.057

.../...

Table 3 (Cont'd)

Variety	Year	No 1/	Yield control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E. 2/
			(Y) 3/	80 (Y)	100/80 (R) 4/	120/80 (R)	0 (Y)	30/0 (R)	60/0 (R)	0 (Y)	40/0 (R)	80/0 (R)	
Nong Kwang	1968	8	3.72	5.12	0.23	0.44	5.24	0.13	0.18	5.27	0.10	0.12	0.017
	1969	8	4.01	5.18	0.14	0.33	5.26	0.07	0.17	5.27	0.08	0.12	0.212
Average		16	3.86	5.15	0.18	0.38	5.25	0.10	0.18	5.27	0.09	0.12	0.114
Yuk Woo 132	1965	5	3.01	4.10	0.32	0.23	4.15	0.06	0.34	4.27	0.14	0.00	0.100
Su Won 118	1965	2	2.56	3.91	0.00	0.27	3.82	0.40	0.58	4.04	0.25	0.07	0.161
Shin Poong	1965	9	3.40	4.63	0.22	0.35	4.69	0.15	0.23	4.82	0.01	-0.02	0.133
Ho Kwang	1965	9	4.61	5.17	0.33	0.49	5.41	0.05	0.06	5.44	-0.02	0.04	0.031
Baek Keum	1967	20	2.90	3.89	0.18	0.27	3.99	0.06	0.08	4.03	0.01	0.01	0.037
Kusabue	1967	20	4.30	5.24	0.25	0.16	5.35	0.06	0.02	5.31	0.06	0.13	0.038
Su Sung	1967	1	3.33	4.46	0.17	-0.14	4.33	0.24	0.20	4.46	-0.17	0.19	0.127
Poong Ok	1967	1	3.73	4.58	0.19	0.46	4.49	0.47	0.46	4.95	-0.03	-0.30	0.242
Su Won 150	1968	3	3.46	4.64	-0.06	-0.20	4.56	0.05	-0.07	4.51	0.10	0.03	0.129
China 31	1969	32	3.73	4.82	0.20	0.39	4.97	0.05	0.08	4.98	0.04	0.07	0.013
Keum Nam Pung	1969	8	-	5.10	0.05	0.14	5.21	-0.02	-0.12	5.18	-0.05	0.00	0.068
Kibiygshi	1969	24	-	4.94	-0.05	0.00	4.97	-0.06	-0.08	4.93	0.01	-0.02	0.050

Table 4

AVERAGE YIELDS OF RICE WITH INCREASING DENSITIES OF PLANTING PER PROVINCE

Province	Number of Hills per Pyong 1/			S.E.
	72	110	144	
	Yield (ton/ha)			
Kyong Gi	3.32	3.61	3.72	0.047
Chung Chong Puk	4.25	4.24	4.26	0.057
Chung Chong Nam	5.29	5.16	5.26	0.096
Chulla Puk	5.17	5.02	4.92	0.058
Kyong Sang Puk	4.93	4.81	4.73	0.088
Kyong Sang Nam	5.17	5.13	4.98	0.042
Kang Won	3.50	3.60	3.59	0.066

1/ Pyong = 3.3 square metres (m^2).

Table 5

RICE SOILS CHARACTERISTICS

Symbol	Soil	Texture	Drainage
	Alluvial Plains		
Apa	Alluvial low-humic gley	Fine loam to clay	Imperfect to poor
Apb	Red-yellow podzolic	Fine loam to clay	Moderately well to well
Apc	Alluvial	Gravel loam	Imperfect to well
Apd	Alluvial	Gravelly loam to coarse loam	Well drained
	River Wash Floodplains		
Afa	Alluvial	Coarse loam	Moderately well to well
Afb	Alluvial	Coarse to sandy loam	Imperfect to poor
Afd	Alluvial	Gravel sand to coarse loam	Moderate to excessive
	Complex of Soils, Narrow Valleys		
Ana	Alluvial and low-humic gley	Gravel fine loam to clay	Moderately well to poor
Anb	Alluvial and low-humic gley	Gravel coarse loam	Moderately well to imperfect
	Fluvio-Marine Plains		
Fma	Alluvial low-humic gley	Fine loam to clay	Imperfect to poor
Fmk	Acidsolphate	Fine loam to clay	Imperfect to poor
	Older Pediplanes, Red-Yellow Podzolic Soils, Siliceous Crystalline Materials		
Raa	Undifferentiated alluvial and residual material	Clay	Imperfect to moderately well
Rxa	Alluvial and low-humic gley	Fine loam to clay	Imperfect to moderately well

Table 6

YIELD AND RESPONSE OF RICE TO N, P AND K PER SOIL GROUP

Fertiliser levels (kg/ha)		Soil Series												
		Afa	Afb	Afd	Ana	Anb	Apa	Apb	Apc	Apd	Fma	Fmk	Raa	Rxa
N_{80}	(Y)1/	4.66	4.39	4.15	4.98	4.67	4.65	4.81	4.98	4.25	4.66	3.83	4.75	4.58
$N_{100} - N_{80}$	(R)2/	0.15	0.22	0.23	0.13	0.22	0.18	0.18	0.19	0.08	0.22	-0.12	0.28	0.26
$N_{120} - N_{80}$	(R)	0.13	0.32	0.34	0.22	0.32	0.26	0.19	0.31	-0.29	0.31	-0.19	0.57	0.40
P_0	(Y)	4.73	4.51	4.18	5.05	4.79	4.75	4.88	5.10	4.23	4.76	3.72	4.97	4.67
$P_{30} - P_0$	(R)	0.03	0.07	0.20	0.04	0.08	0.06	0.07	0.05	-0.08	0.09	0.03	0.10	0.15
$P_{60} - P_0$	(R)	0.03	0.11	0.28	0.10	0.10	0.09	0.09	0.09	-0.08	0.14	0.00	0.09	0.24
K_0	(Y)	4.74	4.54	4.22	5.05	4.84	4.77	4.91	5.09	4.20	4.79	3.75	5.01	4.77
$K_{40} - K_0$	(R)	0.01	0.04	0.21	0.07	0.00	0.04	0.05	0.07	-0.05	0.06	-0.02	0.00	0.03
$K_{80} - K_0$	(R)	0.02	0.05	0.15	0.07	0.03	0.05	0.03	0.09	-0.01	0.08	-0.04	0.07	0.05
Number of replications		65	207	14	83	73	463	169	68	6	190	16	17	78
S.E.		0.024	0.015	0.089	0.020	0.034	0.008	0.014	0.132	0.075	0.014	0.056	0.065	0.027

1/ Yield in ton/ha.

2/ Response in ton/ha.

Table 7

RESPONSE SURFACES OF EXPERIMENTS ON RICE
PER SOIL GROUP (1965-69) IN TON/HA

Soil group	No	Regression Coefficients									
		b_0	b_1	b_2	b_3	b_{11}	b_{22}	b_{33}	b_{12}	b_{13}	b_{23}
Afa	65	4.8200	0.0644	0.0133	0.0111	-0.0833	-0.0200	0.0000	-0.075	-0.0183	-0.0233
Afb	207	4.6256	0.1589	0.0561	0.0239	-0.0533	-0.0083	-0.0217	-0.0083	0.0058	-0.0050
Afd	14	4.5048	0.1689	0.1406	0.0728	-0.0544	-0.0628	-0.1294	-0.0908	-0.0492	-0.0658
Ana	83	5.1296	0.1083	0.0494	0.0361	-0.0239	0.0061	-0.0305	-0.0067	0.0108	-0.0092
Anb	73	4.9004	0.1572	0.0517	0.0167	-0.0627	-0.0261	0.0156	-0.0158	-0.0258	0.0167
Apa	463	4.8500	0.1288	0.0466	0.0205	-0.0533	-0.0167	-0.0083	-0.0008	-0.0025	-0.0025
Apb	169	5.0304	0.0967	0.0483	0.0150	-0.0811	-0.0261	-0.0361	0.0033	0.0142	-0.0050
Apc	68	5.1915	0.1567	0.0417	0.0478	-0.0345	-0.0061	-0.0278	-0.0208	0.0217	-0.0192
Fma	190	4.9040	0.1561	0.0733	0.0417	-0.0605	-0.0222	-0.0172	0.0050	-0.0025	0.0175
Raa	17	5.0463	0.2883	0.0428	0.0361	0.0028	-0.0572	0.0361	-0.0383	0.0208	-0.0008
Rxa	78	4.8611	0.1994	0.1183	0.0294	-0.0583	-0.0283	-0.0083	-0.0025	0.0033	0.0017
Korea	1 575	4.8689	0.1306	0.0572	0.0250	-0.0516	-0.0117	-0.0083	-0.0067	0.0067	-0.0050

$$y = b_0 + \sum_{1}^{3} b_i x_i + \sum_{1}^{3} b_i x_i^2 + \sum_{\substack{1 \\ ij=1 \\ i \neq j}}^{3} b_{ij} \; x_{ij}$$

b_0 = level of yield of rice at 100-30-40 kg/ha.

Table 8

RESPONSE SURFACES OF EXPERIMENTS ON RICE PER REGION

Regression coefficient	North	Centre	South	Korea
b_0	4.3867	4.8511	5.0470	4.9015
b_1	0.1294	0.1356	0.1361	0.1344
b_2	0.0933	0.0328	0.0528	0.0494
b_3	0.0450	0.0311	0.0217	0.0283
b_{11}	-0.0750	-0.0600	-0.0528	-0.0578
b_{22}	-0.0234	-0.0116	-0.0128	-0.0128
b_{33}	-0.0084	-0.0033	-0.0228	-0.0161
b_{12}	-0.0067	-0.0025	-0.0058	-0.0025
b_{13}	-0.0092	0.0042	0.0042	0.0033
b_{23}	-0.0208	0.0017	0.0008	-0.0025

$$y = b_0 + b_1n + b_2p + b_3k + b_{11}n^2 + b_{22}p^2 + b_{33}k^2 + b_{12}np + b_{13}nk + b_{23}pk.$$

b_0 = yield of rice at 100-30-40 kg/ha.

Table 9

RESPONSE OF RICE TO N, P AND K PER SOIL SERIES

Soil series	No 1/	Control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E. 4/
			80	100 80	120 80	0	30 0	60 0	0	40 0	80 0	
		(Y) 2/	(Y)	(R) 3/	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Baeg Gu	2	3.64	4.96	0.31	0.52	5.15	0.09	0.16	5.13	0.13	0.19	0.085
Ban Cheon	4	2.55	3.90	0.45	0.85	4.20	0.16	0.23	4.26	0.10	0.12	0.041
	4	4.50	5.60	0.09	0.08	5.61	0.05	0.11	5.62	0.06	0.06	0.036
Bang Gi	8	3.66	4.56	0.19	0.42	4.74	0.03	0.05	4.72	0.02	0.12	0.047
Bong Ryang	8	3.37	4.31	0.16	0.22	4.34	0.10	0.19	4.41	0.04	0.05	0.083
	8	3.30	4.52	0.26	0.39	4.76	0.03	0.00	4.69	0.06	0.07	0.063
Bu Yong 5/	1	4.33	5.33	0.02	0.02	5.32	-0.04	0.04	5.48	-0.13	-0.30	0.142
	10	4.11	5.27	0.16	0.19	5.33	0.06	0.10	5.34	0.06	0.09	0.041
	22	3.78	4.82	0.25	0.34	4.95	0.07	0.14	5.00	0.06	0.04	0.025
Cheong Sim	4	3.24	3.52	-0.24	-0.47	3.17	0.13	0.21	3.27	0.01	0.02	0.069
Dam Yang	4	3.38	3.43	-0.17	-0.37	3.33	-0.07	-0.18	3.29	-0.11	-0.02	0.063
Deog Ha	5	3.59	4.80	0.17	0.42	4.97	-0.05	0.12	4.89	0.19	0.13	0.069
Deung Gu	4	3.25	3.59	-0.21	-0.43	3.28	0.11	0.07	3.37	0.01	0.00	0.094
Gang Dong	20	3.95	5.13	0.32	0.45	5.29	0.12	0.17	5.34	0.06	0.08	0.041
	2	2.62	3.79	0.36	0.62	4.08	0.09	0.02	4.14	-0.11	0.03	0.061
Geug Rag	31	3.67	4.76	0.20	0.40	4.91	0.06	0.09	4.92	0.06	0.05	0.027
Gim Hae	4	2.14	2.83	0.03	-0.14	2.82	-0.04	-0.07	2.82	-0.07	-0.05	0.051
Gim Jae	4	3.70	4.43	0.65	0.50	4.59	0.32	0.35	4.73	0.15	0.10	0.054
Gong Deog	4	3.15	4.03	0.03	0.15	4.12	-0.01	-0.10	4.08	0.02	0.00	0.053
Gong Seong	4	2.39	2.98	0.17	0.23	3.02	0.12	0.17	3.03	0.09	0.17	0.042
Gwang Hwal	4	4.06	5.19	0.15	0.08	5.26	0.03	-0.01	5.24	0.02	0.05	0.088
Gyu Am	12	3.88	5.03	0.16	0.12	5.10	0.08	-0.01	5.04	0.06	0.19	0.060
	4	3.39	4.16	-0.01	-0.08	4.20	-0.10	-0.11	4.13	-0.01	0.00	0.046

1/ Number of replications.
2/ Yield in ton/ha.
3/ Response in ton/ha.
4/ Standard error of difference.
5/ Percentage of total land area of the 12 main soil series.

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Table 9 (Cont'd)

Soil series	No	Control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
				100	120		30	60		40	80	
			80	80	80	0	0	0	0	0	0	
		(Y)	(Y)	(R)	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Hae Cheog	4	3.04	4.29	-0.09	-0.23	4.14	0.04	0.08	4.29	0.09	0.06	0.151
Hag San	8	3.04	4.51	0.01	-0.01	4.54	-0.08	-0.02	4.42	0.16	0.11	0.106
Hag Seong	11	4.17	5.12	0.29	0.34	5.28	0.10	0.05	5.28	0.10	0.06	0.040
Ham Chang	12	3.16	4.04	0.50	0.73	4.45	0.01	-0.01	4.45	-0.02	0.02	0.036
Ho Gye	5	3.84	4.89	0.34	0.40	5.06	0.06	0.17	5.13	0.00	0.02	0.065
	2	4.12	5.45	0.09	0.68	5.42	0.53	0.34	5.75	0.03	0.25	0.106
Ho Nam	77	4.02	5.04	0.24	0.30	5.16	0.08	0.10	5.20	0.03	0.03	0.020
Hwa Bong	9	3.30	4.21	0.34	0.49	4.46	0.10	-0.02	4.48	0.01	0.01	0.052
	2	3.50	4.31	0.03	0.47	4.42	0.16	0.01	4.47	0.01	0.02	0.143
Hwa Dong	29	4.58	5.20	0.11	-0.06	5.16	0.07	0.10	5.23	0.03	-0.07	0.039
	14	3.52	4.50	0.25	0.30	4.58	0.13	0.20	4.66	0.00	0.08	0.041
Hyo Cheon	13	4.29	5.21	0.20	0.22	5.32	0.02	0.06	5.37	-0.03	-0.04	0.045
I Hyeon	24	4.24	5.14	0.11	0.02	5.21	-0.05	-0.04	5.16	0.06	0.01	0.064
Jeon Puk	21	3.65	4.73	0.15	0.22	4.81	0.06	0.08	4.79	0.10	0.10	0.028
Ji San	34	3.90	5.09	0.10	0.17	5.10	0.06	0.18	5.12	0.09	0.09	0.030
	1	4.78	5.83	-0.07	-0.06	5.83	-0.12	-0.01	5.66	0.06	0.32	0.164
Jung Dong	4	3.94	3.96	0.19	0.14	3.90	0.25	0.26	4.14	-0.05	-0.16	0.090
Man Gyeong	19	3.31	4.58	0.29	0.38	4.69	0.13	0.18	4.72	0.10	0.12	0.023
Man Seong	8	3.68	4.67	0.21	0.40	4.84	0.12	-0.02	4.88	-0.01	-0.01	0.070
Nag Dong	10	3.43	4.63	0.16	0.27	4.66	0.10	0.24	4.73	0.08	0.01	0.048
Sam Am	14	4.54	5.37	0.13	-0.01	5.36	0.08	0.08	5.34	0.11	0.11	0.031
Seog Gye	8	4.22	5.03	0.06	0.04	5.04	0.06	0.02	4.96	0.13	0.18	0.062
Sin Dab	42	3.42	4.58	0.09	0.16	4.61	-0.01	0.06	4.62	0.00	0.02	0.020
	4	3.19	5.08	0.57	0.83	5.36	0.26	0.29	5.50	0.04	0.10	0.101
Shin Heung	67	3.38	4.46	0.17	0.28	4.52	0.09	0.05	4.56	0.05	0.08	0.021
Su Bug	6	3.19	4.92	0.55	0.83	5.22	0.20	0.28	5.32	0.07	0.12	0.075
	6	4.54	5.20	0.12	0.24	5.24	0.12	0.12	5.14	0.22	0.30	0.063

.../...

Table 9 (Cont'd)

Soil series	No	Control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
				100	120		30	60		40	80	
			80	80	80	0	0	0	0	0	0	
		(Y)	(Y)	(R)	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Su Gye	15	3.85	4.58	0.15	0.20	4.67	0.02	0.06	4.70	0.00	0.00	0.027
	5	4.28	5.59	0.02	0.47	5.80	-0.02	-0.11	5.70	0.11	0.06	0.134
Tong Cheon	20	3.92	4.77	0.28	0.36	4.90	0.13	0.09	4.94	0.06	0.05	0.039
Yong San	8	3.04	4.51	0.01	-0.01	4.54	-0.08	-0.02	4.42	0.16	0.11	0.106
Yong Ji	8	3.14	4.26	0.55	1.17	4.64	0.17	0.41	4.80	0.04	0.06	0.063
Yu Ga	5	3.61	4.55	-0.08	-0.30	4.50	-0.15	-0.07	4.42	0.07	-0.06	0.057

Table 10

ECONOMICS OF FERTILIZER USE

(Averages for Korea - 1965-69)

N	P	K	1965 (309) 1/	1966 (411)	1967 (260)	1968 (262)	1969 (333)	1965-69 (1575)	Response (t/ha)	Value of Response ('000 ₩)	Cost of Fertilizer ('000 ₩)	Gross Profit ('000 ₩)	Value/ Cost Ratio (%)
(kg/ha)													
0	0	0	3.93	3.81	3.76	3.38	3.42	3.67	-	-	-	-	-
80	0	0	4.73	4.58	4.60	4.42	4.46	4.56	0.89	42.44	4.74	37.70	895
80	30	80	4.80	4.78	4.80	3.51	4.61	4.71	1.04	49.59	7.49	42.10	662
80	60	40	4.78	4.80	4.81	4.53	4.63	4.72	1.05	50.07	8.00	42.07	626
100	0	80	4.89	4.93	4.86	4.58	4.68	4.81	1.14	54.36	7.42	46.94	733
100	30	40	4.93	4.95	4.96	4.66	4.79	4.86	1.19	56.74	7.93	48.81	716
100	60	0	4.95	4.95	4.90	4.72	4.75	4.86	1.19	50.74	8.44	48.30	672
120	0	40	5.15	4.99	4.97	4.68	4.79	4.92	1.25	59.61	7.85	51.76	759
120	30	0	5.14	4.99	4.95	4.68	4.83	4.93	1.26	60.08	8.36	51.72	719
120	60	80	5.22	5.11	5.06	4.72	4.91	5.02	1.35	64.37	11.12	53.25	579
80	0	40	4.72	4.67	4.70	4.47	4.52	4.62	0.95	45.30	5.48	39.82	827
80	30	0	4.73	4.73	4.72	4.47	4.58	4.65	0.98	46.73	6.00	48.73	779
80	60	80	4.81	4.80	4.76	4.55	4.63	4.72	1.05	50.07	8.75	41.32	572
100	0	0	4.93	4.81	4.83	4.60	4.66	4.77	1.10	52.45	5.92	46.53	886
100	30	80	5.02	4.97	4.96	4.69	4.70	4.89	1.22	58.18	8.67	49.50	671
100	60	40	5.05	4.96	4.97	4.70	4.81	4.90	1.23	58.65	9.19	49.46	638
120	0	80	5.10	4.98	4.94	4.64	4.81	4.90	1.23	58.65	8.60	50.05	682
120	30	40	5.11	5.04	5.00	4.69	4.83	4.94	1.27	60.56	9.11	51.45	665
120	60	0	5.12	5.03	5.00	4.67	4.85	4.95	1.28	61.03	9.62	51.42	634
80	0	80	4.79	4.67	4.67	4.44	4.53	4.63	0.96	45.78	6.23	39.55	735
80	30	40	4.80	4.77	4.76	4.50	4.57	4.69	1.02	48.64	6.74	41.90	722
80	60	0	4.82	4.75	4.76	4.50	4.60	4.76	1.09	51.98	7.26	44.72	716
100	0	40	4.94	4.89	4.86	4.60	4.71	4.81	1.14	54.36	6.67	47.69	815
100	30	0	4.97	4.91	4.92	4.60	4.75	4.84	1.17	55.79	7.18	48.61	777
100	60	80	5.02	5.07	5.00	4.74	4.89	4.96	1.29	61.51	9.93	51.58	619
120	0	0	5.03	4.91	4.85	4.53	4.71	4.82	1.15	54.84	7.11	47.73	771
120	30	80	5.10	5.04	4.97	4.70	4.87	4.95	1.28	61.04	9.86	51.18	619
120	60	40	5.12	5.10	5.02	4.69	4.91	4.98	1.31	62.47	10.37	52.10	602
S.E.			0.020	0.018	0.02	0.045	0.018	0.009	0.013	0.62		0.62	

1/ Figures in brackets give the number of replications.

Table 11

RESPONSE SURFACES OF EXPERIMENTS ON RICE PER PROVINCE

Province	No 1/	Regression Coefficients									
		b_0	b_1	b_2	b_3	b_{11}	b_{22}	b_{33}	b_{12}	b_{13}	b_{23}
Kyong Gi	164	4.8770	0.1788	0.0827	0.0500	-0.0878	-0.0061	-0.0044	-0.0117	-0.0083	-0.0142
Kang Won	158	4.3704	0.0611	0.0967	0.0567	-0.0578	-0.0411	-0.0278	0.0167	0.0008	0.0025
Chung Puk	64	4.4567	0.0906	0.0100	-0.0022	-0.0183	-0.0133	-0.0166	0.0125	0.0000	0.0125
Chung Nam	146	5.0985	0.0317	0.0050	0.0356	-0.0905	-0.0105	0.0145	0.0025	0.0083	-0.0067
Chun Puk	157	4.8689	0.3506	0.1361	0.0311	-0.0817	-0.0284	-0.0200	-0.0075	0.0075	0.0133
Chun Nam	255	4.6937	0.1700	0.0483	0.0133	-0.0345	-0.0195	-0.0078	0.0008	-0.0008	0.0058
Kyong Puk	339	5.0019	0.1272	0.0383	0.0172	-0.0506	-0.0139	-0.0206	-0.0042	0.0017	-0.0017
Kyong Nam	292	5.1452	0.0478	0.0189	0.0294	-0.0389	-0.0056	-0.0206	-0.0083	0.0117	-0.0092
Korea	1 575	4.8689	0.1306	0.0572	0.0250	-0.0516	-0.0117	-0.0083	-0.0067	0.0067	-0.0050

1/ Number of replications.

Table 12

OPTIMUM LEVELS OF N, P AND K FOR RICE PER PROVINCE

Province	Number of replications	Optimum Levels (kg/ha) N	P	K	Expected yield (ton/ha)
Kyong Gi	164	100	60	80	5.00
Kang Won	158	106	55	69	4.47
Chung Chong Puk	64	136	12	16	4.54
Chung Chong Nam	146	100	0	13	5.08
Chulla Puk	157	140	88	55	5.39
Chulla Nam	255	142	46	34	4.92
Kyong Sang Puk	339	120	43	41	5.09
Kyong Sang Nam	292	106	10	53	5.17
Korea	1 575	120	69	62	5.00

Table 13

OPTIMUM LEVELS OF N, P AND K FOR RICE PER REGION

Region	Optimum Levels (kg/ha) N	P	K	Expected yield (ton/ha)
North	128	68	16	4.51
Centre	120	42	80	5.00
South	120	54	50	5.17
Korea (average)	119	53	57	5.02

Table 14

OPTIMUM LEVELS OF N, P AND K FOR RICE PER SOIL GROUP
(1965-69)

Soil group	Number of replications	Optimum Levels (kg/ha) N	P	K	Expected yield (ton/ha)
Afa	65	104	21	80	4.86
Afb	207	125	83	47	4.80
Afd	14	126	57	48	4.58
Ana	83	135	60+	53	5.22
Anb	73	121	44	80	5.03
Apa	463	119	48	52	4.95
Apb	169	108	42	40	5.07
Apc	68	138	67	63	5.39
Fma	190	121	61	70	5.09
Rxa	78	129	78	73	5.16
Average	1 575	119	68	61	5.00

Table 15

ECONOMICS OF FERTILIZER USE ON RICE AT OPTIMUM LEVEL IN COMPARISON TO 100 KG/HA N ALONE, PER PROVINCE

Province	Number of replications	Yield at 100 kg/ha N (ton/ha)	Opt. level (ton/ha)	Additional response (ton/ha)	Value of response (1 000 Won)	Cost of additional fertilizer at optimum level (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)	S.E.
Kyong Gi	164	4.69	5.00	0.31	14.78	4.01	10.77	268	0.020
Kang Won	158	4.17	4.47	0.30	14.31	3.95	10.36	262	0.066
Chung Chong Puk	64	4.45	4.54	0.09	4.29	2.93	1.36	46	0.009
Chung Chong Nam	146	5.05	5.08	0.03	1.43	0.24	1.19	496	0.030
Chulla Puk	157	4.67	5.39	0.72	34.33	7.09	27.24	384	0.028
Chulla Nam	255	4.64	4.92	0.28	13.35	5.05	8.30	164	0.023
Kyong Sang Puk	339	4.93	5.09	0.16	7.63	3.75	3.88	103	0.017
Kyong Sang Nam	292	5.06	5.17	0.11	5.24	1.76	3.48	198	0.034
Korea	1 575	4.77	5.00	0.23	10.97	5.24	5.73	109	0.006

Table 16

ECONOMICS OF FERTILIZER USE ON RICE AT OPTIMUM LEVEL IN COMPARISON TO 80 KG/HA N ALONE, PER SOIL GROUP

Soil group	Optimum Level (kg/ha)			Yield at optimum level (ton/ha)	Yield at 80 kg/ha N (ton/ha)	Response at optimum level (ton/ha)	Value of response (1 000 Won)	Cost of additional fertilizer at optimum level (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
	N	P	K							
Afa	104	21	80	4.86	4.57	0.29	13.83	3.79	10.04	365
Afb	125	83	47	4.80	4.31	0.49	23.36	9.63	13.73	242
Afd	126	57	48	4.58	3.40	1.18	56.27	6.01	50.26	936
Ana	135	60+	53	5.22	4.86	0.36	17.17	6.76	10.41	254
Anb	121	44	80	5.03	4.55	0.48	22.89	5.76	17.13	397
Apa	119	48	52	4.95	4.56	0.39	18.60	5.29	13.31	351
Apb	108	42	40	5.07	4.74	0.33	15.74	4.16	11.58	378
Apc	138	67	63	5.39	4.80	0.59	28.13	7.42	20.71	379
Fma	121	61	70	5.09	4.52	0.57	27.18	6.29	20.89	432
Rxa	129	78	73	5.16	4.34	0.82	39.10	7.53	31.57	519
Average	119	68	61	5.00	4.56	0.44	20.98	6.42	14.56	327

Table 17

ECONOMICS OF FERTILIZER USE ON RICE AT OPTIMUM LEVEL IN COMPARISON TO 100 KG/HA N ALONE, PER SOIL GROUP

Soil group	Optimum Level (kg/ha)			Yield at optimum level (ton/ha)	Yield at 100 kg/ha N (ton/ha)	Response at optimum level (ton/ha)	Value of response (1 000 Won)	Cost of additional fertilizer at optimum level (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
	N	P	K							
Afa	104	21	80	4.86	4.81	0.05	2.38	2.61	-0.23	91
Afb	125	83	47	4.80	4.49	0.31	14.78	8.45	6.33	175
Afd	126	57	48	4.58	4.31	0.27	12.87	4.83	8.04	266
Ana	135	60	53	5.22	5.06	0.16	7.63	5.58	2.05	137
Anb	121	44	80	5.03	4.84	0.19	9.06	4.58	4.48	198
Apa	119	48	52	4.95	4.76	0.19	9.06	4.11	4.95	220
Apb	108	42	40	5.07	4.92	0.15	7.15	2.98	4.17	240
Apc	138	67	63	5.39	5.10	0.29	13.83	6.24	7.59	222
Fma	121	61	70	5.09	4.74	0.35	16.69	5.11	11.58	326
Rxa	129	78	73	5.16	4.67	0.49	23.36	6.35	17.01	368
Average	119	68	61	5.00	4.77	0.23	10.97	5.24	5.73	209

Table 18

YIELD OF UPLAND RICE WITH N, P AND K ON CHEJU ISLAND
(in ton/ha grain)

	N_{60} 1/	N_{80}	N_{100}	Mean	K_0	K_{40}	K_{80}
P_0	1.61	1.79	1.71	1.70	1.48	1.82	1.81
P_{30}	1.84	2.02	2.00	1.95	1.88	1.98	2.00
P_{60}	1.87	1.94	2.26	2.03	1.93	2.02	2.12
Mean	1.77	1.92	1.99	(1.89)	1.76	1.94	1.98
K_0	1.66	1.78	1.84	1.76			
K_{40}	1.78	2.00	2.03	1.94	Control: 1.07		
K_{80}	1.88	1.97	2.09	1.98	S.E. (Body of table) = ±0.04 S.E. (Marginal means) = ±0.02		

1/ Rates of fertilizers in kg/ha.

Table 19

ECONOMICS OF FERTILIZER USE ON UPLAND RICE ON CHEJU ISLAND

N	P	K	Yield	Response	Value of response	Cost of fertilizer	Gross profit	V/C ratio
(kg/ha)			(ton/ha)		(1 000 Won)	(1 000 Won)	(1 000 Won)	(%)
0	0	0	1.07					
60	0	0	1.37	0.30	13.92	3.55	10.37	392
60	30	80	1.88	0.81	37.58	6.31	31.27	595
60	60	40	1.80	0.73	33.86	6.82	27.04	496
80	0	80	1.90	0.83	38.50	6.23	32.27	618
80	30	40	2.07	1.00	46.39	6.74	39.65	688
80	60	0	1.79	0.72	33.40	7.26	26.14	460
100	0	40	1.87	0.80	37.11	6.67	30.44	556
100	30	0	1.88	0.81	37.58	7.18	30.40	523
100	60	80	2.40	1.33	61.70	9.93	51.77	621
60	0	40	1.67	0.60	27.83	4.30	23.53	647
60	30	0	1.76	0.69	32.01	4.81	27.20	665
60	60	80	1.96	0.89	41.29	7.56	33.73	546
80	0	0	1.55	0.48	22.27	4.74	17.53	470
80	30	80	2.00	0.93	43.14	7.49	35.65	576
80	60	40	2.02	0.95	44.07	8.00	36.07	551
100	0	80	1.74	0.67	31.08	7.42	23.66	419
100	30	40	2.00	0.93	43.14	7.93	35.21	544
100	60	0	2.14	1.07	49.64	8.44	41.20	588
60	0	80	1.80	0.73	33.86	5.05	28.81	670
60	30	40	1.87	0.80	37.11	5.56	31.55	667
60	60	0	1.85	0.78	36.18	6.07	30.11	596
80	0	40	1.92	0.87	40.36	5.48	35.12	736
80	30	0	2.00	0.93	43.14	6.00	37.14	719
80	60	80	2.00	0.93	43.14	8.75	34.39	493
100	0	0	1.51	0.44	20.41	5.92	14.49	345
100	30	80	2.12	1.05	48.71	8.67	40.04	562
100	60	40	2.23	1.16	53.81	9.19	44.62	585
S.E.			0.06	0.09	4.18	-	4.18	

Table 20

EFFECT OF TOP-DRESSING OF N ON UPLAND RICE
AT DIFFERENT STAGES OF GROWTH

Time of top-dressing	Treatments (N in kg/ha)						
	A	B	C	D	E	F	G
Basal dressing	40	40	40	40	40	40	0
15 days after transplanting	60	0	30	30	30	30	40
30 days after transplanting	0	0	30	0	0	0	0
At ear formation stage	0	30	0	30	0	15	30
At heading stage	0	30	0	0	30	15	30
Yield (ton/ha)	2.06	2.10	2.18	2.46	2.06	2.14	2.47
			S.E. = 0.11				

Table 21

CONTROL YIELDS OF BARLEY IN THE YEARS 1964-69, PER REGION

Region	1964/65	1965/66	1966/67	1967/68	1968/69	Average
North	1.37 1/ (24) 2/	0.81 (80)	0.86 (52)	1.77 (36)	1.09 (6)	1.07 (198)
Centre	1.51 (54)	1.41 (217)	1.66 (227)	1.81 (94)	1.56 (28)	1.58 (620)
South	1.88 (65)	1.64 (239)	1.64 (291)	1.79 (185)	2.06 (94)	1.73 (874)
Average	1.65 (143)	1.42 (536)	1.58 (570)	1.79 (315)	1.90 (128)	1.60 (1 692)

1/ Ton/ha.

2/ Figures in brackets give the number of replications.

Table 22

CONTROL YIELDS OF BARLEY IN THE YEARS 1964-69, PER PROVINCE

Province	1964/65	1965/66	1966/67	1966/67 1/	1967/68	1968/69
Kyong Gi	1.58 2/ (24) 3/	1.30 (66)	1.30 (59)	1.30 (18)	1.64 (24)	-
Kang Won	1.34 (12)	0.79 (65)	0.83 (66)	0.89 (22)	2.04 (12)	1.09 (6)
Chung Puk	1.76 (14)	1.16 (44)	1.96 (50)	1.86 (17)	1.20 (16)	-
Chung Nam	1.54 (17)	1.30 (52)	1.75 (54)	1.77 (18)	1.56 (21)	1.54 (16)
Chulla Puk	1.34 (24)	1.23 (54)	1.33 (54)	1.22 (18)	1.26 (36)	1.58 (12)
Chulla Nam	1.97 (12)	1.66 (80)	1.80(108)	1.60 (36)	2.38 (36)	1.71 (24)
Kyong Puk	1.22 (11)	1.81 (99)	1.74(101)	1.63 (35)	1.75 (78)	2.17 (48)
Kyong Nam	2.15 (29)	1.70 (76)	1.61 (78)	1.82 (30)	2.12 (56)	2.20 (22)
Che Ju	1.12 (6)	0.82 (15)	1.68 (12)	2.36 (4)	0.89 (12)	-
Average	1.63 (149)	1.41(551)	1.56(582)	1.55(198)	1.76(291)	1.90(128)
S.E.	0.02	0.02	0.02	0.04	0.03	0.04
C.D.	0.09	0.07	0.05	0.10	0.08	0.10
C/V (%)	12.36	19.91	14.17	17.70	15.65	12.69

1/ Parallel series of trials using the Box design.

2/ Ton/ha.

3/ Figures in brackets give the number of replications.

Table 23

UNIT RESPONSES OF BARLEY TO N, P AND K, PER REGION

	North	Centre	South
N at 90 kg/ha	15.33	17.22	17.33
P_2O_5 at 60 "	20.17	17.83	14.17
K_2O at 60 "	12.00	10.17	6.67

Table 24

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER REGION 1/

			North	Centre	South
N (kg/ha)	0	(Y) 2/	1.24	1.85	2.00
	30	(R) 3/	0.56	0.60	0.58
	60	(R)	1.00	1.05	1.06
	90	(R)	1.38	1.55	1.56
	120	(R)	1.38	1.61	1.70
	Mean	(R)	1.08	1.20	1.23
P (kg/ha)	0	(Y)	1.41	2.33	2.71
	20	(R)	0.62	0.57	0.45
	40	(R)	0.90	0.80	0.58
	60	(R)	1.21	1.07	0.85
	80	(R)	1.16	1.03	0.90
	Mean	(R)	0.97	0.87	0.70
K (kg/ha)	0	(Y)	1.90	2.79	3.16
	20	(R)	0.35	0.37	0.17
	40	(R)	0.38	0.45	0.28
	60	(R)	0.72	0.61	0.40
	80	(R)	0.61	0.47	0.34
	Mean	(R)	0.52	0.48	0.30

1/ Response to N, in the presence of 60 kg/ha of P and K; P in the presence of 90 and 60 kg/ha of N and K; and to K in the presence of 90 and 60 kg/ha of N and P respectively.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 25

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER PROVINCE
(1964/65)

Province	No 1/	Control	N (kg/ha)			S.E. (±)	P (kg/ha)		K (kg/ha)		S.E. (±)
				90	120			100		100	
			60	60	60		50	50	50	50	
		(Y) 2/	(Y)	(R) 3/	(R)		(Y)	(R)	(Y)	(R)	
Kyong Gi	24	1.58	2.86	0.43	0.91	0.04	3.22	0.18	3.28	0.05	0.03
Kang Won	12	1.34	2.34	0.16	0.21	0.08	2.39	0.14	2.39	0.14	0.07
Chung Puk	14	1.76	2.98	0.53	0.95	0.07	3.37	0.21	3.44	0.07	0.06
Chung Nam	17	1.54	2.66	0.31	0.70	0.07	2.90	0.19	2.94	0.12	0.06
Chulla Puk	24	1.34	2.62	0.50	0.92	0.05	3.01	0.18	3.05	0.10	0.04
Chulla Nam	12	1.97	3.70	0.50	0.81	0.08	4.02	0.23	4.15	-0.03	0.06
Kyong Puk	11	1.22	2.03	0.15	0.28	0.08	2.17	0.01	2.08	0.18	0.06
Kyong Nam	29	2.15	3.58	0.35	0.39	0.06	3.74	0.18	3.86	-0.07	0.05
Cheju	6	1.12	2.61	0.44	0.93	0.07	2.95	0.23	3.01	0.11	0.06
Korea	149	1.63	2.90	0.39	0.68	0.02	3.17	0.17	3.23	0.06	0.02

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 26

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER PROVINCE
(1965/66)

Province		Kyong Gi	Kang Won	Chung Puk	Chung Nam	Chulla Puk	Chulla Nam	Kyong Puk	Kyong Nam	Cheju	Korea
Control	(Y)1/	1.30	0.79	1.16	1.30	1.23	1.66	1.81	1.70	0.82	1.41
N	0 (Y)	1.88	1.09	1.60	1.73	1.50	1.92	2.28	2.14	1.00	1.80
(kg/ha)	30 (R)2/	0.75	0.55	0.64	0.56	0.48	0.60	0.32	0.63	0.55	0.59
	60 (R)	1.28	0.95	1.10	0.95	0.93	1.06	1.04	1.04	1.08	1.05
	90 (R)	1.74	1.41	1.64	1.24	1.66	1.54	1.61	1.40	1.62	1.54
	120 (R)	1.88	1.52	1.26	1.40	1.82	1.81	1.57	1.52	1.79	1.62
P	0 (Y)	2.28	1.47	2.19	2.00	2.25	2.84	2.66	2.74	1.73	2.35
(kg/ha)	20 (R)	0.64	0.61	0.54	0.56	0.34	0.40	0.56	0.52	0.63	0.52
	40 (R)	1.10	0.77	0.72	0.83	0.57	0.42	0.75	0.65	0.81	0.72
	60 (R)	1.34	1.03	1.05	0.97	0.91	0.62	1.23	0.80	0.89	0.99
	80 (R)	1.46	0.95	0.86	0.86	1.02	0.68	1.14	0.86	0.91	0.98
K	0 (Y)	3.00	1.75	2.61	2.54	2.72	3.21	3.16	3.13	2.40	2.81
(kg/ha)	20 (R)	0.24	0.44	0.25	0.42	0.11	0.07	0.43	0.22	-0.04	0.27
	40 (R)	0.45	0.44	0.26	0.42	0.37	0.11	0.49	0.36	0.09	0.36
	60 (R)	0.62	0.75	0.63	0.43	0.44	0.25	0.73	0.41	0.22	0.53
	80 (R)	0.56	0.61	0.36	0.36	0.52	0.17	0.52	0.36	0.20	0.43
S.E. (±)		0.07	0.07	0.09	0.08	0.06	0.07	0.06	0.07	0.09	0.03
Number of replications		66	65	44	52	54	80	99	76	15	551

1/ Yield in ton/ha.

2/ Response in ton/ha.

Table 27

YIELD AND RESPONSE OF BARLEY TO N AND P, PER PROVINCE (1966/67)

Province	No 1/	Control (Y) 2/	N (kg/ha) 50 (Y)	N (kg/ha) 80/50 (R) 3/	N (kg/ha) 110/50 (R)	S.E.	P (kg/ha) 60 (Y)	P (kg/ha) 100/60 (R)	S.E.
Kyong Gi	59	1.30	2.77	0.39	0.67	0.04	3.04	0.17	0.03
Kang Won	66	0.83	1.95	0.33	0.56	0.04	2.16	0.18	0.04
Chung Puk	50	1.96	3.03	0.33	0.42	0.08	3.24	0.07	0.07
Chung Nam	54	1.75	2.94	0.31	0.51	0.06	3.16	0.10	0.04
Chulla Puk	54	1.33	2.30	0.39	0.69	0.03	2.60	0.12	0.03
Chulla Nam	108	1.80	2.80	0.15	0.30	0.04	2.91	0.09	0.03
Kyong Puk	101	1.74	2.69	0.18	0.15	0.04	2.74	0.12	0.04
Kyong Nam	78	1.61	2.74	0.23	0.41	0.04	2.90	0.10	0.03
Cheju	12	1.68	2.74	0.47	0.86	0.11	3.18	0.00	0.10
Korea	582	1.56	2.66	0.27	0.43	0.02	2.84	0.11	0.01

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 28

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER PROVINCE
(1967/68)

Province	No 1/	Control	N (kg/ha)			P (kg/ha)			S.E.	K (kg/ha)				S.E.
				100	130		75	100			40	60	80	
			70	70	70	50	50	50		0	0	0	0	
		(Y)2/	(Y)	(R)3/	(R)	(Y)	(R)	(R)		(Y)	(R)	(R)	(R)	
Kyong Gi	24	1.64	2.72	0.35	0.52	2.87	0.11	0.30	0.07	2.86	0.24	0.15	0.37	0.12
Kang Won	12	2.04	4.11	0.43	0.61	4.36	0.07	0.21	0.09	4.09	0.25	0.40	0.77	0.16
Chung Puk	16	1.20	1.93	0.30	0.55	2.26	-0.04	0.01	0.06	2.34	0.01	-0.14	-0.06	0.11
Chung Nam	21	1.56	2.86	0.25	0.36	2.90	0.18	0.31	0.08	2.82	0.17	0.39	0.26	0.14
Chulla Puk	36	1.26	2.40	0.74	0.95	2.77	0.25	0.33	0.05	2.67	0.31	0.55	0.55	0.09
Chulla Nam	36	2.38	3.30	0.28	0.43	3.47	0.11	0.10	0.06	3.63	-0.19	0.01	-0.05	0.11
Kyong Puk	78	1.75	2.44	0.03	0.16	2.44	0.07	0.11	0.04	2.40	0.19	0.11	0.12	0.07
Kyong Nam	56	2.12	3.49	0.16	0.28	3.52	0.18	0.16	0.05	3.64	0.13	0.09	0.11	0.08
Cheju	12	0.89	2.67	0.34	0.57	2.83	0.16	0.26	0.09	2.85	0.22	0.11	0.35	0.15
Korea	291	1.76	2.85	0.26	0.41	2.97	0.13	0.18	0.02	2.98	0.14	0.16	0.20	0.04

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 29

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER PROVINCE
(1968/69)

Province	No 1/	Control	N (kg/ha)			P (kg/ha)			S.E.	K (kg/ha)				S.E.
				100	130		75	100			40	60	80	
			70	70	70	50	50	50		0	0	0	0	
		(Y) 2/	(Y)	(R) 3/	(R)	(Y)	(R)	(R)		(Y)	(R)	(R)	(R)	
Kyong Gi	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kang Won	6	1.09	2.49	0.41	0.58	2.80	0.13	-0.07	0.16	2.46	0.51	0.21	0.33	0.29
Chung Puk	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chung Nam	16	1.54	2.67	0.39	0.53	2.90	0.13	0.10	0.07	3.07	0.02	0.12	0.01	0.13
Chulla Puk	12	1.58	2.47	0.95	1.31	2.97	0.30	0.46	0.04	3.17	0.14	0.35	0.52	0.08
Chulla Nam	24	1.71	2.84	0.24	0.36	3.06	-0.01	-0.05	0.07	2.95	0.03	0.18	0.10	0.12
Kyong Puk	48	2.17	3.59	0.26	0.35	3.74	0.09	0.07	0.05	3.73	0.02	0.13	0.16	0.08
Kyong Nam	22	2.20	3.42	0.01	0.11	3.40	0.06	0.12	0.06	3.40	0.16	-0.02	0.03	0.11
Cheju	4	1.91	4.16	0.29	0.45	4.49	-0.05	-0.19	0.19	4.10	0.31	0.53	0.34	0.32
Korea	132	1.90	3.18	0.30	0.43	3.37	0.09	0.08	0.07	3.36	0.09	0.15	0.16	0.12

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 30

YIELD AND RESPONSE OF MAIN BARLEY VARIETIES TO N, P AND K

Treatment		Year	Variety of Barley						
			Suwon 4	Suwon 6	Suwon 18	Suwon 31	Baek Dong	Non San Kwa	Bang Ju
Control 120-75-75	(Y) 1/		1.52	-	1.75	2.29	1.43	1.34	1.97
Response to N P K	(R) 2/	1964/65	1.36	-	2.20	2.77	2.04	2.20	2.54
No. of replications			6	-	20	5	20	24	12
Control 120-60-60	(Y)		0.79	1.56	1.60	1.90	1.26	0.86	1.66
Response to N P K	(R)	1965/66	1.86	1.79	2.08	1.98	2.06	2.04	2.07
No. of replications			65	28	145	45	57	26	80
Control 110-80-50	(Y)		-	1.15	1.97	2.11	1.34	1.30	1.80
Response to N P K	(R)	1966/67	-	1.49	1.97	1.37	1.60	1.88	1.30
No. of replications			-	123	88	14	42	12	108
Control 130-75-60	(Y)		2.04	1.17	1.46	-	1.30	1.63	2.34
Response to N P K	(R)	1967/68	2.68	1.09	1.47	-	2.03	1.69	1.37
No. of replications			12	6	40	-	45	12	44
Control 120-75-80	(Y)		1.95	1.22	1.70	1.98	1.31	1.31	1.86
Response to N P K	(R)	Average	1.94	1.53	1.97	1.91	1.93	2.01	1.63
No. of replications			83	157	293	64	164	74	244

1/ Yield in ton/ha.

2/ Response in ton/ha.

Table 31

YIELD AND RESPONSE OF BARLEY VARIETIES TO N, P AND K
(1964/65)

Variety	No 1/	Control	N (kg/ha)			S.E.	P (kg/ha)		K (kg/ha)		S.E.
				90	120			100		100	
			60	60	60		50	50	50	50	
		(Y)2/	(Y)	(R)3/	(R)		(Y)	(R)	(Y)	(R)	
Suwon 4	6	1.52	2.40	0.36	0.48	0.12	2.64	0.08	2.65	0.07	0.09
Suwon 18	20	1.75	2.99	0.50	0.96	0.06	3.38	0.20	3.45	0.06	0.05
Suwon 31	5	2.29	4.35	0.53	0.71	0.11	4.64	0.24	4.73	0.05	0.09
Chil Bo	18	1.53	2.80	0.44	0.89	0.04	3.15	0.19	3.22	0.04	0.03
Baek Dong	20	1.43	2.70	0.33	0.77	0.04	2.97	0.19	2.98	0.17	0.05
Non San Kwa 1 - 6	24	1.34	2.62	0.50	0.92	0.06	3.01	0.18	3.05	0.10	0.05
Bang Ju	12	1.97	3.70	0.50	0.81	0.10	4.02	0.23	4.15	-0.03	0.08
Che Chun 5	11	1.22	2.03	0.15	0.28	0.08	2.17	0.01	2.08	0.18	0.06
Boo Heung	3	1.42	2.35	0.34	0.65	0.24	2.54	0.28	2.77	-0.18	0.20
Chong Maek	6	2.15	3.46	0.17	0.03	0.09	3.53	-0.01	3.53	-0.01	0.07
Yong Wol 6 Gag	6	1.16	2.26	-0.02	-0.04	0.11	2.14	0.21	2.13	0.22	0.09
Kwan Chui Gi 1	18	2.11	3.41	0.36	0.42	0.08	3.56	0.22	3.73	-0.12	0.07

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 32

YIELD AND RESPONSE OF BARLEY VARIETIES TO N, P AND K
(1965/66)

Variety	No 1/	Control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
				90	120		60	80		60	80	
			60	60	60	40	40	40	40	40	40	
		(Y)2/	(Y)	(R)3/	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Suwon 4	65	0.79	2.04	0.46	0.61	2.24	0.26	0.18	2.19	0.31	0.18	0.10
Suwon 6	28	1.56	2.88	0.46	0.47	2.84	0.50	0.51	3.01	0.33	0.14	0.12
Suwon 18	145	1.60	3.18	0.60	0.50	3.42	0.36	0.18	3.54	0.24	-0.02	0.07
Suwon 31	45	1.90	3.43	0.33	0.45	3.66	0.10	0.22	3.66	0.10	0.12	0.12
Chil Bo	40	1.15	3.14	0.34	0.40	3.20	0.28	0.48	3.37	0.11	0.10	0.10
Baek Dong	57	1.26	2.52	0.43	0.70	2.78	0.17	0.29	2.88	0.07	0.21	0.09
Non San Kwa 1 - 6	26	0.86	2.05	0.67	0.85	2.38	0.34	0.46	2.66	0.06	0.13	0.12
Bang Ju	80	1.66	2.98	0.48	0.75	3.26	0.20	0.26	3.32	0.14	0.06	0.09
Do Won	24	1.37	2.81	0.39	0.46	2.88	0.32	0.32	3.10	0.10	-0.02	0.16
Kwan Chui Gi 1	7	1.53	2.82	0.46	0.81	3.38	-0.10	-0.19	3.67	-0.39	-0.60	0.45
Kyong Nam Dae 89	19	1.78	3.32	0.39	0.36	3.34	0.37	0.39	3.69	0.02	-0.01	0.16
Jook Ha	15	0.82	2.08	0.54	0.71	2.54	0.08	0.10	2.49	0.13	0.11	0.12

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 33

YIELD AND RESPONSE OF BARLEY VARIETIES TO N AND P
(1966/67)

Variety	No 1/	Control	N (kg/ha)			S.E.	P (kg/ha)		S.E.
		(Y) 2/	50 (Y)	80/50 (R) 3/	110/50 (R)		60 (Y)	100/60 (R)	
Suwon 6	123	1.15	2.23	0.27	0.41	0.04	2.38	0.16	0.03
Suwon 18	88	1.97	3.34	0.41	0.60	0.06	3.62	0.11	0.05
Suwon 31	14	2.11	3.10	0.06	0.38	0.14	3.16	0.17	0.11
Chil Bo	47	1.20	2.41	0.31	0.54	0.04	2.61	0.17	0.03
Baek Dong	42	1.34	2.28	0.35	0.66	0.05	2.56	0.12	0.04
Non San Kwa 1- 6	12	1.30	2.35	0.55	0.83	0.07	2.74	0.15	0.06
Bang Ju	108	1.80	2.81	0.14	0.29	0.04	2.91	0.09	0.03
Che Chun 5	60	1.81	2.78	0.18	0.20	0.05	2.88	0.06	0.04
Boo Heung	12	1.62	2.16	0.04	-0.18	0.09	2.03	0.17	0.07
Chong Maek	46	1.51	2.52	0.19	0.30	0.05	2.66	0.04	0.04
Do Won	18	1.44	3.01	0.47	0.74	0.06	3.32	0.19	0.05
Golden Melon	12	1.68	2.74	0.47	0.86	0.10	3.18	0.00	0.08

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 34

YIELD AND RESPONSE OF BARLEY VARIETIES TO N, P AND K
(1967/68)

Variety	No 1/	Control	N (kg/ha)			P (kg/ha)			S.E.	K (kg/ha)			S.E.
				100	130		75	100			60	80	
			70	70	70	50	50	50		40	40	40	
		(Y)2/	(Y)	(R)3/	(R)	(Y)	(R)	(R)		(Y)	(R)	(R)	
Suwon 4	12	2.04	4.11	0.43	0.61	4.36	0.07	0.21	0.09	4.34	0.15	0.52	0.16
Suwon 6	6	1.17	1.98	0.22	0.28	2.17	-0.04	-0.03	0.10	2.27	-0.06	0.10	0.17
Suwon 18	40	1.46	2.40	0.37	0.53	2.62	0.06	0.19	0.06	2.80	-0.11	0.00	0.10
Baek Dong	45	1.30	2.47	0.66	0.86	2.78	0.21	0.32	0.05	2.97	0.17	0.18	0.08
Non San Kwa 1 - 6	12	1.63	2.93	0.31	0.39	2.95	0.31	0.33	0.11	3.05	0.28	0.19	0.20
Bang Ju	44	2.34	3.30	0.30	0.41	3.46	0.12	0.12	0.05	3.49	0.16	0.15	0.10
Che Chun 5	36	2.22	2.89	-0.02	0.05	2.86	0.06	0.06	0.06	2.93	-0.04	-0.04	0.10
Boo Heung	68	1.88	2.95	0.08	0.29	2.96	0.16	0.19	0.05	3.25	-0.10	-0.15	0.08
Chong Maek	16	1.41	2.69	0.06	0.11	2.68	0.12	0.09	0.08	2.68	0.01	0.23	0.15
Golden Melon	12	0.89	2.67	0.34	0.57	2.83	0.16	0.26	0.08	3.07	-0.11	0.13	0.15

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 35

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER SOIL SERIES
(1964/65)

Soil series	No 1/	Control	N (kg/ha)			S.E.	P (kg/ha)		K (kg/ha)		S.E.
			60	90 60	120 60		50	100 50	50	100 50	
		(Y) 2/	(Y)	(R) 3/	(R)		(Y)	(R)	(Y)	(R)	
Bancheon	5	1.48	2.22	0.52	0.97	0.12	2.68	0.07	2.66	0.11	0.08
Banggi	1	1.34	2.14	0.17	0.64	-	2.33	0.16	2.36	0.10	-
Bansan	3	1.42	2.35	0.34	0.65	0.23	2.54	0.28	2.77	-0.18	0.18
Chang Pyeong	1	1.06	2.74	0.19	0.50	-	2.96	0.02	3.02	0.09	-
Ho Gye	4	1.97	3.54	0.37	0.75	0.18	3.86	0.11	3.74	0.35	0.25
Jeon Nam	1	0.66	1.83	0.15	0.53	-	1.96	0.20	2.02	0.08	-
Yong Ji	2	3.50	3.12	-0.23	0.21	0.31	2.83	0.57	2.97	0.29	0.25

1/ Number of replications.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 36

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER SOIL SERIES (1965/66)

Soil series	No 1/	Control	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
				90	120		60	80		60	80	
			60	60	60	40	40	40	40	40	40	
		(Y)2/	(Y)	(R)3/	(R)	(Y)	(R)	(R)	(Y)	(R)	(R)	
Ban Cheon	7	2.57	3.58	0.52	0.71	3.64	0.46	0.44	3.97	0.13	-0.01	0.28
Bang Gi	1	0.60	1.39	0.13	0.14	1.47	0.05	-0.03	2.96	-1.44	-1.44	-
Ban San	26	1.27	2.45	0.27	0.86	2.58	0.14	0.46	2.80	-0.08	0.21	0.14
Bong Gye	2	2.34	2.96	0.96	1.30	3.11	0.81	0.91	3.54	0.38	-0.02	0.48
Bong Ryang	7	1.13	2.65	0.55	0.44	2.74	0.46	0.37	2.91	0.29	0.80	0.31
Chang Pyeong	3	3.01	4.69	0.31	0.25	4.26	0.74	0.20	4.95	0.05	-0.32	0.42
Dae Gu	8	1.61	3.19	1.47	1.39	3.48	1.18	1.03	3.82	0.84	0.33	0.27
Dal Cheon	6	1.13	2.49	0.46	0.61	2.53	0.42	0.05	3.17	-0.22	-0.47	0.31
Deog San	2	1.21	2.64	2.38	2.26	3.96	1.06	0.82	4.22	0.80	0.51	0.38
Gag Hwa	10	1.17	3.14	0.50	0.46	3.61	0.03	-0.08	3.34	0.30	-0.21	0.25
Gwang Ju	1	3.14	6.12	-0.02	-1.25	5.40	0.70	-0.61	5.18	0.92	0.51	-
Gwang San	18	1.50	3.21	0.17	-0.03	3.16	0.22	0.08	3.20	0.18	-0.08	0.20
Ho Gye	26	1.58	2.62	0.48	0.87	3.03	0.07	0.15	3.12	-0.02	0.11	0.14
Hwa Bong	15	1.48	2.99	0.25	0.21	3.00	0.24	0.20	3.13	0.11	0.14	0.24
Hwa Dong	3	1.40	1.78	0.12	0.61	2.12	-0.22	0.07	2.05	-0.15	-0.03	0.18
Hwang Yong	7	1.68	3.18	0.62	0.84	3.62	0.18	0.28	3.94	-0.14	0.06	0.25
I Hyeon	11	1.34	2.97	0.71	0.87	3.50	0.18	0.01	3.58	0.10	-0.31	0.24
I Weon	7	1.93	3.50	0.61	0.50	3.73	0.38	0.10	4.01	0.10	-0.15	0.30
Jang Weon	4	1.36	2.67	0.68	0.98	2.97	0.38	-0.11	3.11	0.24	-0.20	0.41
Jeon Nam	14	1.68	2.83	0.55	0.51	2.98	0.40	0.29	3.07	0.31	0.12	0.17
Nag Dong	5	1.84	2.77	0.18	0.02	2.91	0.04	-0.25	3.15	-0.20	-0.17	0.32
Sa Chon	1	1.25	2.28	1.06	1.33	2.84	0.50	0.65	3.28	0.06	0.16	-
Sam Gag	8	1.14	1.95	0.74	0.64	2.34	0.35	0.33	2.61	0.08	0.08	0.27
Seong San	3	1.94	3.57	-0.42	-0.73	3.08	0.07	0.31	3.88	-0.73	-1.08	0.59
Si Rye	6	2.25	4.70	0.74	0.49	5.15	0.29	0.23	5.69	-0.15	-0.41	0.30
Song Jeong	3	0.82	2.28	1.31	1.04	3.01	0.58	0.06	3.32	0.27	-0.56	0.44
Su Bug	1	1.15	2.02	1.12	1.36	2.79	0.35	0.42	3.02	0.12	0.20	-
Tae Hwa	9	1.62	3.04	0.53	0.84	3.47	0.10	-0.13	3.79	-0.22	-0.36	0.37

1/ Number of replications. 2/ Yield in ton/ha. 3/ Response in ton/ha.

Table 37

YIELD AND RESPONSE OF BARLEY TO N, P AND K, PER SOIL SERIES
(1967/68)

Soil series	No 1/	Control	N (kg/ha)			P (kg/ha)			S.E.	K (kg/ha)			S.E.
			70	100/70	130/70	50	75/50	100/50		40	60/40	80/40	
		(Y)2/	(Y)	(R)3/	(R)	(Y)	(R)	(R)		(Y)	(R)	(R)	
Baeg San	12	2.04	4.11	0.43	0.61	4.36	0.07	0.21	0.09	4.34	0.15	0.52	0.15
Ban Cheon	33	1.58	2.76	0.39	0.62	2.94	0.21	0.26	0.07	3.17	-0.01	0.05	0.12
Bang Gi	24	2.29	3.40	0.23	0.40	4.14	0.21	0.37	0.06	3.72	-0.02	0.07	0.12
Ban Ho	12	1.38	1.99	-0.17	0.01	1.89	-0.01	0.16	0.12	2.10	-0.31	-0.27	0.20
Ban San	12	1.58	3.14	0.43	0.54	3.40	0.07	0.13	0.07	3.40	0.14	0.17	0.13
Bong Yang	24	2.18	3.22	0.14	0.01	3.14	0.10	0.28	0.08	3.40	-0.09	0.30	0.15
Chang Pyeong	24	1.74	2.26	0.40	0.63	2.48	0.15	0.22	0.08	2.63	0.15	0.08	0.14
Hag Seong	12	1.68	2.81	-0.02	-0.01	2.40	0.46	0.75	0.06	2.78	0.04	0.05	0.08
Ho Nam	6	1.87	3.06	0.02	0.02	2.93	0.29	0.14	0.14	3.00	0.02	0.27	0.25
I Hyeon	20	1.33	2.36	0.12	0.26	2.39	0.14	0.15	0.07	2.66	-0.10	-0.08	0.13
Jeon Nam	10	0.99	1.63	0.41	0.84	2.08	0.05	-0.11	0.07	2.08	-0.07	0.00	0.13
Nag Dong	22	1.40	2.72	0.21	0.29	2.76	0.17	0.21	0.08	2.79	0.16	0.21	0.14
Seong San	12	2.49	3.29	0.50	0.92	3.64	0.21	0.15	0.08	3.48	0.44	0.27	0.14
Seog Gye	20	2.31	3.45	0.05	0.10	3.46	0.15	0.05	0.10	3.82	0.01	-0.41	0.16
Song Jeong	12	1.88	3.22	0.28	0.65	3.41	0.15	0.22	0.07	3.46	0.12	0.25	0.12
To Gye	6	1.56	2.43	0.39	0.07	2.64	-0.29	0.13	0.21	2.79	-0.26	-0.48	0.37
Tong Cheon	6	1.17	1.98	0.22	0.28	2.17	-0.04	-0.03	0.10	2.27	-0.06	0.10	0.16
Average	279	1.73	2.81	0.24	0.37	2.95	0.12	0.19	0.03	3.05	0.02	0.05	0.04

1/ Number of replications. 2/ Yield in ton/ha. 3/ Response in ton/ha.

Table 38

OPTIMUM LEVELS OF N, P AND K FOR BARLEY, PER SOIL SERIES
(1964/65 to 1967/68)

Soil series	N (kg/ha)	P (kg/ha)	K (kg/ha)	Expected Yield (ton/ha)
Baeg San	130	100	80	4.72
Ban Cheon	130	80	80	3.62
Bang Gi	130	100	40	3.80
Ban Ho	70	100	40	1.99
Ban San	110	90	80	3.33
Bong Gye	120	60	60	4.26
Bong Ryang	90	60	80	3.09
Chang Pyeong	100	60	40	3.12
Dae Gu	90	60	60	4.63
Dal Cheon	120	60	40	3.10
Gag Hwa	100	50	60	3.64
Gwang San	80	60	60	3.38
Hag Seong	70	100	40	3.15
Ho Gye	120	80	80	3.60
Ho Nam	70	80	80	3.06
Hwa Bong	90	60	60	3.24
Hwa Dong	120	40	20	2.39
Hwang Yong	120	90	40	4.02
I Hyeon	120	60	40	3.84
I Weon	90	60	60	4.11
Jang Weon	120	60	60	3.65
Jeon Nam	120	60	40	2.74
Nag Dong	110	70	60	2.94
Sa Chon	120	80	80	3.51
Sam Gag	120	60	40	2.69
Seong San	90	70	60	4.04
Seog Gye	100	75	40	3.82
Si Rye	100	60	40	5.44
Song Jeong	120	90	40	3.60
Su Bug	120	60	60	3.38
Tae Hwa	120	60	40	3.88
To Gye	110	100	50	2.81
Tong Cheon	90	50	40	2.20
Yong Ju	120	80	70	3.33
Average	105	70	55	3.37

Table 39

RESPONSE OF BARLEY TO N, P AND K - COST ANALYSIS

Treatment		Cost of fert. (1 000 Won)	NORTH				CENTRE				SOUTH			
			Yield (ton/ha)	Response (ton/ha)	Value (1 000 Won)	Gross profit (1 000 Won)	Yield (ton/ha)	Response (ton/ha)	Value (1 000 Won)	Gross profit (1 000 Won)	Yield (ton/ha)	Response (ton/ha)	Value (1 000 Won)	Gross profit (1 000 Won)
N	0	-	1.24	-	-	-	1.85	-	-	-	2.00	-	-	-
(kg/ha)	30	1.78	1.80	0.56	16.42	14.46	2.45	0.60	17.59	15.81	2.58	0.58	17.00	15.22
	60	3.55	2.24	1.00	29.32	25.77	2.90	1.05	30.79	27.24	3.06	1.06	31.08	27.53
	90	5.33	2.62	1.38	40.46	35.13	3.40	1.55	45.45	40.12	3.56	1.56	45.74	40.41
	120	7.11	2.62	1.38	40.46	33.35	3.46	1.61	47.20	40.09	3.70	1.70	49.84	42.73
S.E.				0.07		2.05		0.05		1.47		0.05		1.47
P	0	-	1.41	-	-	-	2.33	-	-	-	2.71	-	-	-
(kg/ha)	20	0.84	2.03	0.62	18.18	17.34	2.90	0.57	16.71	15.87	3.16	0.45	13.19	12.35
	40	1.68	2.31	0.90	26.39	24.71	3.13	0.80	23.46	21.78	3.29	0.58	17.00	15.32
	60	2.52	2.62	1.21	35.48	32.96	3.40	1.07	31.37	28.85	3.56	0.85	24.92	22.40
	80	3.36	2.57	1.16	34.01	30.65	3.36	1.03	30.20	26.84	3.61	0.90	26.39	23.03
S.E.				0.07		2.05		0.05		1.47		0.05		1.47
K	0	-	1.90	-	-	-	2.79	-	-	-	3.16	-	-	-
(kg/ha)	20	0.37	2.25	0.35	10.26	9.89	3.16	0.37	10.85	10.48	3.33	0.17	4.98	4.61
	40	0.75	2.28	0.38	11.14	10.39	3.24	0.45	13.19	12.44	3.44	0.28	8.21	7.46
	60	1.12	2.62	0.72	21.11	19.99	3.40	0.61	17.88	16.76	3.56	0.40	11.73	10.61
	80	1.49	2.51	0.61	17.88	16.39	3.26	0.47	13.78	12.29	3.50	0.34	9.97	8.48
S.E.				0.07		2.05		0.05		1.47		0.05		1.47

Table 40

ECONOMICS OF FERTILIZER USE ON BARLEY AT OPTIMUM LEVEL

N (kg/ha)	P (kg/ha)	K (kg/ha)	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	0	0	1.60	–	–	–	–	–
105	70	55	3.37	1.77	51.9	10.2	41.7	509

Table 41

RESPONSE OF BARLEY TO LIME
(ton/ha)

Province	Lime (ton/ha) 0	1.5	2.5	4.0	6.5
Chung Nam	0.76	1.61	1.67	1.84	2.10
Chulla Puk	1.51	1.95	2.02	2.07	2.19
Kyong Nam	2.04	2.65	2.76	2.93	3.07
Average	1.50	2.11	2.19	2.32	2.49
Response over no lime		0.61	0.69	0.82	0.99
Percentage increase over no lime		40	46	55	66

Table 42

AREA, PRODUCTION AND YIELD OF WHEAT IN THE YEARS 1963-68

Year	Area (ha)	Production (ton)	Yield (ton/ha)
1963	138 075	227 787	1.65
1964	147 290	309 303	2.10
1965	152 860	299 871	1.96
1966	154 223	315 333	2.05
1967	152 901	309 843	2.03
1968	158 741	344 977	2.17

Table 43

YIELD OF WHEAT WITHOUT AND WITH N, PER REGION

Region	Year	Control	N (kg/ha) 70	100	130
North	1964/65	0.94 1/	1.20	1.42	1.49
	1966/67	0.87	1.61	1.82	1.49
	1967/68	0.83	1.79	1.92	1.97
	1968/69	0.80	1.39	1.78	2.07
	Average	0.86	1.50	1.74	1.76
Centre	1964/65	1.50	1.37	1.88	2.25
	1966/67	1.78	1.43	1.65	1.74
	1967/68	2.10	0.92	1.17	1.23
	1968/69	1.41	1.58	1.93	2.03
	Average	1.70	1.33	1.66	1.81
South	1964/65	1.97	1.52	1.80	2.05
	1966/67	1.68	1.30	1.52	1.60
	1967/68	1.69	1.45	1.62	1.69
	1968/69	2.00	1.95	2.29	2.42
	Average	1.84	1.56	1.81	1.94

1/ Ton/ha.

Table 44

YIELD OF WHEAT WITH P AND K, PER REGION

Region	Year	P (kg/ha) 50	P 75	P 100	S.E.	K (kg/ha) 0	K 40	K 60	K 80	S.E.
North	1967/68	2.54 1/	2.70	2.93	0.08	2.42	2.65	2.62	2.87	0.13
	1968/69	2.49	2.46	2.70	0.07	2.46	2.24	2.33	2.59	0.12
	Average	2.51	2.58	2.82	0.07	2.44	2.44	2.48	2.73	0.12
Centre	1967/68	3.12	3.20	3.29	0.04	3.16	3.26	3.24	3.27	0.06
	1968/69	3.09	3.31	3.36	0.03	3.25	3.30	3.46	3.36	0.05
	Average	3.10	3.25	3.39	0.03	3.20	3.28	3.35	3.31	0.05
South	1967/68	3.22	3.32	3.28	0.03	3.29	3.31	3.41	3.37	0.05
	1968/69	4.07	4.23	4.35	0.02	4.20	4.31	4.26	4.31	0.04
	Average	3.64	3.77	3.81	0.02	3.74	3.81	3.84	3.84	0.04

1/ Ton/ha.

Table 45

ECONOMICS OF FERTILIZER USE ON WHEAT (NORTHERN REGION)

N (kg/ha)	P (kg/ha)	K (kg/ha)	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	0	0	0.81	-	-	-	-	-
70	50	60	2.22	1.41	41.34	6.25	35.09	661
70	75	60	2.38	1.57	46.03	8.42	37.61	547
70	100	60	2.60	1.79	52.48	9.47	43.01	554
100	50	60	2.62	1.81	53.07	9.14	43.93	581
100	75	60	2.48	1.67	48.96	10.19	38.77	480
100	100	60	2.90	2.09	61.28	11.24	50.04	545
130	50	60	2.69	1.88	55.12	10.92	44.20	505
130	75	60	2.87	2.06	60.40	11.97	48.43	504
130	100	60	2.94	2.13	62.45	13.02	49.43	480
0	75	60	1.00	0.19	5.57	4.27	1.30	130
100	0	60	1.43	0.62	18.18	7.04	11.14	258
100	75	0	2.44	1.63	47.79	9.07	38.72	527
100	75	40	2.44	1.63	47.79	9.82	37.97	487
100	75	80	2.73	1.92	56.29	10.56	45.73	533
130	100	80	3.19	2.38	69.78	13.39	56.39	521

Prices: Wheat = 29.32 W/kg
N = 59.22 W/kg
P = 41.96 W/kg
K = 18.67 W/kg

Table 46

ECONOMICS OF FERTILIZER USE ON WHEAT (CENTRAL REGION)

N (kg/ha)	P (kg/ha)	K (kg/ha)	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	0	0	1.71	-	-	-	-	-
70	50	60	2.86	1.15	33.72	6.25	27.47	540
70	75	60	3.00	1.29	37.82	8.42	29.40	449
70	100	60	3.15	1.44	42.22	9.47	32.75	446
100	50	60	3.22	1.51	44.27	9.14	35.13	484
100	75	60	3.36	1.65	48.38	10.19	38.19	475
100	100	60	3.35	1.64	48.08	11.24	36.84	428
130	50	60	3.24	1.53	44.86	10.92	33.94	411
130	75	60	3.44	1.73	50.72	11.97	38.75	424
130	100	60	3.48	1.77	51.90	13.02	38.88	399
0	75	60	1.92	0.21	6.16	4.27	1.89	144
100	0	60	2.74	1.03	30.20	7.04	23.16	429
100	75	0	3.21	1.50	43.98	9.07	34.91	485
100	75	40	3.28	1.57	46.03	9.82	36.21	469
100	75	80	3.32	1.61	47.20	10.56	46.14	447
130	100	80	3.49	1.78	52.19	13.39	38.80	390

Prices: Wheat = 29.32 W/kg
N = 59.22 W/kg
P = 41.96 W/kg
K = 18.67 W/kg

Table 47

ECONOMICS OF FERTILIZER USE ON WHEAT (SOUTHERN REGION)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
	(kg/ha)							
0	0	0	1.85	-	-	-	-	-
70	50	60	3.43	1.58	46.32	6.25	40.07	741
70	75	60	3.59	1.74	51.02	8.42	42.60	606
70	100	60	3.68	1.83	53.66	9.47	44.19	567
100	50	60	3.74	1.89	55.41	9.14	46.27	606
100	75	60	3.86	2.01	58.93	10.19	48.74	578
100	100	60	3.88	2.03	59.52	11.24	48.28	530
130	50	60	3.85	2.00	58.64	10.92	47.72	537
130	75	60	3.95	2.10	61.57	11.97	49.60	514
130	100	60	3.98	2.13	62.45	13.02	49.43	480
0	75	60	2.17	0.32	9.38	4.27	5.11	220
100	0	60	3.37	1.52	44.57	7.04	37.53	633
100	75	0	3.77	1.92	56.29	9.07	47.22	621
100	75	40	3.84	1.99	58.35	9.82	48.53	594
100	75	80	3.87	2.02	59.23	10.56	48.67	561
130	100	80	3.96	2.11	61.86	13.39	48.47	462

Prices: Wheat = 29.32 W/kg
N = 59.22 W/kg
P = 41.96 W/kg
K = 18.67 W/kg

Table 48

YIELD AND RESPONSE TO N, P AND K OF MAIN WHEAT VARIETIES

		Yong Gwang	Jang Gwang	Jin Gwang	Nong Lik 4 Ho	Yuk Song 3
Yield at 0-75-60	(Y)1/	1.67	1.57	1.64	2.03	0.82
Response to N_{70} 2/	(R)3/	1.30	1.36	1.30	1.21	1.37
" N_{100}	(R)	1.47	1.44	1.43	0.32	0.76
" N_{130}	(R)	1.59	1.43	1.42	0.42	2.05
S.E.		0.034	0.049	0.051	0.030	0.098
Yield at 100- 0-60	(Y)	2.38	2.73	2.75	3.05	1.45
Response to P_{50}	(R)	0.48	-0.04	0.06	0.15	1.04
" P_{75}	(R)	0.81	0.31	0.35	0.35	1.01
" P_{100}	(R)	0.94	0.49	0.42	0.39	1.24
S.E.		0.034	0.049	0.051	0.030	0.098
Yield at 100-75- 0	(Y)	3.04	2.92	3.12	3.34	2.46
Response to K_{40}	(R)	0.06	0.17	-0.04	0.09	-0.22
" K_{60}	(R)	0.14	0.18	0.07	0.05	-0.13
" K_{80}	(R)	0.18	0.15	-0.03	0.08	0.13
S.E.		0.058	0.086	0.089	0.052	0.120

1/ Yield in ton/ha.
2/ Kg/ha.
3/ Response in ton/ha.

Table 49

YIELD OF WHEAT WITH N, P AND K, PER SOIL SERIES

Soil series	Number of replications	No fertilizer	N (kg/ha)			P (kg/ha)			S.E.	K (kg/ha)				S.E.
			70	100	130	50	75	100		0	40	60	80	
Ban Cheon	12	1.01 1/	3.11	3.50	3.59	3.04	3.51	3.66	0.05	3.16	3.49	3.61	3.59	0.09
Bon Ryang	24	1.18	2.68	3.12	3.36	2.87	3.04	3.25	0.04	2.82	3.03	3.06	3.23	0.08
Dal Cheon	12	1.71	2.66	2.84	2.84	2.66	2.77	2.91	0.80	2.78	2.76	2.79	2.72	0.12
Deog San	12	1.23	2.56	3.03	3.01	2.78	2.98	2.85	0.05	3.02	3.06	3.25	2.98	0.09
Gag Hwa	12	1.17	2.86	3.38	3.46	3.08	3.30	3.32	0.04	3.19	3.35	3.42	3.30	0.07
Gwang San	12	1.42	3.27	3.70	4.05	3.56	3.72	3.75	0.06	3.43	3.73	3.67	3.75	0.11
Ho Gye	36	2.09	3.83	4.19	4.32	4.07	4.18	4.09	0.07	4.28	4.17	4.35	4.23	0.12
Ho Nam	12	2.45	4.12	4.22	4.22	3.92	4.31	4.34	0.04	4.15	4.35	4.33	4.44	0.07
Jeong Nam	8	1.22	3.21	3.77	3.89	3.68	3.66	3.53	0.08	3.77	4.02	4.00	3.85	0.14
Jeon Nam	46	1.92	3.40	3.55	3.64	3.45	3.59	3.56	0.04	3.62	3.63	3.72	3.61	0.12
Nag Dong	36	1.81	3.25	3.43	3.45	3.34	3.32	3.48	0.06	3.43	3.39	3.34	3.42	0.10
Sin Heung	24	1.92	4.14	4.49	4.61	4.12	4.38	4.74	0.04	4.15	4.31	4.31	4.40	0.08
Sin Jeong	12	2.91	3.93	3.84	3.75	3.82	3.82	3.88	0.09	3.78	4.19	3.80	3.85	0.16
Si Rye	12	2.37	4.10	4.03	4.13	3.97	4.10	4.19	0.06	4.14	4.10	3.95	4.19	0.10
Tae Hwa	11	2.26	2.73	2.89	2.73	2.78	2.80	2.76	0.06	2.85	2.66	2.83	2.88	0.11
Tong Cheon	12	1.21	2.90	3.24	3.43	3.07	3.20	3.30	0.04	3.02	3.06	3.33	3.29	0.06
Yong Ji	12	0.80	2.19	2.58	2.87	2.49	2.46	2.70	0.07	2.46	2.24	2.33	2.59	0.12

1/ Ton/ha.

Table 50

OPTIMUM LEVELS OF N, P AND K FOR WHEAT, PER SOIL SERIES

Soil series	Optimum levels (kg/ha) N	P	K
Ban Cheon	118	96	60
Bon Ryang	142	100	56
Dal Cheon	105	100	20
Deog San	113	75	60
Gag Hwa	116	85	60
Gwang San	130	86	60
Ho Gye	124	78	60
Ho Nam	97	87	40
Jeong Nam	119	50	40
Jeon Nam	100	78	40
Nag Dong	107	100	40
Shin Heung	123	100	40
Sin Jeong	70	50	30
Si Rye	70	121	0
Tae Hwa	94	45	75
Tong Cheon	140	140	60
Yong Ji	130	100	80

Table 51

YIELD OF WHEAT WITH APPLICATION OF N, P AND K, PER PROVINCE

Province	N (kg/ha)				P (kg/ha)			S.E.	K (kg/ha)				S.E.
	0	70	100	130	50	75	100		0	40	60	80	
Kyong Gi	1.32 1/	2.87	3.43	3.72	3.12	3.38	3.52	0.06	3.16	3.33	3.48	3.51	0.07
Kang Won	0.82	2.41	2.66	2.84	2.51	2.58	2.82	0.08	2.44	2.44	2.48	2.73	0.12
Chung Puk	1.67	2.82	3.04	3.09	2.89	2.99	3.07	0.07	3.06	2.96	3.00	2.98	0.11
Chung Nam	1.14	2.48	2.82	2.92	2.74	2.77	2.72	0.06	2.81	2.92	2.96	2.86	0.10
Chulla Puk	1.42	3.27	3.70	4.05	3.56	3.72	3.75	0.06	3.43	3.73	3.67	3.75	0.11
Chulla Nam	1.34	2.82	3.17	3.24	2.98	3.13	3.12	0.05	3.14	3.10	3.24	3.14	0.08
Kyong Puk	2.24	3.50	3.81	3.84	3.65	3.74	3.76	0.05	3.77	3.95	3.94	3.81	0.08
Kyong Nam	2.22	4.24	4.38	4.44	4.24	4.42	4.38	0.05	4.35	4.36	4.48	4.47	0.09
Korea	1.73	3.27	3.53	3.64	3.37	3.50	3.56	0.02	3.46	3.52	3.56	3.56	0.03

1/ Ton/ha.

Table 52

YIELD OF RAPE WITH N, P AND K, PER REGION
(1965-68)

Location		Control	N (kg/ha) 0	N (kg/ha) 100	P (kg/ha) 0	P (kg/ha) 60	K (kg/ha) 0	K (kg/ha) 60
Cheju								
1964/65	North	0.32 1/	0.44	1.10	0.64	0.90	0.70	0.84
	South	0.73	0.87	1.33	1.01	1.20	1.05	1.16

		N (kg/ha) 0	N 40	N 80	N 120	P (kg/ha) 0	P 30	P 60	P 90	K (kg/ha) 0	K 30	K 60	K 90
1965/66	North	0.48	1.05	1.27	1.46	1.09	1.27	1.40	1.46	1.40	1.34	1.47	1.46
	South	0.43	1.19	1.57	2.10	1.38	1.61	1.86	2.10	1.70	1.72	1.98	2.10

		Control	N (kg/ha) 60	N 95	N 130	P (kg/ha) 60	P 100
1966/67	North	0.84	1.52	1.72	1.84	1.66	1.73

		N (kg/ha) 80	N 130	N 180	S.E.	P (kg/ha) 80	P 120	S.E.
1967/68	North	1.58	1.84	1.90	0.05	1.74	1.81	0.04
	South	1.83	1.96	2.10	0.05	1.95	1.98	0.04

		Control	N (kg/ha) 50	N 70	N 90	P (kg/ha) 95	P 140	P 185	S.E.	K (kg/ha) 0	K 40	K 60	K 80	S.E.
1968/69	North	1.24	2.08	2.29	2.36	2.14	2.21	2.39	0.08	2.04	2.11	2.25	2.30	0.18

1/ Ton/ha.

Table 53

ECONOMICS OF FERTILIZER USE ON RAPE

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	1.24	–	–	–	–	–
50	95	60	1.98	0.74	38.16	8.07	30.09	473
50	140	60	2.12	0.88	45.38	9.96	35.42	456
50	185	60	2.16	0.92	47.44	11.84	45.60	401
70	95	60	2.15	0.91	46.93	9.25	37.68	507
70	140	60	2.25	1.01	52.09	11.14	40.95	468
70	185	60	2.48	1.24	63.95	13.03	50.92	491
90	95	60	2.30	1.06	54.66	10.44	44.22	523
90	140	60	2.26	1.02	52.60	12.32	40.28	427
90	185	60	2.54	1.30	67.04	14.21	52.83	472
0	140	60	1.60	0.36	18.57	6.99	11.58	266
70	0	60	1.97	0.73	37.65	5.26	32.39	716
70	140	0	2.04	0.80	41.26	10.02	31.24	412
70	140	40	2.11	0.87	44.87	10.77	34.10	417
70	140	80	2.30	1.06	54.66	11.51	43.15	475
70	185	80	2.50	1.26	64.98	13.40	51.58	485
S.E.			0.14	0.20	10.31	–	10.31	

Prices: Rape = 51.57 W/kg
N = 59.22 W/kg
P = 41.96 W/kg
K = 18.67 W/kg

Table 54

RESPONSE OF RAPE TO BORON, P AND K

	120-100-90	120-100-90 B5	120-100-90 B10	120-100-90 B20	120-100-0 B10	120-0-90 B10	S.E.
Treatment	N_{120} 1/ P_{100} K_{90}	N_{120} P_{100} K_{90} B_5	N_{120} P_{100} K_{90} B_{10}	N_{120} P_{100} K_{90} B_{20}	N_{120} P_{100} B_{10}	N_{120} K_{90} B_{10}	
Chulla Puk Province	1.69 2/	1.73	1.84	1.93	1.80	1.76	0.022
Chulla Nam Province	0.97	1.11	1.04	1.05	1.08	1.04	0.032
Cheju Province	1.72	1.88	1.91	1.82	1.77	1.55	0.076
Average	1.43	1.51	1.56	1.61	1.54	1.49	0.026

1/ Kg/ha.

2/ Ton/ha.

Table 55

YIELD OF SOYABEAN WITHOUT AND WITH LIME AND N, P AND K

N	P	K (kg/ha)		Experiments I	II	III	IV	Average
0	0	0	No lime	0.97 1/	0.74	1.35	0.96	1.00
0	0	0+	Lime 2/	1.27	0.90	1.40	1.25	1.20
30	40	40	No lime	0.94	0.99	1.38	1.11	1.10
30	40	40+	Lime	1.58	1.08	1.71	1.01	1.34
30	40	80	No lime	1.13	1.07	1.42	1.05	1.17
30	40	80+	Lime	1.01	1.12	1.46	1.31	1.22
30	40	120	No lime	1.29	0.91	1.26	0.93	1.10
30	40	120+	Lime	1.14	1.23	1.45	1.41	1.31
30	80	40	No lime	1.13	0.74	1.34	0.93	1.04
30	80	40+	Lime	1.05	1.07	1.33	1.08	1.13
30	80	80	No lime	1.31	0.75	1.49	1.00	1.14
30	80	80+	Lime	1.39	0.80	1.52	1.18	1.22
30	80	120	No lime	1.04	0.79	1.41	0.93	1.04
30	80	120+	Lime	0.92	0.83	1.56	1.45	1.19
Average			No lime	1.12	0.86	1.38	0.99	1.08
			Lime	1.20	1.00	1.49	1.24	1.23

1/ Ton/ha.

2/ Lime was applied at the rate of 3 tons/ha or more depending on the exchangeable acidity of the soil.

Table 56

ECONOMICS OF FERTILIZER USE ON SOYABEAN
(1966)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	0.67	–	–	–	–	–
0	40	0	0.73	0.06	3.03	1.68	1.35	180
0	80	0	0.77	0.10	5.05	3.36	1.69	150
0	0	60	0.76	0.09	4.54	1.12	3.42	405
0	40	60	0.83	0.16	8.07	2.80	5.27	288
0	80	60	0.84	0.17	8.58	4.48	4.10	192
40	0	0	0.72	0.05	2.52	2.37	0.15	106
40	40	0	0.76	0.09	4.54	4.05	0.49	112
40	80	0	0.79	0.12	6.06	5.73	0.33	106
40	0	60	0.75	0.08	4.04	3.49	0.55	116
40	40	60	0.79	0.12	6.06	5.17	0.89	117
40	80	60	0.81	0.14	7.06	6.85	0.21	103
S.E.			0.012	0.017	0.86		0.86	

Table 57

ECONOMICS OF FERTILIZER USE ON SOYABEAN
(1967)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	0.97	-	-	-	-	-
0	40	30	1.05	0.08	4.04	2.24	1.80	180
0	80	60	1.11	0.14	7.06	4.48	2.58	157
40	0	0	1.05	0.08	4.04	2.37	1.67	170
40	0	30	1.07	0.10	5.05	2.93	2.12	172
40	0	60	1.12	0.15	7.57	3.49	4.08	217
40	40	0	1.08	0.11	5.55	4.05	1.50	137
40	40	30	1.16	0.19	9.59	4.61	4.98	208
40	40	60	1.16	0.19	9.59	5.17	4.42	185
40	80	0	1.14	0.17	8.58	5.73	2.85	150
40	80	30	1.16	0.19	9.59	6.29	3.30	152
40	80	60	1.18	0.21	10.60	6.85	3.75	155
S.E.			0.012	0.017	0.86		0.86	

Table 58

ECONOMICS OF FERTILIZER USE ON SOYABEAN
(1968)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	1.21	-	-	-	-	-
40	0	0	1.38	0.17	8.58	2.37	6.21	362
40	0	40	1.45	0.24	12.11	3.12	8.99	388
40	0	80	1.46	0.25	12.62	3.86	8.76	327
40	30	0	1.48	0.27	13.62	3.63	9.99	375
40	30	40	1.50	0.29	14.63	4.38	10.25	334
40	30	80	1.52	0.31	15.64	5.12	10.52	305
40	60	0	1.55	0.34	17.16	4.89	12.27	351
40	60	40	1.57	0.36	18.16	5.63	12.53	322
40	60	80	1.58	0.37	18.67	6.38	12.29	293
S.E.			0.012	0.017	0.86		0.86	

Table 59

RESPONSE OF ITALIAN MILLET TO N, P AND K

Treatment N	P	K (kg/ha)	Chulla Nam	Kyong Puk		Cheju	Average
0	80	80	2.39 1/	1.57	2.55	2.22	2.28
60	80	80	2.60	1.77	3.06	2.70	2.64
80	80	80	2.65	1.96	3.59	2.71	2.80
100	80	80	2.75	2.08	3.91	2.82	3.04
100	0	80	2.71	2.21	4.12	2.45	2.85
100	40	80	2.68	2.21	4.04	2.58	2.92
100	60	80	2.75	2.22	4.16	2.65	2.96
100	80	0	2.57	2.10	4.13	2.42	2.83
100	80	40	2.68	2.12	4.13	2.68	2.95
100	80	60	2.73	2.12	4.16	2.68	2.99
S.E.			± 0.060	± 0.052	±0.109	± 0.091	± 0.05

1/ Ton/ha.

Table 60

ECONOMICS OF FERTILIZER USE ON ITALIAN MILLET
(CHEJU ISLAND)

N	P	K (kg/ha)	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertiliser (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	0	0	2.70	–	–	–	–	–
40	0	0	3.21	0.51	19.40	2.37	17.03	818
40	0	40	3.38	0.68	24.43	3.12	21.31	783
40	80	0	3.50	0.80	28.74	5.72	23.02	502
40	80	40	3.56	0.86	30.90	6.47	24.43	477
60	0	0	3.51	0.81	29.10	3.55	25.55	820
S.E.			0.08	0.11	3.95		3.95	

Prices: Italian millet = 35.93 W/kg
N = 59.22 W/kg
P = 41.96 W/kg
K = 18.67 W/kg

Table 61

ECONOMICS OF FERTILIZER USE ON ITALIAN MILLET
(Average on Growing Areas)

N	P	K (kg/ha)	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertiliser (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	0	0	1.88	–	–	–	–	–
0	80	80	2.28	0.40	14.37	4.85	9.52	296
60	80	80	2.64	0.76	27.31	8.40	18.91	325
80	80	80	2.80	0.92	33.05	9.59	23.46	345
100	80	80	3.04	1.16	41.68	10.77	30.91	387
100	0	80	2.85	0.97	34.85	7.42	27.43	470
100	40	80	2.92	1.04	37.67	9.09	28.58	414
100	60	80	2.96	1.08	38.80	9.93	28.87	391
100	80	0	2.83	0.95	34.13	9.28	24.85	368
100	80	40	2.95	1.07	38.44	10.03	28.41	383
100	80	60	2.99	1.11	39.88	10.40	29.48	383
S.E.			0.05	0.07	2.52	–	2.52	

Table 62

YIELD OF MAIZE WITH N, P AND K

	N_{80} 1/	N_{120}	N_{160}	Mean	K_0	K_{70}	K_{140}
P_0	3.98 2/	4.35	4.56	4.30	4.25	4.38	4.26
P_{80}	4.82	5.25	5.32	5.13	4.79	5.25	5.35
P_{160}	4.87	5.46	5.52	5.28	5.22	5.25	5.39
Mean	4.56	5.02	5.14	(4.90)	4.75	4.96	5.00
K_0	4.42	4.83	5.01				
K_{70}	4.59	5.12	5.17	Control: 1.77			
K_{140}	4.65	5.11	5.23	S.E. (for body of table) = 0.09 S.E. (for marginal means)= 0.05			

Optimum levels of N 148 kg/ha
P 125 kg/ha
K 110 kg/ha

1/ Kg/ha.
2/ Ton/ha.

Table 63

ECONOMICS OF FERTILIZER USE ON MAIZE

N (kg/ha)	P (kg/ha)	K (kg/ha)	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	0	0	1.77	–	–	–	–	–
80	0	0	3.90	2.13	59.64	4.74	54.90	1 258
80	80	140	4.98	3.21	89.88	10.71	79.17	839
80	160	70	4.68	2.91	81.48	12.76	68.72	639
120	0	140	4.33	2.56	71.68	9.72	61.96	737
120	80	70	5.41	3.64	101.92	11.77	90.15	866
120	160	0	5.36	3.59	100.52	13.82	86.70	727
160	0	70	4.58	2.81	78.68	10.78	67.90	730
160	80	0	5.03	3.26	91.28	12.83	78.45	711
160	160	140	5.60	3.83	107.24	18.80	88.44	570
80	0	70	4.08	2.31	64.68	6.04	58.64	1 071
80	80	0	4.46	2.69	75.32	8.09	67.23	931
80	160	140	5.02	3.25	91.00	14.06	76.94	647
120	0	0	4.24	2.47	69.16	7.11	62.05	973
120	80	140	5.46	3.69	103.32	13.08	90.24	790
120	160	70	5.48	3.71	103.88	15.13	88.75	687
160	0	140	4.50	2.73	76.44	12.09	64.35	632
	80	70	5.33	3.56	99.68	14.14	85.54	705
	160	0	5.38	3.61	101.08	16.19	84.89	624
80	0	140	3.96	2.19	61.32	7.35	53.97	834
	80	70	5.02	3.25	91.00	9.40	81.60	968
	160	0	4.91	3.14	87.92	11.45	76.47	768
120	0	70	4.47	2.70	75.60	8.41	67.19	899
	80	0	4.89	3.12	87.36	10.46	76.90	835
	160	140	5.54	3.77	105.56	16.43	89.13	643
160	0	0	4.61	2.84	79.52	9.48	70.04	839
	80	140	5.60	3.83	107.24	15.45	91.79	694
	160	70	5.59	3.82	106.96	17.50	89.46	611
S.E.			0.15	0.21	5.88	–	5.88	–

Prices: Maize = 28.00 W/kg
N = 59.22 W/kg
P = 41.96 W/kg
K = 18.67 W/kg

Table 64

YIELD OF WHITE POTATO WITH N, P AND K IN UPLAND AND PADDY FIELDS

N	P	K	Upland Yield (ton/ha)	Paddy Yield (ton/ha)
0	90	140	10.79	7.36
60	90	140	13.98	12.87
100	90	140	15.78	13.93
140	90	140	14.90	14.41
140	0	140	14.33	8.75
140	30	140	16.38	12.08
140	60	140	15.10	13.42
140	90	140	14.90	14.41
140	90	0	14.95	12.15
140	90	60	16.09	14.59
140	90	100	15.38	13.88
140	140	140	14.90	14.41
S.E.			± 0.60	± 0.55

(N, P, K in kg/ha)

Table 65

ECONOMICS OF FERTILIZER USE ON WHITE POTATO

N	P	K	Yield	Response	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)			(ton/ha)					
0	0	0	8.77	–	–	–	–	–
60	0	50	14.59	5.82	84.45	4.48	79.97	1 885
60	45	150	15.12	6.35	92.14	8.24	83.90	1 118
60	90	100	18.91	10.14	147.13	9.20	137.93	1 599
90	0	150	18.69	9.92	143.94	8.13	135.81	1 770
90	45	100	20.64	11.87	172.23	9.09	163.14	1 895
90	90	50	17.90	9.13	132.48	10.04	122.44	1 320
120	0	100	16.34	7.57	109.84	8.98	100.86	1 223
120	45	50	17.95	9.18	133.20	9.93	123.27	1 341
120	90	150	22.82	14.05	203.86	13.69	190.17	1 489
90	45	0	20.00	11.23	162.95	7.22	155.73	2 257
60	0	100	15.36	6.59	95.62	5.42	90.20	1 764
60	45	50	16.08	7.31	106.07	6.37	99.70	1 665
60	90	150	17.95	9.18	133.20	10.13	123.07	1 315
90	0	50	14.17	5.40	78.35	6.26	72.09	1 252
90	45	150	16.60	7.83	113.61	10.02	103.59	1 134
90	90	100	20.71	11.94	173.25	10.98	162.27	1 578
120	0	150	16.51	7.74	112.31	9.91	102.40	1 133
120	45	100	18.58	9.81	142.34	10.87	131.47	1 309
120	90	50	17.50	8.73	126.67	11.82	114.85	1 072
90	45	200	18.85	10.08	146.26	10.95	135.31	1 336
60	0	150	15.44	6.67	96.78	6.35	90.43	1 524
60	45	100	16.24	7.47	108.39	7.31	101.08	1 483
90	90	50	16.52	7.75	112.45	8.26	104.19	1 361
90	0	100	15.51	6.74	93.88	7.20	86.68	1 304
90	45	50	17.00	8.23	119.42	8.15	111.27	1 465
90	90	150	20.35	11.58	168.03	11.91	156.12	1 411
120	0	50	15.97	7.20	104.47	8.04	96.43	1 299
120	45	150	18.37	9.60	139.30	11.80	127.50	1 180
120	90	100	20.61	11.84	171.80	12.76	159.04	1 346
S.E.			0.40	0.56	8.21	–	8.21	

Table 66

YIELD AND RESPONSE OF SWEET POTATO TO N, P AND K, PER PROVINCE
(1966)

Province	P_{75} 1/, K_{240} N 0 (Y) 2/	30 (R) 3/	60 (R)	90 (R)	N_{90}, K_{240} P 0 (Y)	25 (R)	50 (R)	75 (R)	N_{90}, P_{75} K 0 (Y)	80 (R)	160 (R)	240 (R)	S.E.
Kyong Gi	20.66	3.96	7.22	9.88	20.51	4.82	7.29	10.03	19.62	4.78	8.48	10.92	0.44
Chulla Puk	9.77	4.00	7.37	10.30	11.88	3.90	6.12	8.19	16.73	1.29	2.75	3.34	0.42
Kyong Nam	18.56	-0.07	0.20	- 0.07	17.73	0.61	2.18	0.76	16.06	1.46	1.76	2.43	0.58
Cheju	22.53	1.26	1.61	2.34	23.89	0.39	1.03	0.98	21.71	1.12	3.25	3.16	0.82
Average	17.95	2.27	4.07	5.57	18.56	2.42	4.14	4.96	18.54	2.17	4.08	4.98	0.40

1/ Fertilizer rates in kg/ha.

2/ Yield in ton/ha.

3/ Response in ton/ha.

Table 67

YIELD AND RESPONSE OF SWEET POTATO TO N, P AND K, PER PROVINCE
(1967)

Province	Yield (ton/ha)	N (kg/ha) 40	70	100	P (kg/ha) 0	45	90	K (kg/ha) 0	100	200	S.E.
		Average response (ton/ha)			Average response (ton/ha)			Average response (ton/ha)			
Kyong Gi	9.24	3.19	5.55	8.56	5.15	5.86	6.29	5.35	5.81	6.14	0.20
Chung Puk	19.01	4.21	3.16	2.08	2.71	3.57	3.18	2.53	3.31	3.31	0.35
Chung Nam	16.06	6.39	5.84	5.48	4.94	6.80	5.98	4.23	6.15	7.33	0.65
Chulla Puk	11.55	4.43	6.13	7.48	5.19	6.11	6.73	5.88	6.14	6.01	0.13
Chulla Nam	12.67	0.80	1.02	0.95	0.77	0.98	1.03	0.43	1.21	1.13	0.32
Kyong Puk	15.56	3.03	4.19	4.58	3.76	4.08	3.97	3.25	4.07	4.48	0.37
Kyong Nam	14.29	2.90	2.55	1.98	1.98	2.47	2.99	0.74	2.57	4.12	0.24
Cheju	10.30	2.30	2.40	2.40	2.40	2.50	2.30	1.60	2.70	2.80	0.54
Korea	13.61	3.44	4.06	4.48	3.53	4.19	4.27	3.24	4.16	4.59	0.13

Table 68

YIELD AND RESPONSE OF SWEET POTATO TO N, P AND K, PER PROVINCE
(1968)

Province	Yield (ton/ha)	N (kg/ha) 0	40	80	P (kg/ha) 0	45	90	K (kg/ha) 70	140	210	S.E.
		Average response (ton/ha)			Average response (ton/ha)			Average response (ton/ha)			
Chung Nam	15.90	1.99	4.33	3.64	3.40	3.14	3.31	3.44	3.82	2.71	0.53
Chulla Nam	27.09	0.54	0.65	0.51	-0.63	0.33	1.00	0.37	-0.03	0.36	0.67
Kyong Puk	20.22	2.96	3.09	3.09	2.43	3.32	3.39	2.61	3.23	3.30	0.24
Cheju	27.24	5.76	9.54	11.49	5.89	9.22	11.68	7.27	9.08	10.44	0.46
Average	22.42	5.55	7.11	7.93	5.22	7.01	8.36	5.95	6.91	7.72	0.28

Table 69

UNIT RESPONSE OF SWEET POTATO AT DIFFERENT LEVELS OF
N, P AND K, PER PROVINCE
(1966)

Province	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	30	60	90	25	50	75	80	160	240
Kyong Gi	132.0	120.3	109.8	192.8	145.8	133.7	59.8	53.0	45.5
Chulla Puk	133.3	122.8	114.4	156.0	122.4	109.2	16.1	17.2	13.9
Kyong Nam	-2.3	3.3	-0.8	24.4	43.6	10.1	18.2	11.0	10.1
Cheju	42.0	26.8	26.0	15.6	20.6	13.1	14.0	20.3	13.2
Average	75.7	67.8	61.9	96.8	82.8	66.1	27.1	25.5	20.8

Table 70

UNIT RESPONSE OF SWEET POTATO AT DIFFERENT LEVELS OF N, P AND K, PER PROVINCE (1967)

Province	N (kg/ha)			P (kg/ha)		K (kg/ha)	
	40	70	100	45	90	100	200
Kyong Gi	79.8	79.3	85.6	130.2	69.9	58.1	30.7
Chung Puk	105.2	45.1	20.8	79.3	35.3	33.1	16.6
Chung Nam	159.8	83.4	54.8	151.1	66.4	61.5	36.7
Chulla Puk	110.8	87.6	74.8	135.8	74.8	61.4	30.0
Chulla Nam	20.0	14.6	9.5	21.8	11.4	12.1	5.6
Kyong Puk	75.8	59.8	45.8	90.7	44.1	40.7	22.4
Kyong Nam	72.5	36.4	19.8	54.9	33.2	25.7	20.6
Cheju	57.5	34.3	24.0	55.6	25.6	27.0	14.0
Average	86.0	58.0	44.8	93.1	47.4	41.6	23.0

Table 71

UNIT RESPONSE OF SWEET POTATO AT DIFFERENT LEVELS OF N, P AND K, PER PROVINCE (1968)

Province	N (kg/ha)		P (kg/ha)		K (kg/ha)		
	40	80	45	90	70	140	210
Chung Nam	108.2	45.5	69.8	36.8	49.1	27.3	19.4
Chulla Nam	16.2	6.4	7.3	11.1	5.3	-0.2	2.6
Kyong Puk	77.2	38.6	73.8	37.7	37.3	23.1	23.6
Cheju	238.5	143.6	204.9	129.8	103.8	64.8	74.6
Average	177.8	99.1	155.8	92.9	85.0	49.4	55.2

Table 72

RESPONSE OF SWEET POTATO TO N, P AND K IN NEWLY RECLAIMED AND OLDER UPLAND SOILS

Level (kg/ha)	Newly reclaimed			Older upland		
x	y_N	y_P	y_K	y_N	y_P	y_K
Control	14.09 1/	16.57	17.80	21.89	22.14	21.09
10	1.46	3.21	1.83	0.31	0.33	-0.32
20	2.42	3.99	2.11	0.60	0.73	-0.10
30	3.33	4.71	2.38	0.86	1.07	0.32
40	4.19	5.35	2.64	1.08	1.34	0.52
60	5.76	6.43	3.14	1.43	1.67	0.89
80	7.12	7.23	3.60	1.64	1.73	1.23
100	8.29	7.75	4.03	1.72	1.51	1.53
120	9.26	7.98	4.42	1.66		1.81
140	10.03	7.94	4.78			2.04
160	10.60		5.10			2.25
180	10.96		5.39			2.42
200	11.13		5.64			2.56
220	11.10		5.86			2.67
240	10.87		6.04			2.74

1/ Ton/ha.

Table 73

ECONOMICS OF FERTILIZER USE ON SWEET POTATO (1966)

N (kg/ha)	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
0	75	240	17.95	-	-	-	-	-
30	75	240	20.22	2.27	29.06	1.78	27.28	1 636
60	75	240	22.02	4.07	52.10	3.55	48.55	1 466
90	75	240	23.52	5.57	71.30	5.33	65.97	1 338
90	0	240	18.56	-	-	-	-	-
90	25	240	20.98	2.42	30.98	1.05	29.93	2 953
90	50	240	22.70	4.14	52.99	2.10	50.89	2 526
90	75	240	23.52	4.96	63.49	3.15	60.34	2 017
90	75	0	18.54	-	-	-	-	-
90	75	80	20.71	2.17	27.78	1.49	26.29	1 859
90	75	160	22.62	4.08	52.22	2.99	49.23	1 748
90	75	240	23.52	4.98	63.74	4.48	59.26	1 423
S.E.			0.28	0.40	5.12	-	5.12	

Table 74

ECONOMICS OF FERTILIZER USE ON SWEET POTATO
(1967)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	13.61	-	-	-	-	-
40	0	0	15.55	1.94	24.83	2.37	22.46	1 048
40	45	200	17.95	4.34	55.55	7.99	47.56	695
40	90	100	17.78	4.17	53.38	8.01	45.36	666
70	0	200	18.09	4.48	57.34	7.88	49.46	728
70	45	100	18.11	4.50	57.60	7.90	48.80	729
70	90	0	16.95	3.34	42.75	7.92	34.83	540
100	0	100	17.60	3.99	51.07	7.79	43.28	656
100	45	0	17.84	4.23	54.14	7.81	46.33	694
100	90	200	18.57	4.96	63.49	13.43	50.06	473
40	0	100	16.90	3.29	42.11	4.24	37.88	994
40	45	0	16.64	3.03	38.78	4.26	34.53	911
40	90	200	18.35	4.74	60.67	9.88	50.79	614
70	0	0	16.30	2.69	34.43	4.14	30.29	830
70	45	200	18.06	4.45	56.96	9.77	47.28	583
70	90	100	18.32	4.71	60.29	9.79	50.50	616
100	0	200	18.30	4.69	60.03	9.66	50.38	622
100	45	100	18.32	4.71	60.29	9.68	50.61	623
100	90	0	17.67	4.06	51.97	9.70	42.27	536
40	0	200	16.85	3.24	41.47	6.10	35.37	680
40	45	100	17.15	3.54	45.32	6.12	39.20	740
40	90	0	16.29	2.68	34.30	6.14	28.16	558
70	0	100	17.46	3.85	49.28	6.01	48.27	820
70	45	0	17.16	3.55	45.44	6.03	39.41	753
70	90	200	18.63	5.02	64.26	11.66	52.60	551
100	0	0	17.22	3.61	46.21	5.92	40.29	780
100	45	200	18.99	5.38	68.86	11.54	57.32	597
100	90	100	18.32	4.71	60.29	11.56	48.72	521
S.E.			0.27	0.38	4.86	-	4.86	

Table 75

ECONOMICS OF FERTILIZER USE ON SWEET POTATO
(Newly reclaimed soils - 1968)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertiliser (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	16.45	-	-	-	-	-
40	0	70	17.57	1.12	14.34	3.68	10.66	390
40	45	210	19.51	3.06	39.17	8.18	30.99	479
40	90	140	20.30	3.85	49.28	8.76	40.52	562
70	0	210	20.39	3.94	50.43	8.07	42.37	625
70	45	140	21.48	5.03	64.38	8.65	55.73	745
70	90	70	22.25	5.80	74.24	9.23	65.01	804
100	0	140	21.27	4.82	61.69	8.54	53.15	723
100	45	70	22.37	5.92	75.78	9.12	66.66	831
100	90	210	24.34	7.89	100.99	13.62	87.37	742
70	90	0	19.42	2.97	38.02	7.92	30.10	480
40	0	140	18.34	1.89	24.19	4.98	19.21	485
40	45	70	18.11	1.66	21.25	5.56	15.69	382
40	90	210	20.41	3.96	50.69	10.07	40.62	503
70	0	70	19.14	2.69	34.43	5.45	28.98	632
70	45	210	21.77	5.32	68.10	9.95	58.15	684
70	90	140	22.22	5.77	73.86	10.54	63.32	701
100	0	210	21.27	4.82	61.70	9.84	51.86	627
100	45	140	22.22	5.77	73.86	10.42	63.44	709
100	90	70	22.11	5.66	72.45	11.00	61.45	658
70	90	280	24.61	8.16	104.45	13.15	91.30	794
40	0	210	17.96	1.51	19.33	6.29	13.04	307
40	45	140	19.52	3.07	39.30	6.87	32.43	572
40	90	70	19.94	3.49	44.67	7.45	37.22	599
70	0	140	19.93	3.48	44.54	6.76	37.78	659
70	45	70	20.94	4.49	57.47	7.34	50.13	783
70	90	210	22.96	6.51	83.33	11.84	71.49	704
100	0	70	20.71	4.26	54.53	7.23	47.30	754
100	45	210	23.00	6.55	83.84	11.73	72.11	715
100	90	140	23.69	7.24	92.67	12.31	80.36	754
S.E.			0.36	0.51	6.53	-	6.53	

Table 76

ECONOMICS OF FERTILIZER USE ON SWEET POTATO
(Older upland soils - 1968)

N	P	K	Yield (ton/ha)	Response (ton/ha)	Value of response (1 000 Won)	Cost of fertilizer (1 000 Won)	Gross profit (1 000 Won)	V/C ratio (%)
(kg/ha)								
0	0	0	22.42	-	-	-	-	-
0	0	70	24.05	1.63	20.86	1.31	19.56	1 596
0	45	210	28.08	5.66	72.45	5.81	66.64	1 247
0	90	140	28.04	5.62	71.94	6.39	65.55	1 126
40	0	210	28.75	6.33	81.02	6.29	74.73	1 288
40	45	140	28.90	6.48	82.94	6.87	76.07	1 207
40	90	70	29.45	7.03	89.98	7.45	82.54	1 208
80	0	140	27.60	5.18	66.30	7.35	58.95	902
80	45	70	28.51	6.09	77.95	7.93	70.02	983
80	90	210	31.57	9.15	117.12	12.43	104.68	942
0	0	140	26.78	4.36	55.81	2.61	53.19	2 135
0	45	70	26.98	4.56	58.37	3.20	55.17	1 827
0	90	210	30.84	8.42	107.78	7.70	100.08	1 404
40	0	70	26.86	4.44	56.83	3.68	53.15	1 546
40	45	210	30.08	7.66	98.05	8.18	89.87	1 199
40	90	140	31.54	9.12	116.74	8.76	107.98	1 333
80	0	210	29.90	7.48	95.74	8.66	87.08	1 106
80	45	140	30.86	8.44	108.03	9.24	98.79	1 169
80	90	70	31.03	8.61	110.21	9.82	100.39	1 122
0	0	210	27.45	5.03	64.38	3.92	60.46	1 642
0	45	140	29.47	7.05	90.24	4.50	85.74	2 004
0	90	70	30.03	7.61	97.41	5.08	92.33	1 916
40	0	140	28.48	6.06	77.57	4.98	72.59	1 557
40	45	70	29.57	7.15	91.52	5.56	85.96	1 645
40	90	210	32.17	9.75	124.80	10.07	114.73	1 240
80	0	70	28.88	6.46	82.69	6.04	76.64	1 368
80	45	210	32.46	10.04	128.51	10.55	117.96	1 218
80	90	140	32.34	9.92	126.98	11.13	115.85	1 141
S.E.			0.61	0.86	11.00	-	11.00	

Table 77

ITALIAN RYE GRASS - DRY MATTER PRODUCTION
WITH INCREASING FERTILIZER LEVELS

Province	Gun		N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
			150	225	300	150	215	280	170	255	340	
Kyong Gi	Pyong Taek	I 1/	1.06 2/	1.28	1.02	0.81	1.41	1.02	0.98	1.14	1.02	
		II	3.33	3.66	4.55	4.01	3.70	4.55	4.23	4.35	4.55	
		Sum	4.39	4.94	5.57	4.82	5.21	5.57	5.21	5.49	5.57	0.34
Chulla Puk	Kim Je	I	3.51	4.31	5.26	4.77	5.50	5.26	5.00	5.50	5.26	
		II	2.08	2.30	2.73	2.82	2.78	2.73	2.58	2.82	2.73	
		Sum	5.59	6.61	7.99	7.59	8.28	7.99	7.58	8.32	7.99	0.27
Chulla Nam	Kwang Ju	I	3.58	4.78	4.55	4.09	4.84	4.55	4.89	5.10	4.55	
		II	4.09	3.66	4.48	4.34	3.86	4.48	4.38	4.13	4.48	
		Sum	7.67	8.44	9.03	8.43	8.70	9.03	9.27	9.23	9.03	0.33
	Kwang San	I	2.46	2.39	3.06	1.54	3.14	3.06	2.76	2.92	3.06	
		II	4.76	4.88	4.42	4.60	4.85	4.42	4.54	4.43	4.42	
		III	4.26	4.56	5.41	4.90	5.00	5.41	5.46	4.98	5.41	
		Sum	11.48	11.83	12.89	11.04	12.99	12.89	12.76	12.33	12.89	0.24
Kyong Puk	Wal Sung	I	1.99	2.55	2.74	2.69	3.05	2.74	2.55	2.93	2.74	
		II	2.18	2.70	2.90	3.03	3.17	2.90	3.16	3.06	2.90	
		III	0.80	0.94	1.09	0.87	1.01	1.09	0.96	0.97	1.09	
		Sum	4.97	6.29	6.73	6.59	7.23	6.73	6.67	6.96	6.73	0.22
	Dal Sung	I	2.50	2.98	3.44	3.04	2.94	3.44	3.12	3.10	3.44	
		II	1.89	2.27	2.60	2.29	2.50	2.60	2.37	2.60	2.60	
		III	1.80	1.96	2.26	2.00	2.04	2.26	2.23	2.29	2.26	
		Sum	6.19	7.21	8.30	7.23	7.48	8.20	7.72	7.99	8.30	0.16
Kyong Nam	Wul Ju	I	3.49	4.01	4.60	4.58	4.39	4.60	4.93	4.89	4.60	
		II	4.05	4.13	4.77	4.88	5.12	4.77	5.40	5.62	4.77	
		III	0.65	0.82	0.76	0.99	0.75	0.76	0.80	0.92	0.76	
		Sum	8.19	8.96	10.13	10.45	10.26	10.13	11.13	11.43	10.13	0.68
Cheju	North	I	3.00	3.91	3.73	2.85	3.04	3.73	2.86	3.46	3.73	
		II	2.80	2.78	2.83	2.62	3.25	2.83	2.70	2.74	2.83	
		III	2.00	2.58	2.38	3.17	3.43	2.38	2.50	2.52	2.38	
		Sum	7.80	9.27	8.94	8.64	9.72	8.94	8.06	8.72	8.94	0.61
Korea (Average)			6.53	7.43	8.32	7.75	8.20	8.32	8.11	8.44	8.32	0.14

1/ Number of cutting. 2/ Ton/ha dry matter.

Table 78

LADINO CLOVER DRY MATTER PRODUCTION WITH INCREASING FERTILIZER LEVELS

Province	Gun		N (kg/ha) 50	100	150	P (kg/ha) 150	200	250	K (kg/ha) 250	375	500	S.E.
Kyong Gi	Pyong Taek	I	0.86	1.32	1.80	1.74	1.61	1.80	1.86	1.49	1.80	0.16
Chulla Nam	Kwang San	I	0.61	0.54	0.60	0.62	0.60	0.60	0.50	0.61	0.60	
		II	0.55	0.58	0.66	0.60	0.62	0.66	0.61	0.60	0.66	
		Sum	1.16	1.12	1.26	1.22	1.22	1.26	1.11	1.21	1.26	0.17
	Kwang Ju	I	1.75	2.04	1.91	1.90	1.94	1.91	1.80	2.02	1.91	
		II	0.93	0.98	1.01	1.06	1.03	1.01	0.90	1.08	1.01	
		III	0.63	0.73	0.72	0.71	0.71	0.72	0.73	0.73	0.72	
		Sum	3.31	3.75	3.64	3.67	3.68	3.64	3.44	3.83	3.64	0.17

Table 79

ALFALFA DRY MATTER PRODUCTION WITH INCREASING FERTILIZER LEVELS

Province	Gun		N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
			45	90	135	180	240	300	225	337.5	450	
Kyong Gi	Pyong Taek	I	0.75	0.86	1.62	1.42	1.36	1.62	1.42	1.34	1.62	0.11
Kyong Puk	Wal Sung	I	0.43	0.53	0.70	0.62	0.52	0.70	0.73	0.54	0.70	
		II	0.51	0.52	0.75	0.71	0.75	0.75	0.85	0.63	0.75	
		Sum	0.94	1.05	1.45	1.33	1.27	1.45	1.58	1.17	1.45	0.15
	Ye Chun	I	0.72	1.00	1.13	1.30	1.39	1.13	1.11	1.43	1.13	
		II	1.03	1.57	2.10	1.87	2.07	2.10	2.03	2.02	2.10	
		III	1.01	1.50	2.35	2.16	2.24	2.35	2.34	2.21	2.35	
		Sum	2.76	4.07	5.58	5.33	5.70	5.58	5.48	5.65	5.58	0.19
Kyong Nam	Mil Yang	I	1.13	1.61	1.71	1.61	1.65	1.71	1.89	1.80	1.71	
		II	2.52	2.79	2.70	2.49	2.70	2.70	2.70	2.67	2.70	
		Sum	3.65	4.40	4.41	4.10	4.35	4.41	4.59	4.47	4.41	0.08
	Wal Ju	I	0.62	0.78	0.93	0.89	0.78	0.93	0.85	0.84	0.93	
		II	0.40	0.43	0.61	0.60	0.58	0.61	0.50	0.48	0.61	
		Sum	1.02	1.21	1.54	1.49	1.36	1.54	1.35	1.32	1.54	0.12

Table 80

OATS DRY MATTER PRODUCTION WITH INCREASING FERTILIZER LEVELS

Province	Gun	N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
		135.0	202.5	270.0	30	40	50	20	30	40	
Chung Nam		10.17	13.33	11.70	11.63	15.07	11.63	12.08	14.80	11.70	0.88
Kyong Nam	Mil Yang	4.97	5.10	5.87	5.18	5.36	5.87	5.26	4.83	5.87	0.26

Table 81

ORCHARD GRASS DRY MATTER PRODUCTION
WITH INCREASING FERTILIZER LEVELS

		N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
		150	225	300	150	200	250	200	300	400	
Chung Puk Jin Chon	I	0.72	0.96	0.71	0.99	1.50	0.71	0.89	1.45	0.71	
	II	1.00	1.85	1.69	1.92	2.12	1.69	1.79	2.34	1.69	
	III	1.70	2.22	2.95	2.68	2.43	2.95	2.67	2.92	2.95	
	IV	1.76	3.04	3.06	3.18	3.25	3.06	3.38	3.68	3.06	
	Sum	5.18	8.07	8.41	8.77	9.30	8.41	8.73	10.39	8.41	0.359
Chung Nam Chun Won	I	2.51	2.84	3.23	2.51	2.80	3.23	2.98	3.40	3.23	
	II	3.80	4.16	4.60	4.27	4.55	4.60	4.53	4.03	4.60	
	III	1.69	3.14	3.41	3.08	3.21	3.41	3.36	3.07	3.41	
	Sum	8.00	10.14	11.24	9.86	10.56	11.24	10.87	10.50	11.24	0.811
Chulla Puk Kim Je	I	1.74	3.22	4.93	4.88	4.37	4.93	4.66	4.19	4.93	
	II	0.59	0.94	1.24	1.20	1.17	1.24	1.13	1.12	1.24	
	III	0.52	0.78	0.97	0.87	1.08	0.97	0.97	1.20	0.97	
	Sum	2.85	4.94	7.14	6.95	6.62	7.14	6.76	6.51	7.14	0.241
Kyong Puk Wol Song	I	1.39	1.76	2.02	1.78	2.09	2.02	2.08	2.24	2.02	
	II	1.74	1.74	2.32	2.36	2.32	2.32	2.31	2.14	2.32	
	III	1.64	1.88	2.33	2.54	2.04	2.33	2.07	2.44	2.33	
	IV	1.22	1.76	2.13	1.93	2.11	2.13	1.80	2.41	2.13	
	Sum	5.99	7.14	8.80	8.61	8.56	8.80	8.26	9.23	8.80	0.173
Dal Sung	I	1.80	2.40	2.70	2.30	2.50	2.70	2.60	2.70	2.70	
	II	1.30	1.60	1.90	1.80	1.90	1.90	1.90	2.10	1.90	
	III	1.70	2.10	2.60	2.40	2.70	2.60	2.70	2.60	2.60	
	Sum	4.80	6.10	7.20	6.50	7.10	7.20	7.20	7.40	7.20	0.095
Kyong Nam Wul Ju	I	2.32	2.68	3.04	2.68	2.80	3.04	2.81	3.40	3.04	
	II	1.64	2.53	2.90	2.73	3.12	2.90	2.45	3.02	2.90	
	III	1.64	2.24	2.50	2.76	2.70	2.50	2.26	2.55	2.50	
	Sum	5.60	7.45	8.44	8.17	8.62	8.44	7.52	8.97	8.44	0.439
Cheju North Cheju	I	2.14	3.46	4.07	3.36	3.88	4.07	3.88	3.77	4.07	
	II	2.04	2.37	2.67	2.11	3.02	2.67	1.51	1.59	2.67	
	III	3.92	3.77	4.28	3.82	4.12	4.28	3.50	3.76	4.28	
	IV	1.53	1.89	2.00	1.88	2.12	2.00	1.52	1.94	2.00	
	Sum	9.63	11.49	13.02	11.17	13.14	13.02	10.41	11.06	13.02	0.353
Average		6.01	7.90	9.18	8.58	9.13	9.18	8.54	9.15	9.18	0.133

Table 82

RED CLOVER DRY MATTER PRODUCTION WITH INCREASING FERTILIZER LEVELS

		N (kg/ha)			P (kg/ha)			K (kg/ha)			S.E.
		50	100	150	150	200	250	250	375	500	
Chung Puk											
Jin Chon	I	0.41	1.01	1.11	0.86	0.64	1.11	0.99	0.74	1.11	
	II	0.12	0.49	0.31	0.34	0.45	0.31	0.31	0.68	0.31	
	Sum	0.53	1.50	1.42	1.20	1.09	1.42	1.30	1.42	1.42	0.255
Chung Nam											
Chon Won	I	0.61	0.96	0.73	0.18	0.41	0.73	0.71	0.88	0.73	
	II	7.68	8.66	7.19	3.56	4.72	7.19	5.25	6.99	7.19	
	III	3.88	3.85	3.96	2.56	2.37	3.96	3.72	4.32	3.96	
	Sum	12.17	13.47	11.88	6.30	7.50	11.88	9.68	12.19	11.88	1.715
Chulla Puk											
Kim Je	I	0.75	1.10	1.94	1.81	1.74	1.94	1.89	1.73	1.94	
	II	0.19	0.34	0.48	0.42	0.47	0.48	0.45	0.50	0.48	
	Sum	0.94	1.44	2.42	2.23	2.21	2.42	2.34	2.23	2.42	0.152
Chulla Nam											
Kwang Ju	I	1.30	2.00	2.06	1.31	1.94	2.06	1.55	2.18	2.06	
	II	1.16	1.20	1.26	1.21	1.04	1.26	1.14	1.22	1.26	
	III	0.78	0.84	0.91	0.94	0.82	0.91	0.89	0.88	0.91	
	Sum	3.24	4.04	4.23	3.40	3.80	4.23	3.58	4.28	4.23	0.331
Kwang San	I	1.29	0.63	1.49	1.13	0.60	1.49	1.20	0.54	1.49	
	II	1.13	0.76	1.17	0.96	0.65	1.17	1.25	0.70	1.17	
	III	0.86	0.76	1.10	0.92	0.96	1.10	1.08	0.77	1.10	
	Sum	3.28	2.15	3.76	3.01	2.21	3.76	3.53	2.01	3.76	0.570
Kyong Puk											
Mil Yang 1/	I	2.04	2.32	2.36	2.26	2.34	2.36	2.37	2.51	2.36	
	II	3.44	4.01	4.14	3.74	4.26	4.14	4.12	4.21	4.14	
	Sum	5.48	6.32	6.50	6.00	6.60	6.50	6.49	6.72	6.50	0.233
Wul Ju 2/	I	0.34	0.78	1.15	1.01	1.24	1.15	1.36	1.34	1.15	
	II	0.62	1.17	1.35	1.13	1.48	1.35	1.52	1.25	1.35	
	III	0.60	0.84	1.27	1.08	1.03	1.27	1.03	1.19	1.27	
	Sum	1.56	2.79	3.77	3.22	3.75	3.77	3.91	3.78	3.77	0.320
Wul Ju 1/	I	1.13	1.41	1.59	1.30	1.60	1.59	1.56	1.38	1.59	
	II	1.12	1.29	1.42	1.70	1.54	1.42	1.70	1.39	1.42	
	Sum	2.25	2.70	3.01	3.01	3.14	3.01	3.26	2.77	3.01	0.193
Cheju											
North Cheju	I	2.12	2.37	3.86	2.60	2.68	3.86	3.82	3.88	3.86	
	II	1.04	1.19	1.15	1.16	1.12	1.14	1.19	1.06	1.15	
	Sum	3.16	3.56	5.01	3.76	3.80	5.01	5.01	4.94	5.01	0.539

1/ Sown in spring.

2/ Sown in autumn.

FIG. 1

RESPONSE CURVES OF BARLEY TO N PER REGION (1965-66)

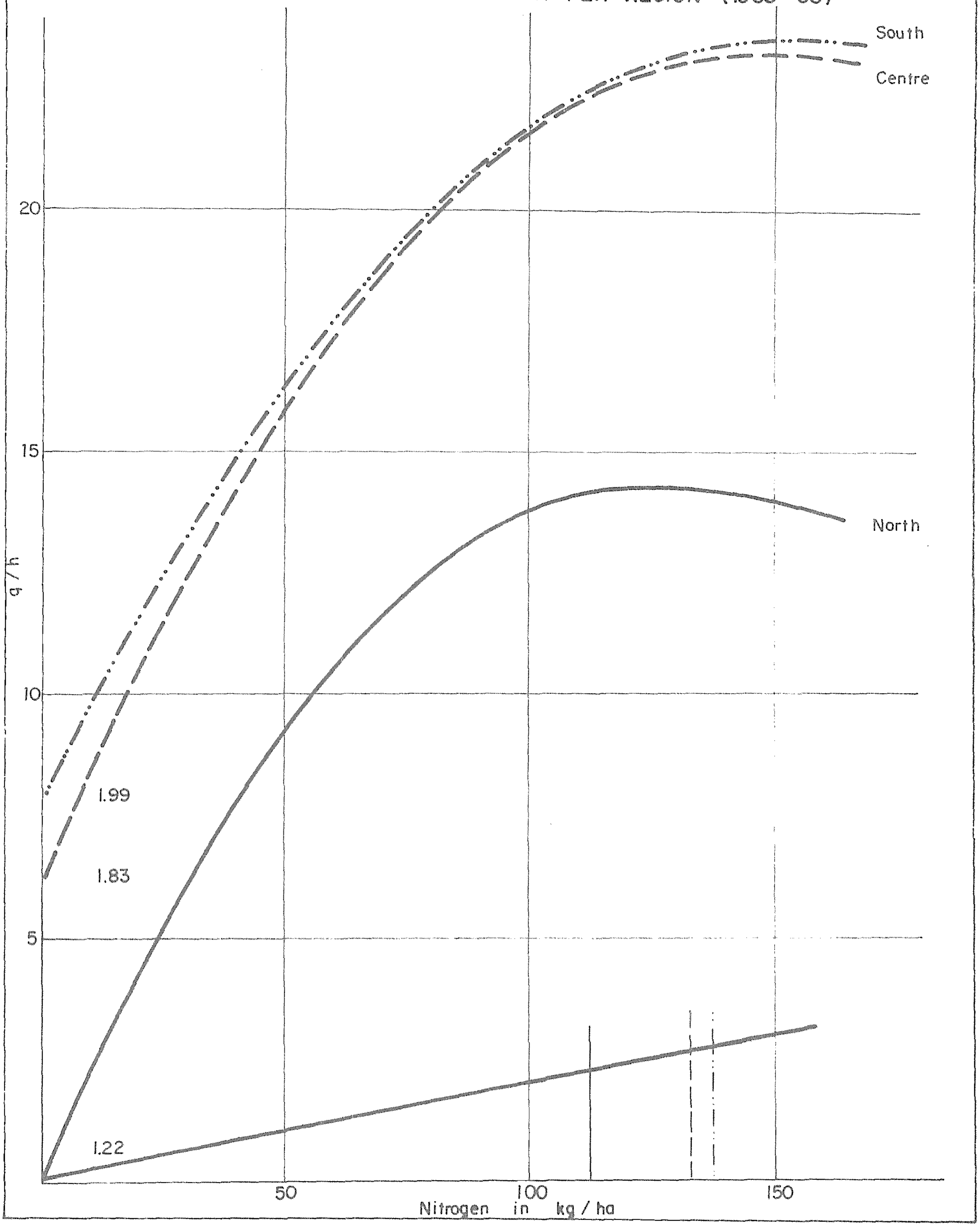


FIG. 2

RESPONSE CURVES OF BARLEY TO P PER REGION (1965 - 66)

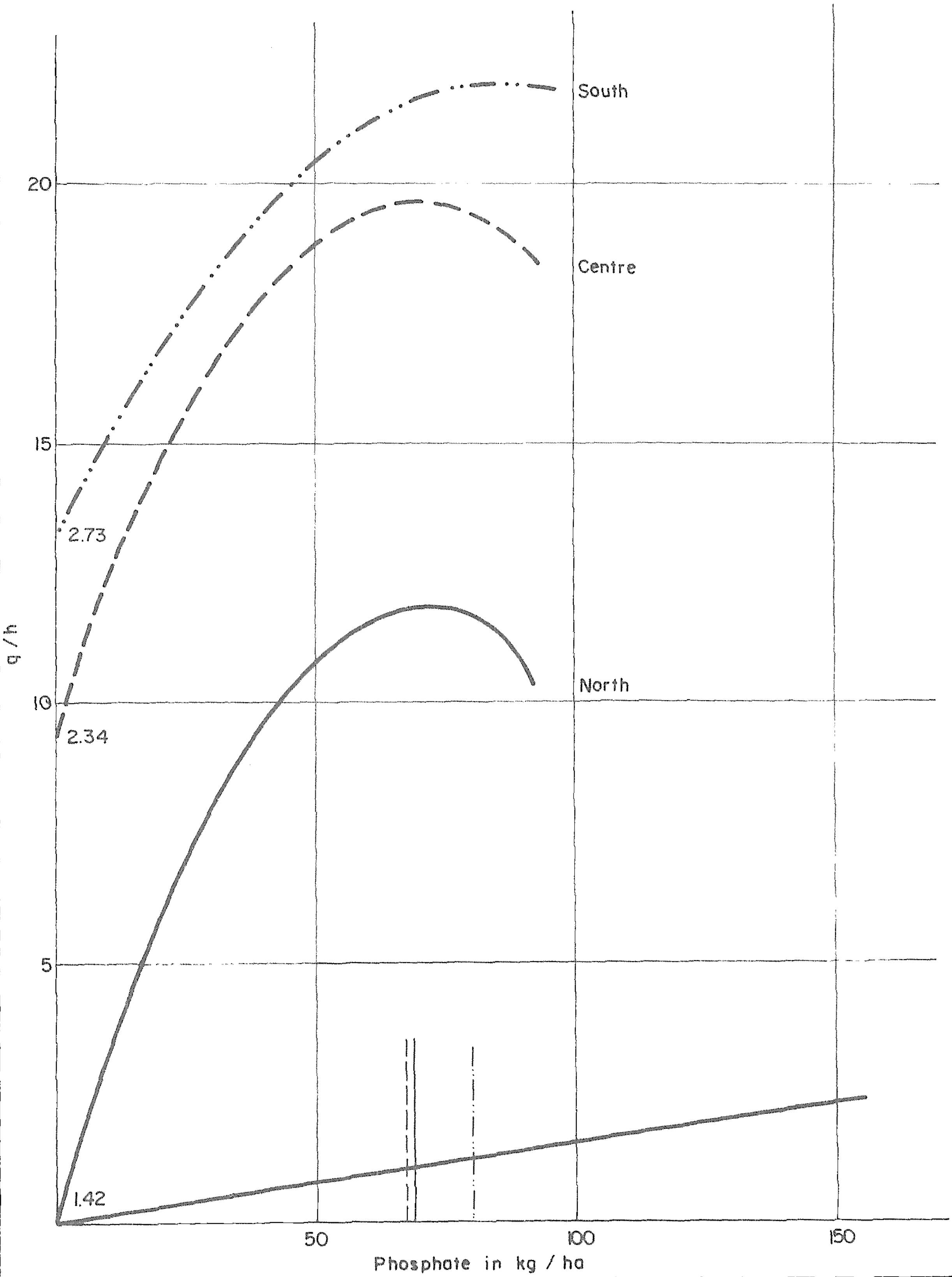


FIG. 3

RESPONSE CURVES OF BARLEY TO K PER REGION (1965-66)

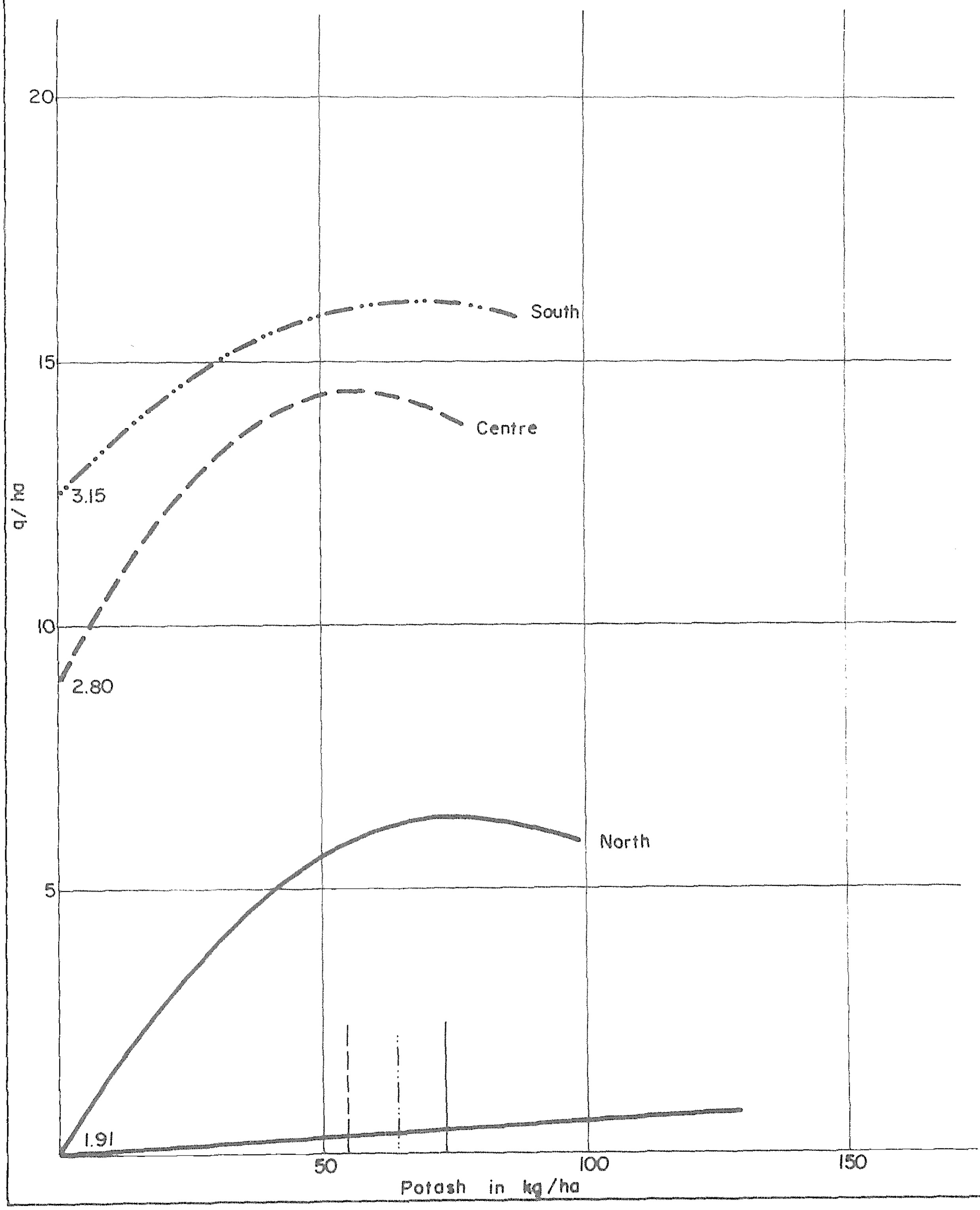
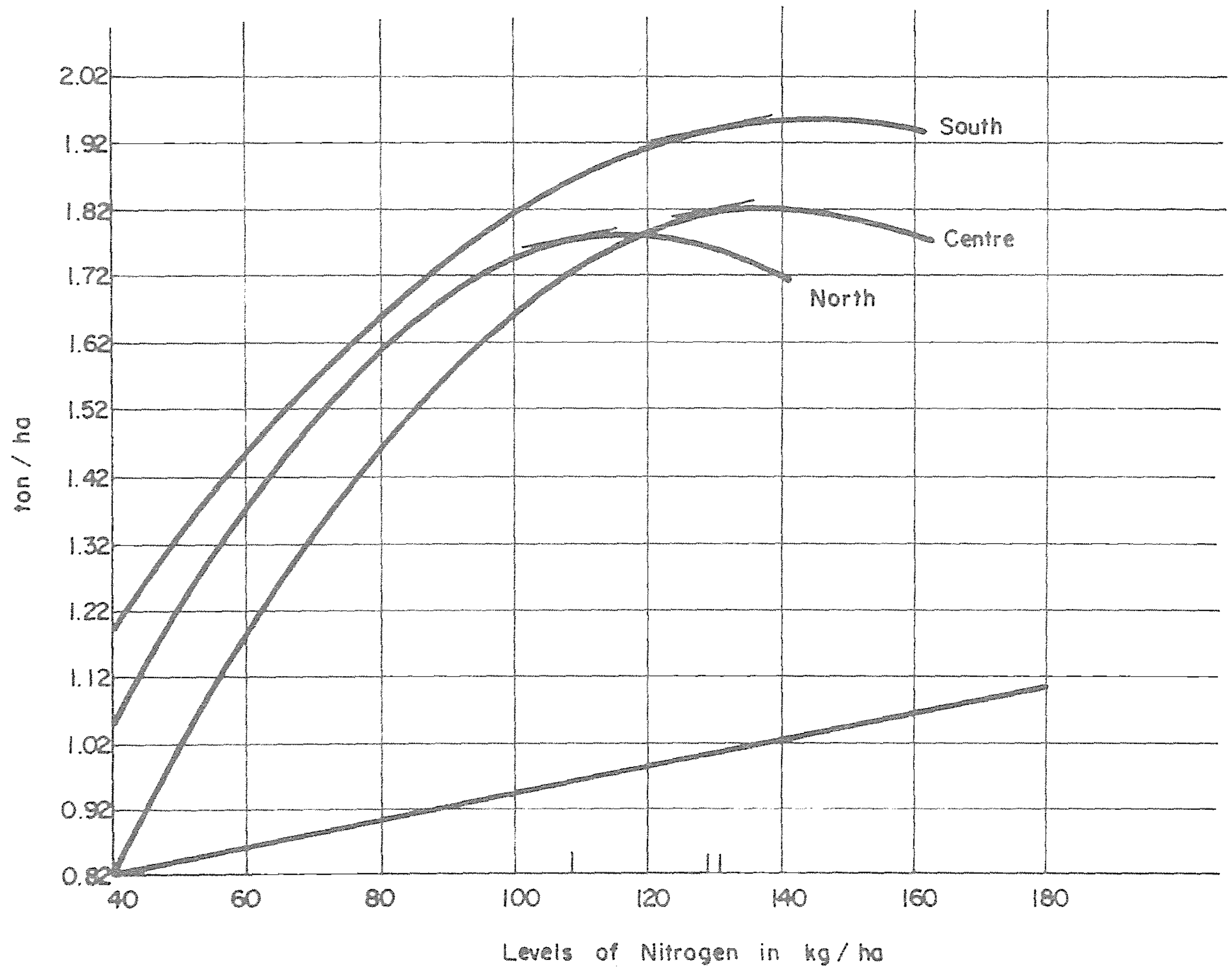


FIG. 4

RESPONSE CURVES OF WHEAT TO N PER REGION



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