THE UTILITY OF AN INDIGENOUS SOURCE OF MAGNESIUM SILICATE FOR RICE IN KUTTANAD SOILS

BY

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THESIS

SUBMITTED TO THE FACULTY OF AGRICULTURE
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1980

DECLARATION

I hereby declare that this thesis entitled "The utility of an indigenous source of magnesium silicate for rice in Kuttanad soils", is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title of any other University or Society.

Vellayani,
11-7-1980.

KARUNAKARA PANICKER, N.

CERTIFICATE

Certified that this thesis, entitled "The utility of an indigenous source of magnesium silicate for rice in Kuttanad soils", is a record of research work done independently by Shri. KARUNAKARA PANICKER, N. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Kuttanad tract, Kerala State, is qualified as the "rice bowl of Kerala". The soils of this tract come under clayey, mixed, acidic isohyperthermic family of Tropic Fluvaquents. The factors which have been particularly dominant in the development of these soils are high rainfall, high temperature, hydrological conditions and vegetation. The major processes involved in their formation are (i) intense leaching in high rainfall of partly decomposed organic matter and (ii) marshy conditions with significant amounts of undecomposed, underdecomposed and peaty organic matter. The organic matter in these soils is resistant to decomposition and waxy in appearance, most of which is lignitic and ether soluble substances (Gopalaswami, 1958). The predominant clay mineral is kaolinite. The degree of soil acidity, depletion of exchangeable bases, nutrient status and plant available nutrients etc. show extreme variations depending on the vagaries of tropical conditions. Problems associated with rice production and their amelioration in these soils etc. have been studied at length (Kurup, 1967; Money and Sukumaran, 1973). Slaked lime, Dolomite etc. are now used as liming materials. Besides neutralising soil acidity and removing toxic concentrations of iron, Aluminium and manganese, the lime materials proliferate microbial activity by supplying calcium and magnesium which brings forth beneficial effects in the soils for increased rice production.

Several liming experiments both pot culture (Kurup, 1967) and field experiments (Money and Sukumaran, 1973) conducted in the different soil types of Kuttanad show significant response to liming. Fractional doses based on lime requirement indicate that ¼th to ½ the lime requirement dose givesresponse depending on whether the soils are moderately acidic as in Karappadom soils or highly acidic as in Kari soils.

These studies as well as the large scale adoption of liming as a practice in the management of these soils by the intelligent and cost conscious farmers of Kuttanad indicate that at economic levels of liming the response is commensurate with the cost of lime input.

However, at present in Kuttanad fully burnt lime is the usual liming material that is commonly used. The FACT bye product lime ($CaCO_3$) is also widely used. However, low cost, cheaper materials have not been tried nor their economics worked out.

Magnesium silicate is a low grade liming material that contribute towards neutralising acidity as well supplying much needed silicon to the soils low in available silica.

The inclusion of silicon as an essential element in plant nutrition still remains controversial. Its role as a beneficial element on the growth and yield of rice has been widely reported. A number of Japanese workers have reported that silicon is required by rice for increased growth and yield. Money (1964), Padmaja et al. (1964), Vijayakumar et al. (1977) have reported considerable increase in all the productive factors of rice such as tillering, plant height, earhead length and grain weight in Indian soils. In soils low in available 'P' silicon increases the availability of 'P'. The application of silica has also been found to ameliorate the toxicity of iron and aluminium. It is reported that silica gets deposited on the cell wall of the rice stem giving it strength and preventing lodging. The increase in silicon content of the cells also results in increased resistance of the plant to the attack of pests and diseases. Other beneficial effects of silica are regulation of transpiration, translocation of nutrients and increase in oxidation power of the roots. These factors tend support for the major and efficient role of silica to augment rice production in submerged soils like that of Kuttanad tract. No field experiment has till now been reported to investigate the effect of any form of silicate in this region. The selection of a cheap and largely available source of a silicate is very important.

The Geological Survey of India, Trivandrum Centre have reported large scale occurrences of steatite (magnesium silicate) mineral in Wyanad. Sample from the above source was supplied to investigate its agricultural utilization

In view of the lack of information regarding the effect of this indigenous material on a field scale in a high lime requirement and low available silica, Kuttanad tract, a field experiment was undertaken to study its effect with a prominent variety of rice 'Jyothi' with the following objectives:-

(a) To investigate the effect of 'Steatite' (magnesium silicate) on the growth and yield characters of 'Jyothi'.

(b) To study the effect of silica in the uptake of other nutrients.

(c) To study the effect of the material in reducing the shedding of grain in Jyothi.

(d) To study the effect of magnesium silicate on the incidence of pest and diseases.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1. Physical properties of soils.

Silica is the major constituent of most soils. Clarke (1924) has placed silicon next to oxygen in the order of abundance in earth's crust. The silica content of soil plays an important part in the physical and chemical properties of soils. According to Joffee (1949) the silica content varies from 95 per cent in some coarse textured podsols to less than 5 per cent in highly weathered laterite soils.

Koen and Raczkowski (1921) investigated the relationship between pore space and clay content and found that these two were positively correlated. The correlation between specific gravity and clay content was found to be negative. Volume expansion was found to be directly correlated to the percentage of clay.

Gopalaswami (1958) while studying the fertility status of some peaty, swampy and marshy soils of India concluded that the soil profiles of Kuttanad area differ considerably in their content of textural separates in the various layers indicating thereby the prominent role played by transportation and sedimentation process in the assemblage of these soils. He found that these soils generally do not show any distinct correlation between water holding capacity and clay contents as in other soils probably due to the subjection of these soils to the influence of water which have hampered such relationships.

Goto (1967) found that in swampy field soils aggregation and density under dry conditions were lower than the soils of well drained fields but porosity, maximum water holding capacity and moisture equivalent were higher.

Leszteka and Darab (1967) noted that peaty, boggy and meadow soils of Hansag region possess high water holding capacity, but low permeability due to compact mineral horizon at about 30 cm.

In a general study of Kerala soils, Venugopal (1969) found that Kari soil had the minimum value for apparent density.

2:2. Chemical Properties.

2:2:1. Soil reaction

Stephenson (1921) stated that highly organic soils and clays exhibited a high degree of buffering while coarse sand showed little of this capacity and that liming is essential when the amount of exchangeable hydrogen exceed the amount of exchangeable calcium in soils.

According to Albrecht and Smith (1952) soil acidity is only a condition of nutrient deficiency, predominently of calcium.

Subramoney (1960) showed that the high acidity of Kari soils was due to the production of sulphuric acid by the sulphur reducing bacteria.

Hhung and Ponnamperuma (1965) observed that acid sulphate soils are extremely acid unproductive soils, derived usually from marine and esturine sediments high in sulphides. The acidity of the aerobic soils has been attributed to the presence of aluminium and ferric sulphates and sometimes free sulphuric acid.

Dolman and Boal (1967) in their study of organic soils (Histosols) found that all the profiles contain a mixture of organic and mineral components. Both contribute to cation exchange process and acidity. Extremely low pH, high C/N ratio and the presence of logs and stumps were observed.

Alexander and Durairaj (1968) showed that loss on ignition, organic carbon, total nitrogen and cation exchange capacity of acid soils were negatively correlated with soil pH.

Schachtschabel (1971) reported that soil pH below 5 was governed by release of protons into the soil solution whereas high pH values are attributed due to biological production of carbondioxide.

Varghese and Aiyer (1973) in their studies on acid soils of Kerala summarised the various treatment effects on pH(S). It was observed that the treatment combination of 1:2.5 soil solution ratio, made with 0.01 M calcium chloride with a shaking period of one hour gives fairly accurate and reproducible values of pH.

2:2:2. <u>Cation Exchange Capacity</u>

Russel (1933) has statistically analysed the physical properties of some Natal soils and concluded that cation exchange capacity was of prime importance for predicting the hygroscopic moisture and water holding capacity. Singh and Nijawan (1936) showed that cations influenced water holding capacity in the order Ca Mn Mg K NH_4 Na.

Mitchell and Muir (1937) have shown that cation exchange capacity of a soil depends mainly on its clay content and its composition.

Nambiar (1947) in a study of eight typical rice soils of Kerala observed that calcium formed the principal replaceable base followed by Mg, Na and K. The low level of exchangeable calcium on the surface soil was attributed to the continuous leaching by the heavy rains as shown by the increase in exchangeable calcium in the lower layers.

Bear and Toth (1948) suggested that for an ideal soil 65% of exchange complex should be occupied by calcium, 10% by Mg, 5% by K and 20% by H.

Milton and Wadbigh (1951) obtained a positive correlation between exchangeable sodium and pH. They concluded that exchangeable sodium could be predicted from pH value.

Menon et al. (1957) observed that C.E.C. increased with depth of soil. Of the different exchangeable cations 80% was calcium. The contents of Ca and Mg increased with depth in different profiles.

Donahue (1958) considered C.E.C. to be a single index of fertility because the more clayey a soil, the more of its

C.E.C. and hence greater are the chances of its being fertile.

Gopalaswami (1961) has reported a high C.E.C. for Kari soils of Kerala which was attributed to the high content of organic matter and illitic and montmorillonitic types of clay present in them.

Alexander and Durairaj (1968) noted that the C.E.C. of black soil tended to increase with increase in pH. In acid soils however, C.E.C. was negatively correlated to pH.

2:2:3. <u>Nutrient Status</u>

<u>Nitrogen</u>

According to Pearsall (1950) the reducing conditions prevailing in waterlogged soils accelerate ammonification. Escape of nitrogen and consequent oxidation of carbonaceous materials slowly results in a wide C/N ratio in these soils.

Rodridge (1962) working on Ceylon soils found considerable loss of nitrogen by denitrification in submerged soils.

Donskikh (1966) observed that the total nitrogen content of the top 120 cm layer of upper peat was 5.45 tons per hectare and of lower peat 36.85 tons per hectare. Organic nitrogen in the surface horizon of upper peat was 47.69% of total nitrogen. In lower peat accumulation of nitrogen is mainly biological. In upper peat soils most of the nitrogen is mobile and soluble in 0.02 N sodium hydroxide. In lower peat more of nitrogen is immobile but hydrolyseable with boiling sulphuric acid.

Varghese (1972) in his studies on acid soils of Kerala recorded 0.49 to 0.55 per cent nitrogen in Kari soils.

Phosphorus

Iyer (1928) in his studies on Kari soils of different areas observed that they are very deficient in lime and phosphate but abnormally high in soluble salts.

Davis (1935) reported that H^{+} ion concentration is largely responsible for phosphate fixation in soils. He also observed that phosphorus availability was maximum in the pH range 6.0 to 6.5.

Raychaudhuri and Mukjerjee (1941) and Chandler (1941) observed that acidity coupled with high content of sesquioxides will favour maximum phosphate fixation.

Kurup (1967) found that the phosphorus availability is substantially increased in the limed than unlimed samples of Kuttanad soils.

Venugopal (1969) also reported the low P_2O_5 contents of Kari soils.

Khanna and Mahajan (1971) observed that in acid soils added phosphorus was transformed mainly into Al-P and Fe-P.

Potassium

Sreedevi and Aiyer (1975) found that the Kari soils showed highest amount of potash fixation. They also reported that the paddy soils of Kerala are fairly rich in total potash content.

Kadrekar (1975) found that the acid soils of Maharashtra which are formed either by leaching or by acid parent material are rich in lattice form of potassium but low in HCl soluble and available forms.

Calcium.

Dunn (1943) found from chemical analysis of the forage from a green house experiment that the available calcium supply was increased in proportion to the amount of lime applied.

The results of investigations by Kipps (1947), Heslep (1951) and others indicated that the beneficial influence on crop-production obtained by liming was not due to the nutrient effect of calcium, but was associated with changes in soil reaction.

Kobayashi et al. (1956) opined that the uptake of silicic acid was reduced by liming since silica was fixed by calcium as calcium silicate.

Reviewing the results of experiments on liming conducted all over India, Chakraborthy et al. (1961) reported that liming increased rice yields in Mysore, Assam, Madras, Bihar and Kerala.

Magnesium

The effect of magnesium on the yield of crops has been studied extensively. The experiments conducted by Picciotta (1913), Shed (1922), Hashimotto and Kawaguchi (1955), Stenut and Piot (1958) all go to show the efficiency of magnesium in increasing the yield of various crops.

According to Kobayashi et al. (1956) magnesium application had little effect on yield, silicon content, or nitrogen content of rice crop.

<u>Silicon</u>

Silicon does not come under the class of essential elements in plant nutrition. But it is considered as a beneficial element since many beneficial effects on growth and yield of crops are recorded by different workers.

<u>Occurrence of silica in soil</u>

Silica in solution is present almost entirely as simple molecule, monosilicic acid $(Si(OH)_4$ at pH below 9. In a saturated solution of pure amorphous silica at 25°C the concentration of monosilicic acid is 120 to 140 ppm expressed as SiO_2.

Jones and Handreck (1965b) established that the silica of soil solution is entirely monosilicic acid, commonly present to the extent of 30 to 40 ppm SiO_2. The concentration in solutions obtained from a wide range of soils of the same pH ranged from 7 to 80 ppm SiO_2.

Using soil solution systems McKeague and Cline (1963) observed that the concentration of silica in soil when extracted with solutions of varying pH was negatively correlated and for a loam textured soil the silica content in the extract at pH value 5.2, 7.3 and 8.3 were 8.7, 2.7 and 1.5 ppm respectively. However, the same trend could not be observed in the case of aqueous extracts of different soils.

Effect of silicon on the growth and yield of crops

Liebig (1840) classified plants as silica plants, lime plants and potash plants. He regarded silicon as a necessary element in plant nutrition. Experimental evidence for the function of silica as promoter of growth and yield was perhaps first furnished by Wolff and Kreuzhage (1884). They observed that though the total growth of oats was not much increased by the presence of silica, the proportion of grain was considerably raised. Lemmerman and Wiessman (1922) observed that the greater the amount of silicic acid available, greater was the crop yield, the marked increase being in fields deficient in phosphorus. Similar results were obtained by Brenchley et al. (1927) in their water culture studies on barley. Onodera (1927) observed better growth of paddy with silicic acid treatments. The work of Okawa and Kinsaku (1936), revealed the influence of silicic acid on increased growth and yield of rice plant. Sreenivasan (1936) obtained similar results with the application of sodium silicate in conjunction with organic matter. Votkovich (1936) attributed the increased yield of rice obtained by silica application to the increased nitrification and solubility of soil phosphorus.

Ishibashi and Hajima (1937), Okamoto (1957) and Azuma et al. (1961), all reported an increase in the dry matter production, height of plants, and the length of earheads and roots by the addition of culture solutions to rice.

Winifred et al. (1927), Takijima et al. (1959), Miyoshi and Ishi (1960), all obtained an increase in the number of tillers by silicon application.

Kido (1958) opined that thousand grain weight was increased by application of calcium silicate.

A different result was obtained by Yoshida (1959) who showed that silicon was not essential for growth in rice.

In a study on the effect of silicon at various stages of plant growth, Takahashi (1961) concluded that the absence of silicon in the vegetative stage led to decrease in the top growth, number of tillers and fresh and dry weight. Absence of silicon in the reproductive phase caused a decrease in the number of spikelets per panicle and percentage of ripe grains.

Yoshida et al. (1962) reported that silica was not essential for growth and tillering of rice but was beneficial during reproductive stage and good for grain output.

Money (1964) in a pot culture experiment reported marked increase in grain yield of rice due to the application of silica in the form of magnesium silicate. Padmaja and Varghese (1964) observed significant increase in yield of grain and straw by the application of magnesium and silica to rice crop in Vellayani soil. They further noticed considerable increase in all the productive factors such as tillering, height of plants, length of earheads, thousand grain weight and root development.

Vijayakumar and Koshy (1977) found an increase in the thousand grain weight by the application of magnesium silicate for rice in a pot culture experiment using Vellayani kayal soil. But contrary to this they found that higher levels of magnesium silicate application showed a tendency to reduce yield in the field experiment. Another finding by the same authors is that the yield of straw increased by the application of magnesium silicate.

2:2:4. Effect of silicon on the availability and uptake of nutrients by plants.

Nitrogen

Lewes (1951) found that silicon increased the dry weight and protein content of rice. Okamoto (1959) and Miyoshi and Ishi (1960) observed that translocation of nitrogen to the earhead and the protein content of the grain were increased in silica treated plants.

Kobayashi et al. (1956) obtained an increased percentage of nitrogen in rice due to slag application. Ishaburo Nagai (1959) claimed that the absence of silicon increased the nitrogen content of rice plant.

Nagava and Ken-Ichi-Kashima (1963) observed that when silicon was applied, though the percentage of nitrogen in every part of the rice plant was lowered the movement of nitrogen to ears was accelerated.

Phosphorus

Akhromsko (1934) found that silica deposited on roots increased its ability to absorb phosphorus. Birch (1948) found that sodium silicate applied to very acid and heavy clay soils produced growth without phosphorus application.

But, Lawes (1951) observed that solubility of phosphorus and the amount of phosphorus absorbed from soil solution decreased by increasing amounts of silica.

Datisse (1952) agreed to the finding that silica reduced phosphorus fixation by iron and aluminium and recommended the liberal use of silica along with phosphorus fertilisers.

But Okuda and Takahashi (1961) reported that phosphorus uptake of rice plants was slightly decreased with increasing supply of silica.

Nagawa and Kashima (1963) reported that silica accelerated the translocation of phosphorus to the earhead. Utagawa and Kiyoto (1963) also obtained similar results. But Miyoshi and Ishii (1963b) found that the amount of phosphorus translocated from the upper leaves to ear was less when silica was given. However, Mitsui and Takahashi (1963) using tagged phosphorus, established that phosphorus remained mostly in the roots, though the major portion of the silica was translocated to the shoots and panicle.

Potassium

Okawa and Kinsaku (1937) found silica to favour the accumulation and utilization of potash by plants. Takijima et al. (1959) noticed increased absorption of potash by the application of silica to rice. Sadanandan and Varghese (1969) also obtained the same results. But Islam and Saha (1969) reported that application of silica decreased the potash content of rice plant.

Calcium, Magnesium and Silicon

Sadanandan and Varghes e (1969) obtained an increase in the uptake of calcium by rice plant when silica was applied as calcium magnesium silicate.

Okawa and Kinsaku (1937), Takijima et al. (1959), Sadanandan and Varghese (1969) and Takijima et al. (1970) noted that silica application resulted in increased uptake of magnesium by rice.

Volk et al. (1957) noted an increased percentage of silica in the leaves and shoot due to the application of silica. Okamoto (1957), Islam and Saha (1969), Bastiesce (1951), Schollenburger (1922), Koyabashi et al. (1956), Tanaka and Park (1966) and Takijima et al. (1970), Vijayakumar and Koshy (1977) also obtained similar results. But Halles and Parish (1963) opined that the silica uptake from soil was influenced by the iron and aluminium content of the soil.

2.3. Resistance to Pests and Diseases

Okuda and Takahashi (1964) reported correction of iron and manganese toxicity symptoms in grasses by the application of silica. But Lanning (1966) reported no direct relationship between the total silica content and the resistance to Hessianfly or to diseases. Again, Takijima et al. (1970) reported that the silica slag reduced the susceptibility of the crop to pests and diseases. In sand culture, Gangopadhyay and Chathopadhyay (1975) found that the incidence of brown spot disease was correlated to the silica content of the leaves.

2.4. General effects of Silica Nutrition

Lawes (1951) found that silica increased the dry weight and protein content of rice. Okamoto (1959) reported earlier heading and an increase in the dry weight of leaf, stem and panicle at adequate levels of irrigation with the application of silica.

Corner (1962) found that silica reduced the concentration of aluminium in the soil solution. Valmis and Williams (1967) reported correlation of manganese as well as iron toxicity symptoms by silica.

Yoshida (1975) found that transpiration rate is reduced, minimising the effect of water stress. It also has an effect in increasing the resistance against insect attack by the presence of the silica barrier.

2.5. Sources of silica and their utility

Ueda and Kimura (1959) reported that the application of weathered serpentine gave 5 per cent increase in yield of rice. Addition of calcium silicate slag increased the yield by 17%. The application of slag along with dolomite powder increased the yield by 25%. Iron ore was able to increase the yield of rice by 14%.

Russel (1961) found that manuring with sodium silicate could increase the yield in phosphorus deficient soils.

Experiments conducted at I.R.R.I., Philippines (Anon.1963) showed that increased yields could be obtained by the addition of silica in the form of calcium or magnesium silicate at the rate of 100 kg/ha. Money 1964) reported marked increase in the grain yield of rice, by the application of magnesium. Manabe and Itose (1966) reported that calcium silicate increased the yield of rice by 105 - 118%. Sadanandan and Varghese (1969) found calcium-magnesium silicate better than sodium silicate in increasing grain yield.

Duprez (1970) manured sugarcane in pots containing different soils with 4.5, 9, 18 t/ha of calcium silicate, blast furnace slag, sodium silicate, Hawaiian metallic slag, portland cement and calcium carbonate. All sources except sodium silicate gave significant yield response. But higher levels of calcium carbonate and cement reduced yield.

Experiments conducted at Central Rice Research Station, Pattambi (Anon, 1975) showed a non-significant increase in yield by the application of magnesium silicate at the rate of 100 kg/ha. But the dose of 200 kg/ha tended to reduce the yield.

EXPERIMENTAL DETAILS

CHAPTER III

EXPERIMENTAL DETAILS

A field experiment was conducted in a farmer's field in Kovalikori Padom, Kuttanad area of Changanacherry village. The details of the field experiment and the analytical methods followed in the present investigation are presented in this chapter.

3:1. Season, Variety, Treatments and Design of the experiment.

3:1:1. Season

The field experiment was conducted during the period November 1979 to April 1980.

3:1:2. Variety

The variety selected for the experiment was 'Jyothi' a high yielding short duration variety which is popular in the locality. But this variety has an unfavourable character of excessive grain shattering. One of the aims of the experiment was to study the influence of magnesium silicate on the grain shattering nature of the crop. Hence this variety was suitable for the study. The seeds were obtained from the Rice Research Station, Moncompu.

3:1:3. Cultural practices

The recommendations of the Kerala Agricultural University as per the Package of Practices were followed during the course of the experiment.

3:1:4. Preparation of the treatment material

The magnesium silicate used for the study is a form of talc known as 'Steatite' occurring in Wynad, Cannanore district, which was supplied by the Geological Survey of India. The material was in the form of lumps and hence it was made to a fine powder (100 mesh) in a mechanical grinder for efficient use in the experiment.

The neutralising value of the sample was 28.1 per cent. It contained 29 per cent MgO; 1 per cent CaO and 55 per cent SiO_2. The formula of the material is $Mg_3\ Si_4\ O_{10}(OH)_2$.

3:1:5. Treatments

There were 5 treatments depending on the levels of magnesium silicate (steatite) applied. They were 0, 100, 200, 300 and 400 kg of steatite/ha. The treatments were over and above the fertiliser recommendations contained in the Package of Practices. The treatments are detailed below:-

Sl. No.	Treatments	Quantity of fertilisers and lime	Quantity of Steatite kg/ha
1.	T_1	Package of Practices recommendation	0
2.	T_2	"	100
3.	T_3	"	200
4.	T_4	"	300
5.	T_5	"	400

3:1:6. Replications

There were 5 replications.

3:1:7. Design of the experiment

Randomised Block Design was adopted for the layout of the experiment.

3:1:8. Plot size, spacing and number of plots

There were twenty five plots each having a size of 6 m x 5 m (Gross area 30 sq.m). The spacing given was 15 x 10 cm. Hence the net plot size was 5.4 x 4.6 m (24.84 sq.m). The lay out plan is given in Fig.1.

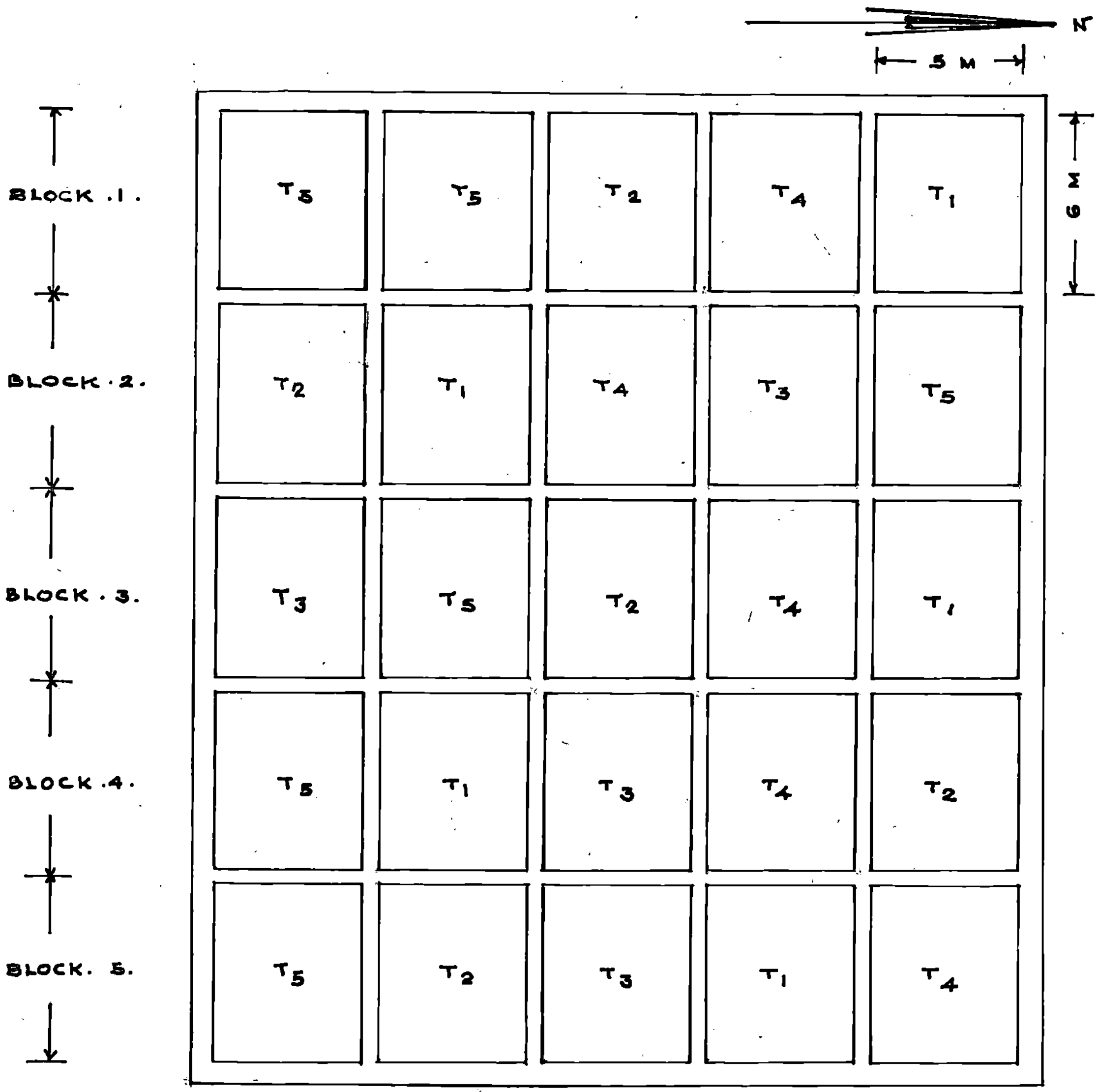
3:2: Experimental Procedure.

3:2:1. Nursery

Since sowing or planting in the field could be done only after dewatering, farmers generally raise nursery on garden lands or dry lands. The nursery for the experiment was raised in a dry land with proper fencing which was about 3 kilometers from the main field. Seeds were sown in the dry nursery on 25-11-79. Proper irrigation was done as per requirement. Pulling out of seedlings, transporting to main field and transplanting started on 21-12-1979 i.e., when the seedlings were 26 days old. Transplanting could be completed by 25-12-1979. Line planting was adopted with a spacing of 15 x 10 cm.

3:2:2. Main field

The site for the experiment was ploughed four times so as to get a good puddled condition. Separate plots were



NO. OF TREATMENTS :- 5

T_1 - CONTROL PACKAGE OF PRACTICES ALONE.

T_2 - PACKAGE OF PRACTICES + 100 Kgs/ha OF STEATITE

T_3 - " " " + 200 " " "

T_4 - " " " + 300 " " "

T_5 - " " " + 400 " " "

DESIGN :- R.B.D REPLICATIONS - 5 PLOT SIZE GROSS - 6 M. x 5 M.

SPACING :- 15 cm. x 10 cm. " NET 5.4 M. x 4.6 M.

FIG: I. LAY OUT PLAN - RANDOMISED BLOCK DESIGN.

formed with bunds 40 cm thick. There were five plots in each block. Irrigation and drainage channels were provided along each block. On all the four sides of the experimental area, bulk crop was raised. Fifty kgs of lime was applied and incorporated into the soil and the field was levelled.

3:2:3. Transplanting

Healthy and vigorous seedlings from the nursery excluding seedlings from the border of nursery beds were pulled out, transported to the main field and transplanted at the rate of 2 seedlings per hill.

3:2:4. Irrigation and drainage

Controlled irrigation and drainage were given according to necessity after transplanting.

3:2:5. Application of Mussorie phosphate

On 29-12-1979, 20 kg of Mussorie phosphate was applied for the 25 plots.

3:2:6. Application of magnesium silicate (Steatite)

On 2-1-1980, the magnesium silicate was weighed out into seperate polythene bags according to the dose for each plot and mixed with fine river sand so as to have enough bulk and applied in each plot.

3:2:7. Top dressing

Half the quantity of urea and muriate of potash was top dressed on 8-1-1980 and the remaining quantity was top dressed three weeks after i.e., on 30-1-1980. The total inputs of nutrients was according to Package of Practices i.e., 70:35:35.

Photograph showing the general stand
of the crop in the field experiment plot

3:2:8. Weeding

The plots were hand weeded twice, i.e. after 22 days and 37 days of transplanting.

3:2:9. Plant protection

To control the thrips attack spraying of Ekalux had to be done twice i.e. on 10th and 17th day of transplanting. The whole padasekharam was affected by thrips attack. Hinosan and Nuvacron was also sprayed twice i.e. on 13-2-1980 and 27-2-1980 against stem borer and sheath blight attack. On 7-3-1980, metacid was sprayed for the control of rice bugs.

3:2:10. General stand of the crop

The general stand of the crop was satisfactory. But for the attack of thrips in early stages and stem borer in the latter stages, the crop would have performed better.

3:2:11. Harvesting

The crop was harvested on the 98th day after transplanting; i.e. on 2-4-1980. The grain from the individual plots were dried, cleaned and weighed separately. The straw was also sun-dried plot-wise and weight recorded separately.

3:3. Observation

Three sampling units of 2 x 2 hills each were selected randomly after eleminating the border rows. Thus tiller count was taken from 12 hills. Plant height was recorded only from one hill each from each of the three sampling units. This procedure is in accordance with the method suggested by Gomez (1972). The plant growth and yield characters studied are detailed below:-

3:3:1. Height of plants

The height of plants in cm was recorded at 3 stages, viz., 30 days after transplanting, 60 days after transplanting and at harvest. The height of one tallest corner plant from each of the three sampling units was measured from the ground level to the tip of the tallest leaf or the tip of the panicle when the observation was taken after panicle emergence.

3:3:2. Tiller count

The tiller count from all the 12 hills of the three sampling units were taken separately for recording. At the final observation the number of productive tillers in each hill was also recorded and the percentage of productive tillers based on the maximum tillering stage was computed.

3:3:3. Length of panicle

The panicles of the sampling units were harvested separately and the length measured in cm from the neck to the tip of the panicle.

3:3:4. Number of spikelets per panicle

The total number of spikelets per panicle was counted separately and the mean values recorded.

3:3:5. Percentage of filled grains per panicle

The total number of spikelets and the number of filled grains were counted separately and the percentage of filled grains computed.

3:3:6. Shattering of grains

One of the aims of the experiment was to study the influence of magnesium silicate on the character of grain shattering in Jyothi variety. For finding out the extent of shedding, the method followed at Rice Research Station, Pattambi was adopted.

Panicles from the sampling units were taken and the number of filled grains and chaff recorded. Then the panicle was placed on the surface of a table of 1½ m height. The panicle was brought to the border of the table surface and then dropped carefully to the concrete floor. Care was taken to drop the panicle in the horizontal position.

The number of grains shattered from the panicle was counted and its percentage was computed.

3:3:7. Yield of grain and straw

The crop was harvested at full maturity. The first two border rows from all the four sides of all the plots were harvested and removed. The remaining net area was harvested, threshed and the weight of grain and straw recorded separately for all the plots.

3:3:8. Grain straw ratio

From the weights of grain and straw obtained from each plot, the grain straw ratio was worked out.

3:3:9. 1000 grain weight

1000 grains were counted from the random samples drawn from the bulk of the dried and cleaned grains of individual plots and their weights recorded.

3:3:10. Incidence of pests and diseases

Observations were made on the attack of stem borer (which was the major attack noted) in all the plots. The number of white earheads were counted and the average worked out.

Regarding disease, the major disease of the locality was sheath blight. Observations were taken on the incidence of sheath blight from all plots and recorded.

3:4. Analysis of soil

Collection and preparation of soil sample

Soil sample of the experimental field was collected, dried in the shade and gently powdered with wooden mallet to pass through a 2 mm sieve. The sieved sample was used for analysis.

3:4:1. Mechanical analysis

Mechanical components like coarse sand, fine sand, silt and clay were determined by the International Pipette Method (Piper, 1966).

3:4:2. Physical properties

Apparent specific gravity, absolute specific gravity, pore space, water holding capacity and volume expansion on wetting were determined by the Keen-Raczkowski brass cup method (Piper, 1966).

3:5. Chemical analysis of soil

3:5:1. Moisture

A known weight of the soil sample was dried in an air oven at 105°C to constant weight and the loss in weight expressed as per cent on oven dry basis.

3:5:2. Loss on ignition

Ten gram of soil was accurately weighed into a silica crucible and ignited in an electric muffle furnace at 700°C until all the organic matter was oxidised off. The loss in weight was expressed as loss on ignition on oven dry basis.

3:5:3. Soil reaction

The pH of the soil sample was measured in a 1:2.5 soil-water suspension, using glass electrode pH meter.

3:5:4. Organic carbon

Organic carbon was estimated by the chromic acid wet digestion method of Walkley and Black (1934).

3:5:5. Total nitrogen

Total nitrogen was estimated by the Kjeldahl method (Piper, 1966).

Preparation of hydrochloric acid extract

The ignited soil was digested with 1:1 hydrochloric acid for 6 hrs and filtered, washed free of chloride. The filtrate was made upto a known volume. From the hydrochloric acid extract thus obtained, the following analyses were made.

3:5:6. Sesquioxides

Sesquioxides were precipitated in a known volume of hydrochloric acid extract as hydroxides. They were filtered, ignited and weighed as combined oxides (Piper, 1966).

3:5:7. Iron oxide

Iron oxide was then determined in a separate aliquot of hydrochloric acid extract by reduction with zinc and dilute sulphuric acid and the ferrous solution thus obtained was then titrated with standard potassium permanganate solution (Piper, 1966).

3:5:8. Aluminium

Aluminium oxide was estimated by the difference between sesquioxides and iron oxide (Piper, 1966).

3:5:9. Calcium

The filtrate from sesquioxide was concentrated and calcium was precipitated as calcium oxalate. The precipitate was washed free of chloride with warm water, dissolved in warm dilute sulphuric acid and titrated against standard potassium permanganate solution (Piper, 1966).

3:5:10. Magnesium

Magnesium content was determined gravimetrically by precipitation as magnesium ammonium phosphate from the filtrate of calcium (Piper, 1966).

3:5:11. Total phosphorus

Phosphorus present in soil was extracted using sulphuric perchloric acid mixture and the phosphorus in the extract determined using vanadomolybdate method (Jackson, 1967).

3:5:12. Acid soluble silica

A known volume of the hydrochloric acid extract was evaporated to dryness on a sand bath until the last traces of moisture were removed. The dried residue was digested with dilute nitric acid and filtered. The residue was ignited in a platinum crucible and sulphated and weighed. The silica was then converted to volatile silicon fluoride by heating with hydrofluoric acid and the reduction in weight recorded as silica (Piper, 1950).

3:5:13. Available silica

Ten g of soil was placed in 250 ml conical flask. Added 100 ml of N.sodium acelate solution buffered at p^H 4. The flask was kept in a water bath at 40°C for 5 hrs. The solution was filtered off through dry filter paper.

Ten ml of this filtrate was placed in a dried beaker and was treated with 5 ml of 0.5 N HCl and 5 ml of 10 per cent ammonium molybdate solution and allowed to stand for approximately 3 minutes. The sample was reduced by 10 ml of 17 per cent sodium sulphite. The transmittance was read by 600-700 mμ after molybdenum blue is formed (Imaizumi and Yoshida, 1958).

3:5:14. Available phosphoric acid

Bray and Kurtz extract No.2 was used for the extraction of phosphorus and it was estimated colourimetrically by reading the molybdic blue colour with red filter in a Klett-Summerson colorimeter.

3:5:15. Available potassium

The potassium in soil was extracted by normal ammonium acetate solution and read in a flame photometer.

3:5:16. Available nitrogen

Estimated as per the alkaline permanganate method (Subbiah and Asija, 1956).

3:5:17. Cation Exchange Capacity

This was obtained by Schollenberger method (Schollenberger and Dreibelbis, 1930) using neutral N ammonium acetate for leaching exchangeable ions.

3:5:18. Electrical conductivity

This was determined using a conductivity bridge (solubridge) taking a 1:2 soil-water suspension.

3:5:19. Periodic recording of pH and E.C.

Periodic recording of pH and E.C. was done at active tillering stage, panicle emergences and after harvest.

The mechanical and chemical composition of the soil is given in Table 1.

3:6. Analysis of plant material

The following chemical analyses of the grain and straw samples were conducted.

(a) Total nitrogen

(b) Total phosphorus

(c) Total potassium

(d) Calcium and magnesium

(e) Silica

The grain was dried in an air drier at 70°C, winnowed and cleaned. The prepared samples were kept in separate labelled bottles. Whole grain samples were used for analysis.

The straw samples were also dried in an air drier at 70°C and ground to powder in a Wiley mill. The ground samples were stored for analysis in separate labelled bottles.

Analytical Procedure

3:6:1. Total nitrogen

Total nitrogen was estimated in the grain and straw by the Microkjeldahl method. The nitrogen present in the organic form was converted into ammoniacal form by digestion with concentrated sulphuric acid in the presence of mercuric oxide potassium sulphate mixture. From the digest, nitrogen was estimated using Microkjeldahl distillation unit.

Triple acid extract

The grain and straw samples were digested with triple acid mixture. Triple acid mixture was prepared by mixing nitric acid, sulphuric acid and perchloric acid in the proportion of 10:1:4.

The triple acid extract of grain and straw was used for the estimation of phosphorus, potassium, calcium and magnesium.

Silica was estimated from the residue on the filter paper.

3:6:2. Phosphorus

The phosphorus in the triple acid extract was estimated colorimetrically by the Vanadomolybdate method (Jackson, 1967).

3:6:3. Potassium

The potassium in the triple acid extract was read in EEL flame photometer. For this the extract was neutralised with ammonia and made upto volume so as to avoid corrosion of the instrument.

3:6:4. Calcium and magnesium

Calcium and magnesium were estimated from the triple acid extract by the Versenate titration method as given by Cheng et al. (1952).

3:6:5. Silica

The residue left after the digestion of the grain and straw with triple acid mixture was washed, filtered, dried, ignited and estimated as silica.

3:7. Statistical analysis.

The statistical analysis of the data was carried out following the methods outlined by Snedecor and Cochran (1967). The principle of transformation of data was adopted in the case of observations in percentages such as filled grains per panicle, grain shattering etc. Angular transformation was used for this. The regression curves for the data on the uptake of different nutrients were also plotted.

EXPERIMENTAL RESULTS

CHAPTER IV

EXPERIMENTAL RESULTS

The results of observation and analysis recorded during the course of the field experiment are presented in this chapter.

4:1. <u>Physical and chemical analysis of soil</u>

The results on the physical and chemical properties and nutrient status of the original (pre-planting) soil sample and post harvest soil samples of the experimental field are furnished in the tables 1 and 1(a).

4:2:1. <u>Mechanical analysis</u>

The values for clay, silt, fine sand and coarse sand fraction of the soil taken from the field before planting are 42.95, 31.63, 14.99 and 4.82 per cent respectively. The soil samples taken after harvest did not show any appreciable change with respect to the content of mechanical separates.

4:2:2. <u>Physical constants</u>

The pre-planting soil recorded a value of 1.12 for apparent specific gravity, 2.06 for absolute specific gravity, 46.70 for maximum water holding capacity, 53.64 for percentage of porespace and 5.87 for volume expansion.

The apparent specific gravity for the soil samples from treatment plots varied from 0.95 to 1.12. But there was no definite relationship regarding this value with varying levels of treatment. Similar was the case with absolute

Table 1. Mechanical and chemical composition of the soil from the field experiment plot before planting.

	Mechanical composition	
1.	Coarse sand (%)	4.82
2.	Fine sand (%)	14.95
3.	Silt (%)	31.65
4.	Clay (%)	42.95
	Chemical composition	
1.	Soil reaction (pH)	3.9
2.	Lime requirement (t/ha)	2.9
3.	Moisture content (%)	8.4
4.	Loss on ignition (%)	24.0
5.	Organic carbon (%)	3.2
6.	Total sesquioxides (%)	12.3
7.	Fe_2O_3 (%)	8.7
8.	Al_2O_3 (%)	3.6
9.	C.E.C. (me/100g)	12.0
10.	Total N(%)	0.354
11.	Total P (%)	0.025
12.	Total K (%)	0.170
13.	Total Ca (%)	0.032
14.	Total Mg (%)	0.014
15.	Available N (%)	0.007
16.	Available P (%)	0.0013
17.	Available K (%)	0.011
18.	Available Silica (%)	0.0014

Table 1(a). Mechanical and chemical composition of the soil from the field experiment plot after harvest.

	Treatment steatite (kg/ha)				
	0	100	200	300	400
Mechanical composition					
1. Coarse sand (%)	4.87	4.85	4.80	5.02	4.95
2. Fine sand (%)	15.03	15.23	16.45	14.84	15.03
3. Silt (%)	30.68	28.34	27.69	29.46	30.56
4. Clay (%)	42.19	42.12	42.74	43.12	42.69
Chemical composition					
1. Soil reaction (pH)	4.2	4.2	4.3	4.2	4.2
2. Lime requirement (t/ha)	2.5	2.5	2.4	2.5	2.5
3. Moisture content (%)	8.1	8.4	8.3	8.2	8.1
4. Loss on ignition (%)	22.0	23.4	24.1	23.8	23.9
5. Organic carbon (%)	3.1	3.1	3.2	3.2	3.2
6. Total sesquioxides (%)	12.7	12.3	12.4	12.2	12.8
7. Fe_2O_3 (%)	8.4	8.3	8.9	8.7	8.9
8. Al_2O_3 (%)	4.3	4.0	3.5	3.5	3.9
9. C.E.C.(me/100 g)	12.0	12.0	11.0	11.0	11.0
10. Total N (%)	0.334	0.330	0.332	0.334	0.334
11. Total P (%)	0.026	0.026	0.027	0.027	0.027
12. Total K (%)	0.175	0.182	0.174	0.172	0.174
13. Total Ca (%)	0.032	0.030	0.030	0.032	0.03
14. Total Mg (%)	0.014	0.016	0.016	0.018	0.01
15. Available N (%)	0.007	0.006	0.006	0.007	0.007
16. Available P (%)	0.0014	0.0013	0.0014	0.0014	0.001
17. Available K (%)	0.012	0.014	0.012	0.012	0.011
18. Available Silica (%)	0.0014	0.0018	0.0017	0.0018	0.001

Table 33. Influences of different levels of magnesium silicate application on the single value physical constants of soil.

Treatment	Single value physical constants				
Magnesium silicate kg/ha	Apparent specific gravity	Absolute specific gravity	Maximum water holding capacity	Percentage of pore space	Volume expansion
Before crop	1.22	2.06	46.70	53.64	5.67
0	0.98	1.87	48.24	54.79	6.17
100	1.01	1.67	47.58	52.01	6.21
200	0.97	1.73	49.50	53.27	6.03
300	0.98	1.83	50.21	54.05	5.89
400	0.95	1.75	51.34	54.00	5.77

specific gravity also.

Maximum water holding capacity of the pre-planting soil was 46.70 per cent. The post-harvest soil samples showed a variation from 47.58 per cent to 51.34 per cent.

The values for percentage of pore space and for the volume expansion showed no relationship with the varying levels of treatment.

4:2:3. Chemical analysis of soil

In tables 1 and 1(a) are given the data for chemical analysis of pre-planting and post-harvest soil samples. In the case of magnesium content, there was a steady increase with increasing levels of steatite. It varied from 0.014 per cent in the case of preplanting soil to 0.016 per cent in the case of treatment levels of 100 kg and 200 kg/ha of steatite. It again increased to 0.018 per cent in the case of treatments at the level of 300 kg and 400 kg/ha.

Similarly, the available silica content also increased steadily with increase in the level of treatment. It increased from 0.0014 per cent in the case of pre-planting soil to 0.0019 per cent in the case of post-harvest soil which received the treatment at 400 kg/ha of steatite.

All the other values for soil chemical analysis revealed no appreciable change.

4:3. Effect of magnesium silicate (Steatite) application on the biometric characters of rice (Jyothi)

4:3:1. Tillering of plants

The data relating to tiller count at different growth

Table 2. Effect of different levels of magnesium silicate on tillering of rice at 30 days after planting.

Treatment Magnesium silicate kg/ha	Average number of tillers per hill.					
	R_1	R_2	R_3	R_4	R_5	Total mean
0	9.70	8.75	7.42	7.00	7.10	7.99
100	9.00	11.58	9.00	9.50	9.84	9.78
200	15.30	7.80	9.58	9.00	10.00	10.34
300	8.25	6.00	6.83	9.75	9.08	7.98
400	10.20	7.50	8.42	7.50	9.84	8.69

Critical difference for comparison between treatment means at 0.05 level = 2.18

Table 3. Effect of different levels of magnesium silicate on tillering of rice at 60 days after planting.

Treatment Magnesium silicate kg/ha	Average number of tillers per hill					
	R_1	R_2	R_3	R_4	R_5	Mean
0	10.40	8.95	7.50	7.28	7.00	8.23
100	9.20	11.60	9.40	9.60	10.12	9.98
200	15.00	8.25	10.10	8.90	10.73	10.59
300	8.87	6.25	6.95	9.83	9.32	8.24
400	11.70	9.40	10.20	9.30	10.23	10.16

Critical difference for comparison between treatment means at 0.05 level = 2.019

Table 4. Effect of different levels of magnesium silicate on tillering of rice at harvest.

Treatment Magnesium silicate kg/ha	Average number of tillers per hill					
	R_1	R_2	R_3	R_4	R_5	Mean
0	10.50	8.95	7.50	7.28	6.85	8.22
100	9.10	11.60	9.40	9.60	10.00	9.94
200	15.00	8.25	10.10	8.90	10.95	10.64
300	8.87	6.57	6.95	9.83	9.40	8.32
400	11.70	9.40	10.00	9.50	10.30	10.18

Critical difference for comparison between treatment means at 0.05 level = 2.02

Table 5. Influence of different levels of magnesium silicate on the percentage of productive tillers of rice (var. Jyothi).

Treatment Magnesium silicate kg/ha	Percentage of productive tillers					
	R_1	R_2	R_3	R_4	R_5	Mean (After transformation)
0	68.57	78.21	74.67	92.86	74.65	0.154
100	77.17	81.90	95.74	67.71	90.12	0.159
200	76.47	84.85	80.20	79.56	76.44	0.156
300	80.50	90.56	86.35	59.30	82.98	0.156
400	76.07	76.60	89.22	95.68	92.23	0.162

Critical difference for comparison between treatment means at 0.05 level = 0.012

stages are presented in tables 2, 3 and 4.

Steatite application at 200 kg/ha was statistically significant over the zero kg/ha level of treatment in all the three growth stages i.e. 30 days after planting, 60 days after planting and at the time of harvest respectively.

Regarding all other levels of treatment there was increase in the number of tillers though not statistically significant when the observation was taken at 60 days after planting and at harvest.

4:3:2. Percentage of productive tillers

The percentage of productive tillers are given in table 5. Though steatite treatments in general increased productive tillers, treatment differences were not statistically significant. However, the highest level of 400 kg/ha of steatite recorded the highest mean value of 0.162 (transformed data).

4:3:3. Height of plants

The data relating to the height of plants at 30th days after planting are given in table 6. The height of plants was higher in all the treatments over control. However the increase was not statistically significant.

On 60th day after planting (Table 7) the increase in height of plants at 400 kg level of steatite was significant over control. Except a slight decrease in the height of plants in the case of 300 kg/ha treatment, the other two treatments also showed increase in height though not

Table 6. Effect of different levels of magnesium silicate on the height of rice plant at 30 days after planting.

Treatment Magnesium silicate kg/ha	Height of plant in cm					
	R_1	R_2	R_3	R_4	R_5	Mean
0	49.5	53.0	48.5	51.5	49.5	50.4
100	54.0	60.0	49.5	56.0	50.5	54.0
200	59.0	49.5	52.0	53.0	52.0	53.1
300	53.5	52.5	52.0	51.0	46.5	51.1
400	59.5	51.0	48.5	46.5	56.5	52.4

Critical difference for comparison between treatment means at 0.05 level = 4.82

Table 7. Effect of different levels of magnesium silicate on the height of rice plant at 60 days after planting.

Treatment Magnesium silicate kg/ha	Height of plant in cm					
	R_1	R_2	R_3	R_4	R_5	Mean
0	73.0	78.0	68.5	75.5	74.5	73.9
100	74.5	85.5	74.5	70.5	77.0	76.4
200	85.0	74.3	77.0	73.0	74.0	76.7
300	75.5	70.5	71.5	75.5	73.0	73.2
400	84.5	83.0	85.0	83.5	81.0	83.4

Critical difference for comparison between treatment means at 0.05 level = 5.34

Table 8. Effect of different levels of magnesium silicate on the height of rice plant at harvest.

Treatment Magnesium silicate kg/ha	Plant height in cm					
	R_1	R_2	R_3	R_4	R_5	Mean
0	82.0	87.0	77.0	82.0	83.0	82.2
100	85.0	95.0	81.0	86.0	85.0	87.4
200	95.0	85.0	87.0	86.0	81.0	86.8
300	85.0	80.0	79.0	85.0	85.0	82.8
400	95.0	93.0	95.0	92.0	90.0	93.0

Critical difference for comparison between treatment means at 0.05 level = 2.06

Table 9. Influence of different levels of magnesium silicate on the yield of rice grain.

Treatment Magnesium silicate kg/ha	Yield of grain kg/plot					
	R_1	R_2	R_3	R_4	R_5	Mean
0	8.1	9.0	8.8	11.0	8.0	8.98
100	10.5	11.0	9.0	8.5	10.5	9.90
200	14.5	9.5	12.2	8.8	8.3	10.66
300	11.3	9.4	11.3	10.2	10.2	10.48
400	12.5	9.7	14.0	13.0	12.5	12.34

Critical difference for comparison between treatment means at 0.05 level = 2.13

Table 10. Influence of different levels of magnesium silicate on the yield of rice straw.

Treatment Magnesium silicate kg/ha	Yield of straw kg/plot					
	R_1	R_2	R_3	R_4	R_5	Mean
0	14.0	14.5	14.0	20.0	13.0	15.1
100	15.0	18.5	15.0	14.0	18.5	16.2
200	21.5	14.5	18.5	15.5	14.0	16.8
300	17.5	14.0	17.0	17.5	17.0	16.6
400	20.0	14.0	24.0	21.0	20.0	19.8

Critical difference for comparison between treatment means at 0.05 level = 3.76

Table 11. Influence of different levels of magnesium silicate on panicle length.

Treatment Magnesium silicate kg/ha	Length of panicle (cm)					
	R_1	R_2	R_3	R_4	R_5	Mean
0	17.0	18.0	18.5	18.5	17.5	17.9
100	17.5	20.0	17.0	18.0	18.0	18.1
200	18.0	17.0	18.5	17.0	17.5	17.6
300	18.0	17.5	18.0	17.0	18.0	17.7
400	18.0	18.0	18.5	18.0	17.5	18.0

Critical difference for comparison between treatment means at 0.05 level = 1.002

statistically significant.

At harvest (Table 8) all the four treatments recorded increased height over control. The effect of steatite application at 100, 200 and 400 kg was statistically significant over control.

4:3:4. Length of panicle.

The values pertaining to the length of panicles are given in table 11 which showed no significant difference between the treatments.

4:3:5. Yield of grain

The yield of grain data is given in table 9. All the four levels of treatment showed an increase in grain yield over control. The treatment of 400 kg/ha of steatite showed a statistically significant increase in grain.

4:3:6. Yield of straw

In table 10 are given the data on yield of straw.

The effect of steatite application on the yield of straw was similar to that of grain yield. The yield of straw for treatment 400 kg/ha was statistically superior.

4:3:7. Grain straw ratio

The grain straw ratio was found to be 2:3 which is almost the same in all the five treatments.

4:3:8. Thousand grain weight

The data reporting thousand grain weight are presented in table 12.

Table 12. Influence of different levels of magnesium silicate on thousand grain weight of paddy (var.Jyothi).

Treatment Magnesium silicate kg/ha	Weight of thousand grain in grams					
	R_1	R_2	R_3	R_4	R_5	Mean
0	23.12	24.78	22.87	23.50	24.15	23.68
100	25.58	25.48	24.18	25.05	25.20	25.10
200	23.93	24.78	25.40	23.78	24.68	24.51
300	24.78	24.92	24.54	24.30	24.45	24.60
400	24.78	24.98	25.44	26.07	24.80	25.21

Critical difference for comparison between treatment means at 0.05 level = 0.815

Table 13. Influence of different levels of magnesium silicate on incidence of stem borer attack in paddy (var.Jyothi).

Treatment Magnesium silicate kg/ha	Intensity of pest attack (Number of white earheads)					
	R_1	R_2	R_3	R_4	R_5	Mean
0	4	28	10	19	8	13.8
100	7	21	9	9	8	10.8
200	26	23	11	26	18	20.8
300	21	8	10	12	6	11.4
400	44	9	4	9	5	14.2

Critical difference for comparison between treatment means at 0.05 level = 12.51

The effect of steatite application showed statistically significant increase in the thousand grain weight in all the four treatment levels over control. Though the increase in weight was not perfectly linear the highest value (25.21) was recorded for 400 kg/ha of steatite.

4:4. Effect of steatite (Magnesium silicate) on the nutrient contents of rice grain (variety Jyothi)

The results on the effect of different levels of treatment of steatite on the N, P, K, Ca, Mg and Si content of rice grain, straw, and protein percentage are presented in tables 18 to 23, 24 to 29 and 15 respectively.

4:4:1. Nitrogen content of grain

A negative correlation was observed between the levels of treatment and the nitrogen content. It varied from 1.21 per cent in the case of zero kg level to 1.02 in the case of 400 kg magnesium silicate. The reduction in nitrogen content was statistically significant in the case of 200, 300 and 400 kg/ha over zero kg/ha.

4:4:2. Phosphoruse content of grain

The data relating to the phosphorus content of grain is given in table 19. The phosphorus content was found to decrease as the level of magnesium silicate application increased. The phosphorus content varied from 0.36 to 0.30 per cent. All the four levels of magnesium silicate application was statistically significant over zero kg level in decreasing the percentage of phosphorus content.

Table 18. Influence of different levels of magnesium silicate on the nitrogen content of rice grain.

Treatment Magnesium silicate kg/ha	Nitrogen content (%)					
	R_1	R_2	R_3	R_4	R_5	Mean
0	1.09	1.32	1.30	1.05	1.29	1.21
100	1.17	1.20	1.10	1.17	1.16	1.16
200	1.15	1.12	1.10	1.14	1.09	1.12
300	1.10	1.12	1.06	1.08	1.09	1.09
400	1.02	1.00	1.03	1.05	1.00	1.02

Critical difference for comparison between treatment means at 0.05 level = 0.088

Table 19. Influence of different levels of magnesium silicate on phosphorus content of rice grain.

Treatment Magnesium silicate kg/ha	Phosphorus content (%)					
	R_1	R_2	R_3	R_4	R_5	Mean
0	0.35	0.37	0.34	0.37	0.37	0.36
100	0.32	0.33	0.35	0.35	0.35	0.34
200	0.35	0.34	0.35	0.31	0.32	0.33
300	0.32	0.32	0.33	0.32	0.31	0.32
400	0.30	0.29	0.31	0.30	0.30	0.30

Critical differences for comparison between treatment means at 0.05 level = 0.017

4:4:3. Potash content of grain

The potash content of grain from different treatments are given in table 20.

The potash content showed a decreasing trend as the level of magnesium silicate application increased. The treatment effect was significant statistically in all the four levels over that of zero kg level.

4:4:4. Calcium content of grain

The calcium content of grain for various treatments are given in table 21.

The calcium content got reduced due to magnesium silicate application. The decrease in calcium content was not linear with increase in the level of magnesium silicate. But all the treatment levels were statistically significant over zero kg level of magnesium silicate application.

4:4:5. Magnesium content of grain

The magnesium content of grain is presented in table 22.

The magnesium content of grain was increased linearly with increase in the level of magnesium silicate application. The increase in magnesium content was statistically significant.

4:4:6. Silica content of grain

Silica content of rice grain of various treatments are given in table 23.

The silica content gradually increased with increase in the level of magnesium silicate application. The effect of application of magnesium silicate was statistically significant

Table 20. Effect of different levels of magnesium silicate on potash content of rice grain.

Treatment	Potash content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	0.91	0.95	0.97	0.96	0.96	0.95
100	0.90	0.94	0.96	0.94	0.96	0.94
200	0.88	0.92	0.94	0.92	0.94	0.92
300	0.90	0.90	0.92	0.94	0.94	0.92
400	0.89	0.88	0.92	0.93	0.93	0.91

Critical difference for comparison between treatment means at 0.05 level = 0.019

Table 21. Influence of different levels of magnesium silicate on calcium content of rice grain.

Treatment	Calcium content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	0.17	0.16	0.16	0.19	0.17	0.17
100	0.18	0.15	0.15	0.16	0.16	0.16
200	0.14	0.15	0.15	0.16	0.15	0.15
300	0.15	0.14	0.16	0.16	0.14	0.16
400	0.14	0.13	0.13	0.15	0.15	0.15

Critical difference for comparison between treatment means at 0.05 level = 0.012

Table 22 . Influence of different levels of magnesium silicate on magnesium content of rice grain.

Treatment Magnesium silicate kg/ha	Magnesium content (%)					
	R_1	R_2	R_3	R_4	R_5	Mean
0	0.09	0.07	0.10	0.10	0.09	0.09
100	0.09	0.10	0.10	0.11	0.10	0.10
200	0.11	0.10	0.11	0.11	0.12	0.11
300	0.10	0.11	0.10	0.12	0.12	0.11
400	0.12	0.10	0.11	0.13	0.14	0.12

Critical difference for comparison between treatment means at 0.05 level = 0.011

Table 23 . Influence of different levels of magnesium silicate on silica content of rice grain.

Treatment Magnesium silicate kg/ha	Silicate content (%)					
	R_1	R_2	R_3	R_4	R_5	Mean
0	4.20	3.10	4.00	4.10	4.10	4.10
100	4.36	4.40	4.60	4.70	4.74	4.56
200	4.70	4.65	4.77	4.71	4.72	4.71
300	5.35	5.44	5.34	5.33	5.34	5.36
400	5.56	5.80	5.82	5.80	5.82	5.76

Critical difference for comparison between treatment means at 0.05 level = 0.137

at all the four levels over zero.

4:4:7. Nitrogen content in straw

The nitrogen content of straw for various treatments are given in table 24.

The nitrogen content decreased as the level of magnesium silicate increased. All the four levels of magnesium silicate application resulted in statistically significant decrease in nitrogen content over zero kg level.

4:4:8. Phosphorus content

The data relating to phosphorus content in straw is given in table 25.

The phosphorus content was found to decrease as the level of magnesium silicate application increased. The decrease in phosphorus content was statistically significant in all the four treatments above zero level.

4:4:9. Potash content in straw

The potash content in straw for various treatment samples is given in table 26.

The potash content was found to reduce as the level of magnesium silicate application increased. All the four levels of treatment resulted in statistically significant decrease in potash content of straw over control.

4:4:10. Calcium content of straw

The data regarding calcium content of straw is given in table 27.

Table 24. Influence of different levels of magnesium silicate on nitrogen content of paddy straw.

Treatment	Nitrogen content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	0.95	0.95	0.99	1.01	0.97	0.97
100	0.95	0.93	0.94	0.90	0.93	0.93
200	0.93	0.91	0.90	0.88	0.88	0.90
300	0.79	0.78	0.82	0.82	0.84	0.81
400	0.65	0.64	0.71	0.70	0.70	0.68

Critical difference for comparison between treatment means at 0.05 level = 0.035

Table 25. Influence of different levels of magnesium silicate on phosphorus content of paddy straw.

Treatment	Phosphorus content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	0.05	0.06	0.05	0.07	0.07	0.06
100	0.05	0.04	0.06	0.05	0.05	0.05
200	0.04	0.04	0.05	0.04	0.03	0.04
300	0.03	0.04	0.04	0.03	0.06	0.04
400	0.03	0.03	0.04	0.02	0.03	0.03

Critical difference for comparison between treatment means at 0.05 level = 0.012

Table 26. Influence of different levels of magnesium silicate on potash content of paddy straw.

Treatment	Potash content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	2.22	2.21	2.23	2.18	2.21	2.21
100	2.18	2.19	2.17	2.16	2.20	2.18
200	2.12	2.14	2.15	2.15	2.14	2.14
300	2.10	2.09	2.08	2.12	2.11	2.10
400	2.05	2.00	2.01	2.02	2.02	2.02

Critical difference for comparison between treatment means at 0.05 level = 0.023

Table 27. Influence of different levels of magnesium silicate on calcium content of paddy straw.

Treatment	Calcium content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	0.65	0.63	0.66	0.68	0.63	0.65
100	0.60	0.64	0.60	0.60	0.61	0.61
200	0.52	0.56	0.57	0.55	0.55	0.55
300	0.53	0.54	0.54	0.55	0.54	0.54
400	0.50	0.48	0.47	0.47	0.48	0.48

Critical difference for comparison between treatment means at 0.05 level = 0.023

All the four treatment levels resulted in a statistically significant decrease in calcium content of straw over zero kg level of magnesium silicate application.

4:4:11. Magnesium content of straw

The data relating to magnesium content of straw is given in table 28.

The magnesium content was found to increase with increase in the level of magnesium silicate application. All the four treatments resulted in statistically significant increase in magnesium content of straw over zero kg level of treatment.

4:4:12. Silica content of straw

The data relating to silica content of straw is presented in table 29.

All the four levels of treatments resulted in increased silica content over control. The increase was statistically significant also. The increase was linear with the level of magnesium silicate. It varied from 8.5 per cent in zero kg level of magnesium silicate to 11.67 per cent in the case of 400 kg level of treatment.

4:4:13. Protein content of rice grain

The data regarding protein content of the rice grain is given in table 15. The protein content decreased from 7.56 per cent in the case of zero kg/ha of steatite (magnesium silicate) application to 6.38 per cent in the case of 400 kg/ha level. The reduction in protein content showed

Table 28. Influence of different levels of magnesium silicate on magnesium content of paddy straw.

Treatment	Magnesium content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	0.17	0.16	0.18	0.16	0.18	0.17
100	0.18	0.19	0.18	0.22	0.23	0.20
200	0.19	0.19	0.24	0.24	0.24	0.22
300	0.22	0.24	0.25	0.24	0.25	0.24
400	0.25	0.26	0.29	0.30	0.30	0.28

Critical difference for comparison between treatment means at 0.05 level = 0.018

Table 29. Influence of different levels of magnesium silicate on silica content of paddy straw.

Treatment	Silica content (%)					
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	Mean
0	8.40	8.45	8.80	8.40	8.45	8.50
100	9.20	9.00	9.10	9.30	9.40	9.20
200	9.35	9.42	9.59	9.67	9.27	9.46
300	10.25	10.40	10.55	10.30	10.50	10.40
400	11.15	11.45	11.65	11.86	11.90	11.67

Critical difference for comparison between treatment means at 0.05 level = 0.204

a linear relationship with increasing levels of treatment.

4:5. Uptake of nutrients

The data relating to the uptake of nutrients by rice plant (var.Jyothi) is given in table 31.

4:5:1. Nitrogen

The variation in uptake of nitrogen did not follow any definite pattern in comparison to the level of magnesium silicate application. The mean uptake of nitrogen for rice plant was found highest i.e. 270 g/plot in 200 kg steatite treated plots, the lowest being 255 g/plot for control plot.

4:5:2. Phosphorus

Phosphorus uptake was not linear with the variation in the level of treatments. It varied from 39 g/plot in the case of 200 kg/ha level of magnesium silicate application to 43 g/plot in the case of 400 kg/ha level.

4:5:3. Potash

The increase in uptake of potash did not show any straight line relationship with the level of magnesium silicate application. The variation was from 419 g/plot to 511 g/plot corresponding to zero kg and 400 kg/ha levels of magnesium silicate.

4:5:4. Calcium

The uptake of calcium also did not show a straight line relationship with the level of magnesium silicate application. It varied from 105 g/plot to 115 g/plot for the treatment levels of 300 kg/ha and 100 kg/ha respectively.

Table 30. Influence of different levels of magnesium silicate application on the mechanical composition of soil.

Treatment Magnesium silicate kg/ha	Percentage composition			
	Coarse sand	Fine sand	Silt	Clay
0	4.67	15.05	30.68	42.19
100	4.65	15.23	28.34	42.12
200	4.80	16.45	27.69	42.74
300	5.02	14.84	29.46	43.12
400	4.95	15.03	30.56	42.89

Table 31. Influence of different levels of magnesium silicate on the uptake of nutrients by rice plant (var.Jyothi).

Treatment Magnesium silicate kg/ha	Uptake of nutrients (g/plot)					
	N	P	K	Ca	Mg	Si
0	255	41	419	113	34	1651
100	266	42	446	115	41	1941
200	270	39	457	108	49	2091
300	248	41	445	105	51	2288
400	261	43	511	112	70	3021

4:5:5. Magnesium

The uptake of magnesium showed an increasing trend with increase in the level of treatment. The zero kg level of magnesium silicate application recorded an uptake of 34 g/plot while the treatment level of 400 kg/ha of magnesium silicate recorded an uptake of 70 g/plot. The increase in uptake was linear with increase in the level of the treatment.

4:5:6. Silica

The uptake of silica also showed an increasing trend. The lowest value of 1651 g/plot was recorded for control and the highest value of 3021 g/plot was recorded in the 400 kg steatite treatment plots. Here also the uptake was linear with the increase in the level of treatment.

4:7. Periodic variation in pH and E.C.

The data relating to the changes in pH and E.C. of the soil at different growth stages are presented in table 32.

There was not appreciable variation in the pH and E.C. between different levels of treatments at the definite growth stage. Greater difference in pH and E.C. could be noted between different growth stages. The pH was found to increase when the soil was in the submerged condition i.e. at tillering stage and at panicle emergence stage. On drying the soil, i.e. at harvest, the pH value decreased considerably.

4:8. Grain shattering

The percentage of shattered grains per panicle for various treatments is given in table 16. The effect of

Table 16. Influence of different levels of magnesium silicate on grain shattering in rice (var. Jyothi).

Treatment	Percentage of shattered grains per panicle										
Magnesium silicate kg/ha	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	Mean
0	11.20	1.63	2.08	5.66	1.23	5.88	3.57	3.51	6.56	11.86	12.60
100	3.08	2.08	8.00	8.54	2.82	5.13	1.59	8.16	9.62	7.02	13.18
200	1.14	25.67	4.17	8.19	7.04	5.33	4.48	1.72	4.17	10.61	14.42
300	1.92	15.79	1.78	1.69	11.49	1.75	3.22	2.53	8.19	6.35	12.45
400	3.30	3.84	1.47	1.52	9.46	7.04	4.08	5.66	6.78	4.28	12.16

Critical difference for comparison between treatments at 0.05 level = 4.64

Table 32. Changes in the pH and E.C. at different stages of crop growth.

Stage	Treatment	pH	E.C.
Pre-planting (dry soil)	-	5.9	0.49
Tillering (wet soil)	T_1	5.8	0.24
	T_2	5.7	0.21
	T_3	5.7	0.23
	T_4	5.8	0.19
	T_5	5.7	0.17
Panicle emergence	T_1	5.6	0.19
	T_2	5.8	0.18
	T_3	5.9	0.15
	T_4	5.8	0.14
	T_5	5.7	0.14
After harvest (dry soil)	T_1	4.2	0.12
	T_2	4.2	0.13
	T_3	4.3	0.12
	T_4	4.2	0.12
	T_5	4.2	0.12

magnesium silicate was not statistically significant in any of the treatments. However there was a non-significant decrease in the extent of grain shattering with respect to the treatment level of 400 kg/ha over control. There are indications that the shattering can be controlled by the increased application of steatite.

4:9. Incidence of stem borer attack

The treatments at the level of 100 kg/ha and 300 kg/ha recorded a decrease in the number of white ear heads (mean being 10.8 and 11.4; table 13). But the treatments at the level of 400 kg and 100 kg/ha recorded an increase in the number of white ear heads with means of 14.2 and 20.8 respectively. Any how, none of the treatment effect was statistically significant with respect to stem borer attack.

4:10. Incidence of sheath blight

No statistically significant result was obtained for any of the treatments with respect to sheath blight disease.

Table 14. Influence of different levels of magnesium silicate on the incidence of disease (sheath blight) in paddy (var.Jyothi).

Treatment Magnesium silicate kg/ha	Number of hills infected					
	R_1	R_2	R_3	R_4	R_5	Mean
0	0	3	2	3	4	2.4
100	0	9	5	4	7	5.0
200	3	2	2	5	3	3.0
300	5	0	2	2	4	2.6
400	6	1	4	1	2	2.8

Critical difference for comparison between treatment means at 0.05 level = 3.19

Table 15. Influence of different levels of magnesium silicate on the protein content of rice grain (var.Jyothi).

Treatment Magnesium silicate kg/ha)	Average protein content (%)
0	7.56
100	7.25
200	7.00
300	6.81
400	6.38

DISCUSSION

CHAPTER V

DISCUSSION

The present field investigation was taken up to study the effect of an indigenous source of magnesium silicate (Steatite) on the growth and yield characters of rice (Jyothi) under Kuttanad conditions. The results are discussed below in the light of observations and data collected.

5:1. Tillering

Application of magnesium silicate at the level of 200 kg/ha increased tillering significantly over control in all the three stages, viz., 30 days, and 60 days after planting and at harvest. This can be explained due to the combined effect of magnesium and silicon in stimulating meristematic tissues of the plants. This finding is in conformity with that of Okuda et al. (1961) who found that silicon greatly influenced the growth of rice plants.

The results regarding the effect of various treatments with respect to productive tillers were not statistically significant.

This is in conformity with the results obtained by Winifred et al. (1927), Takijima et al. (1959), Miyoshi and Ishi (1960).

5:2. Height of plants

The height of rice plants recorded an overall increase in all the treatment levels over control at 30th day after planting, but the increase was not statistically significant.

On 60th day after planting, the treatment of 400 kg/ha only showed statistically significant increase in height of plants over control.

Of the four treatment levels over control, 400 kg/ha level only showed statistically significant increase in plant height at harvest.

On the whole, it can be inferred that the influence of magnesium silicate on rice is to increase the height of plants, vegetative growth, as well as dry matter production, under Kuttanad soil conditions. Silicon absorbed by rice plant increases the oxidation power of rice roots and this effect of silicon may always exert a good influence on growth of rice plants; sometimes it may prevent excessive iron uptake and alleviate iron toxicity.

Similar findings have been recorded by Ishibashi and Hajima (1937), Okamoto (1957) and Azuma et al. (1961).

Takahashi (1961) also concluded that absence of silicon in the vegetative stage led to decrease in the top growth.

5:3. Yield of grain

The grain yield increased consequent to the application of magnesium silicate at all the four levels over control. The increase recorded in the case of 400 kg/ha was only found to be statistically significant. The combined effect of magnesium and silicon has given such a result. This result is similar to that of Yoshida et al. (1962) who opined that

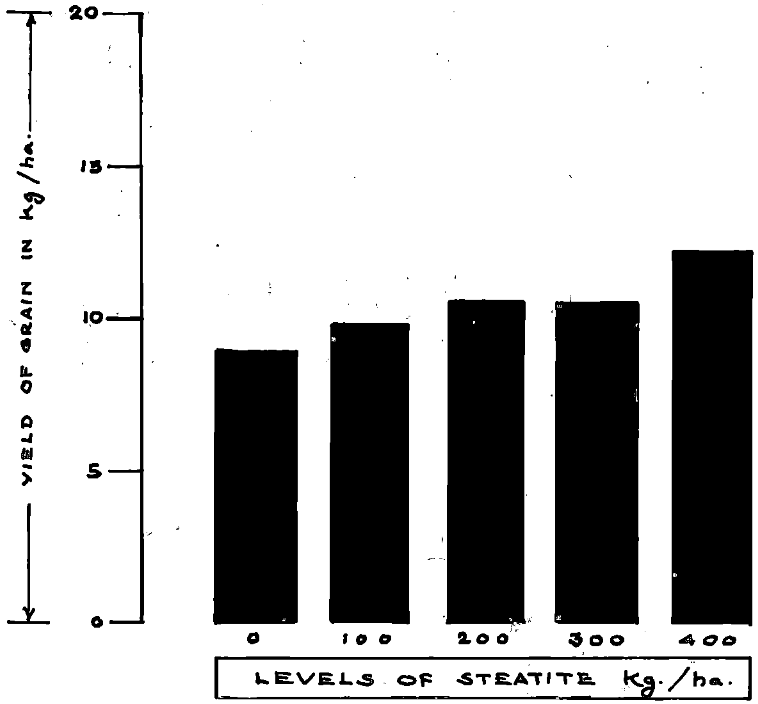


FIG: II. INFLUENCE OF STEATITE ON THE GRAIN YIELD OF RICE VAR: JYOTHI

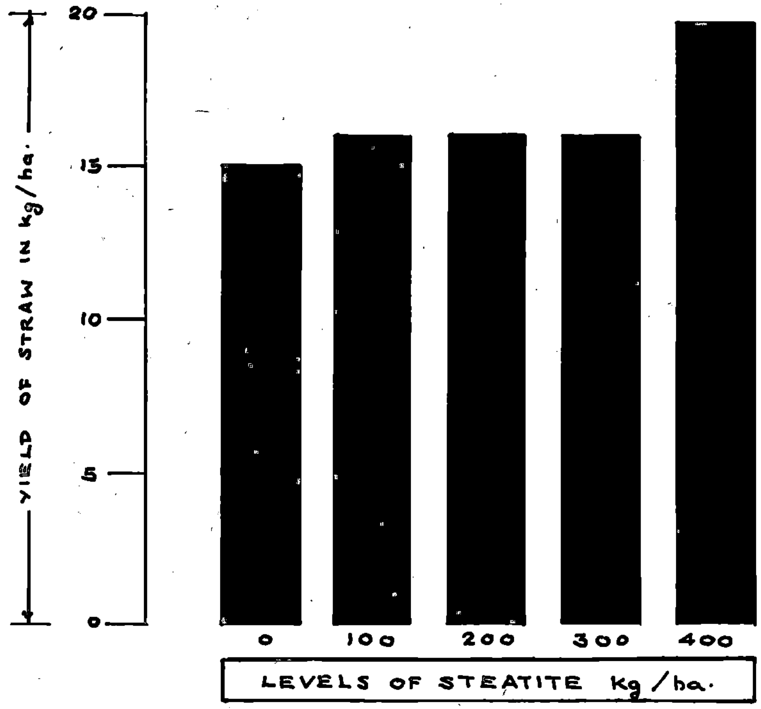


FIG: III. INFLUENCE OF STEATITE ON THE YIELD OF STRAW (RICE VAR: JYHOTHI) silica was beneficial during reproductive stage for increase in grain output.

Okawa and Kinsoku (1936) revealed the influence of silicic acid on increased growth of rice. Money (1964) and Padmaja (1964) also observed similar trend in the increase of grain yield and straw by the application of silicate in Vellayani soil.

5:4. Yield of straw

The yield of straw also showed the same trend as that of grain. All the four levels of silicate treatment recorded an increase in straw yield over control.

Similar observation has been obtained by Padmaja and Varughese (1964). They have stated that all the productive factors such as tillering, height of plants, length of earhead, thousand grain weight and root development increased considerably by the application of magnesium and silica to rice in Vellayani.

5:5. Grain straw ratio

Only slight variation was recorded between the different levels of treatment with respect to the grain straw ratio. The ratio was almost constant, being 2:3 approximately, for all the treatments.

The result is contrary to the findings of Vijayakumar and Koshy (1977) who found that addition of magnesium silicate resulted in lower grain straw ratio in Vellayani kayal soil. This can be explained by the fact that the soil at Vellayani and the conditions existing there are entirely different from those in Kuttanad where the present experiment was conducted.

5:6. Length of panicle

There was no appreciable variation in the length of panicle at different levels of magnesium silicate application.

Vijayakumar and Koshy (1977) also arrived at the same conclusion.

But Padmaja and Varughese (1964) obtained an increase in the length of panicle in rice variety Ptb-10. This may be explained by the fact that vegetative increase in plant parts is a genotypic character of the variety also. Silicate application in the case of Ptb-10, a comparatively low yielder, might have responded to silicate application in increasing panicle length.

5:7. Thousand grain weight

The thousand grain weight recorded a statistically significant increase in all the four levels of treatment over zero level which is in agreement with the result obtained by Padmaja and Varughese (1964) and Vijayakumar and Koshy (1977). The increased photosynthetic activity consequent to the increased uptake of magnesium might have increased the grain weight.

5:8. Incidence of stem borer attack

The incidence of stem borer attack was not seen influenced by any treatment level of magnesium silicate in this experiment.

Lanning (1966) also found that no direct relationship existed between the total silica content and the resistance to Hessianfly or to disease.

But a different result had been reported by Takijima et al. (1970) that the silica slag reduced the susceptibility of the crop to pests and diseases.

It was expected that magnesium silicate would enhance resistance of rice to pests due to the increased uptake of silica.

5:9. <u>Incidence of sheath blight</u>

Incidence of sheath blight disease with varying levels of magnesium silicate application did not show any favourable effect. This is in agreement with the findings of Lanning (1966). Gangopadhyay and Chathopadhyay (1975) found that the incidence of brown spot disease was correlated to the silica content of the leaves.

However the present study did not give any definite result regarding the increased resistance of 'Jyothi' with magnesium silicate application.

5:10. <u>Grain shattering</u>

There was no direct relationship between the different levels of magnesium silicate application and the grain shattering percentage. However, a non-significant decrease in grain shattering was noted in the treatment level of 400 kg/ha. It was expected that the increased uptake of silica by rice plant would result in decreased grain shattering. But the result of the present study does not conclusively prove this.

5:11. Nitrogen content of grain

There was a negative correlation between the levels of treatment and the nitrogen content. The reduction in nitrogen content was statistically significant also in the case of treatment levels of 200 kg, 300 kg and 400 kg per hectare of steatite over control.

Ishaburo (1959) and Vijayakumar (1977) also obtained similar results.

5:12. Phosphorus content of grain

Phosphorus content of grain also showed a negative correlation with varying levels of steatite application. The phosphorus content varied from 0.36 to 0.30 per cent as the level of steatite application increased from zero kg to 400 kg per hectate. All the four levels of treatments recorded a statistically significant decrease in phosphorus content.

This finding is in conformity with the results obtained by Okuda and Takahashi (1961), Vijayakumar and Koshy (1977) who have reported a slight decrease in the phosphorus uptake by rice plants consequent to increased supply of silica.

Brenchly (1927) reported that the effect of silicate application (two to four times the phosphorus application) on the growth of barley was high in phosphorus deficient solution and that the phosphorus content of the plant was decreased by silicate application. He speculated that silicate promoted the efficiency of absorbed phosphorus in barley.

From the results of experiments, it can be concluded that silicon seems to retard the excessive uptake of phosphorus by rice and to promote translocation of phosphorus in rice plant.

5:13. <u>Potash content of grain</u>

Potash content of grain also recorded a statistically significant decrease in all the four treatment levels of steatite over control.

Islam and Saha (1969) obtained similar results. They reported that application of silica decreased the potash content of rice.

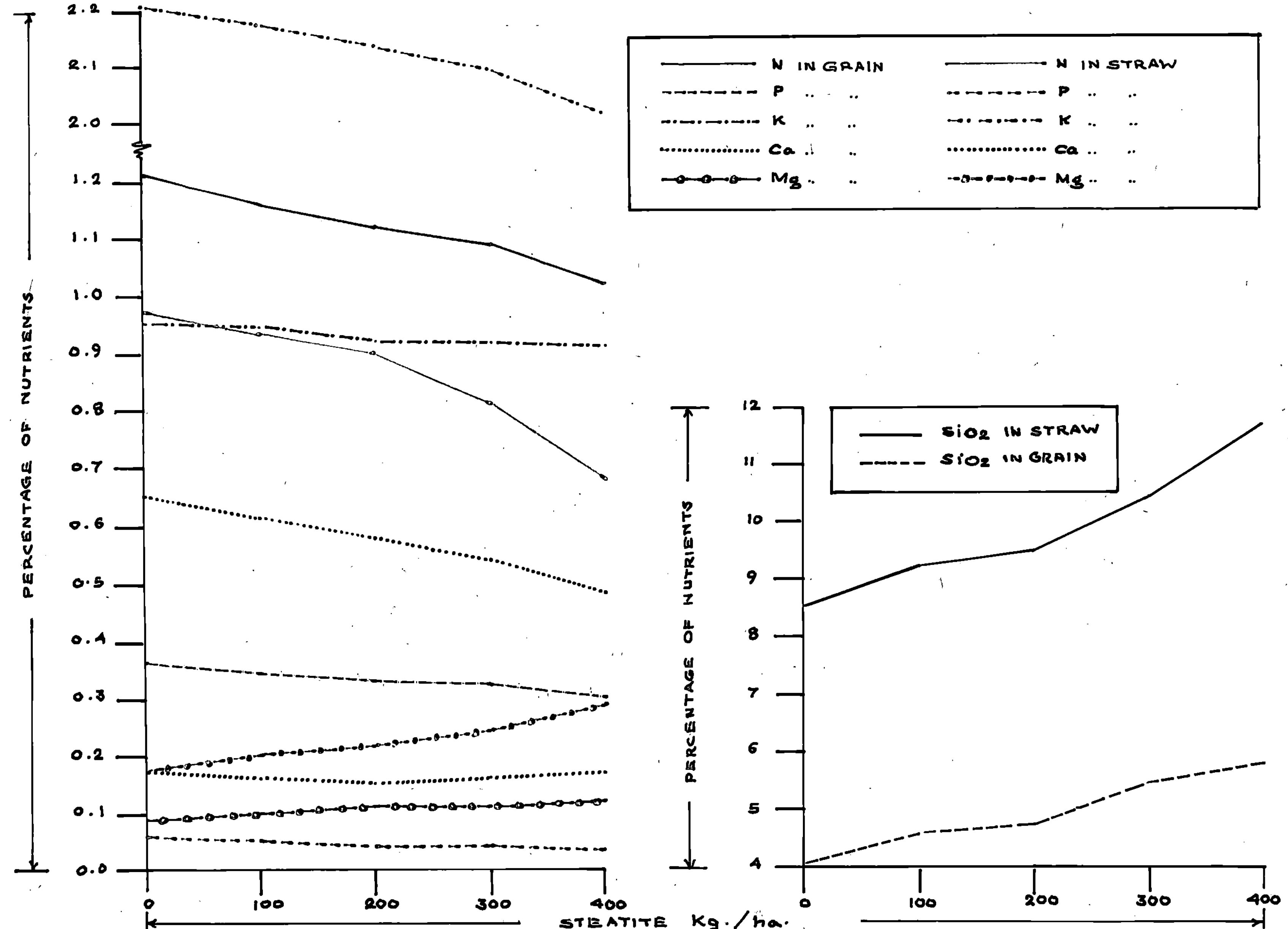
However Vijayakumar and Koshy (1977) found that magnesium silicate application slightly increased the potash content of rice (var. Triveni) under Vellayani field conditions.

5:14. <u>Calcium content of grain</u>

The calcium content of rice grain was also decreased as a result of steatite application. The decrease was statistically significant in all the four levels of treatment over control. The high absorption of magnesium might have reduced the uptake of calcium. Vijayakumar and Koshy (1977) also obtained similar results.

5:15. <u>Magnesium content of grain</u>

Magnesium content of rice grain was increased by the



GRAPH. I. GRAPH SHOWING THE INFLUENCE OF DIFFERENT LEVELS OF STEATITE ON THE NUTRIENT CONTENT OF GRAIN AND STRAW OF RICE VARIETY JYOTHI.

GRAPH. II. SILICA (SiO_2) CONTENT OF GRAIN AND STRAW AT VARYING LEVELS OF STEATITE application of steatite. The increase was statistically significant also in all the four levels over control.

Similar results were obtained by Okawa and Kinsaku (1937), Takijima et al. (1959) and Sadanandan and Varughese (1969).

5:16. Silica content of grain

There was positive correlation between the silica content of rice grain and the levels of magnesium silicate application. All the four treatment levels recorded statistically significant silicate increase.

Okamoto (1957), Islam and Saha (1969), Takijima et al. (1970) and Vijayakumar and Koshy (1977) obtained similar results.

5:17. Nutrient contents of straw

The percentage of nitrogen, phosphorus, potash, calcium, magnesium and silica in straw samples also showed similar variation consequent to the application of magnesium silicate at varying levels. Though the trend in variation of the nutrient contents was similar, there was difference in concentration of nutrients in grain and straw. The average nitrogen content of grain varied between 1.21 per cent to 1.02 per cent; while the corresponding figures for straw were 0.97 per cent and 0.68 per cent. Regarding phosphorus content, the mean of treatments varied from 0.36 per cent to 0.30 per cent in the case of grain while the corresponding figures for straw were 0.06 per cent and 0.03 per cent.

The mean value for the potash content of grain varied from 0.95 to 0.91 per cent. The corresponding variation in the case of straw was from 2.21 to 2.02 per cent.

The variation of calcium content was from 0.17 to 0.15 per cent in the case of grain while that observed in straw was from 0.65 to 0.48 per cent.

The magnesium content of grain was less when compared to that in straw. It varied from 0.09 to 0.12 per cent in the case of grain; and the corresponding variation noted in straw was from 0.17 to 0.28 per cent.

Similar was the case with silica. The percentage of silica varied from 4.10 to 5.76 in grain while the corresponding variation in straw was from 8.5 to 11.67 per cent.

9:18. Protein content of grain

There was negative correlation between the protein content of rice grain and the quantity of magnesium silicate applied. The percentage of protein decreased linearly from 7.56 to 6.38 when the treatment levels of magnesium silicate (steatite) varied from zero kg to 400 kg/ha.

9:19. Mechanical composition of soil

The mechanical composition of the soil was not appreciably influenced by the different treatment levels of magnesium silicate. The slight variations noted did not give any definite relationship with the levels of treatment. Hence it can be concluded that magnesium silicate treatment had no significant influence on the mechanical composition

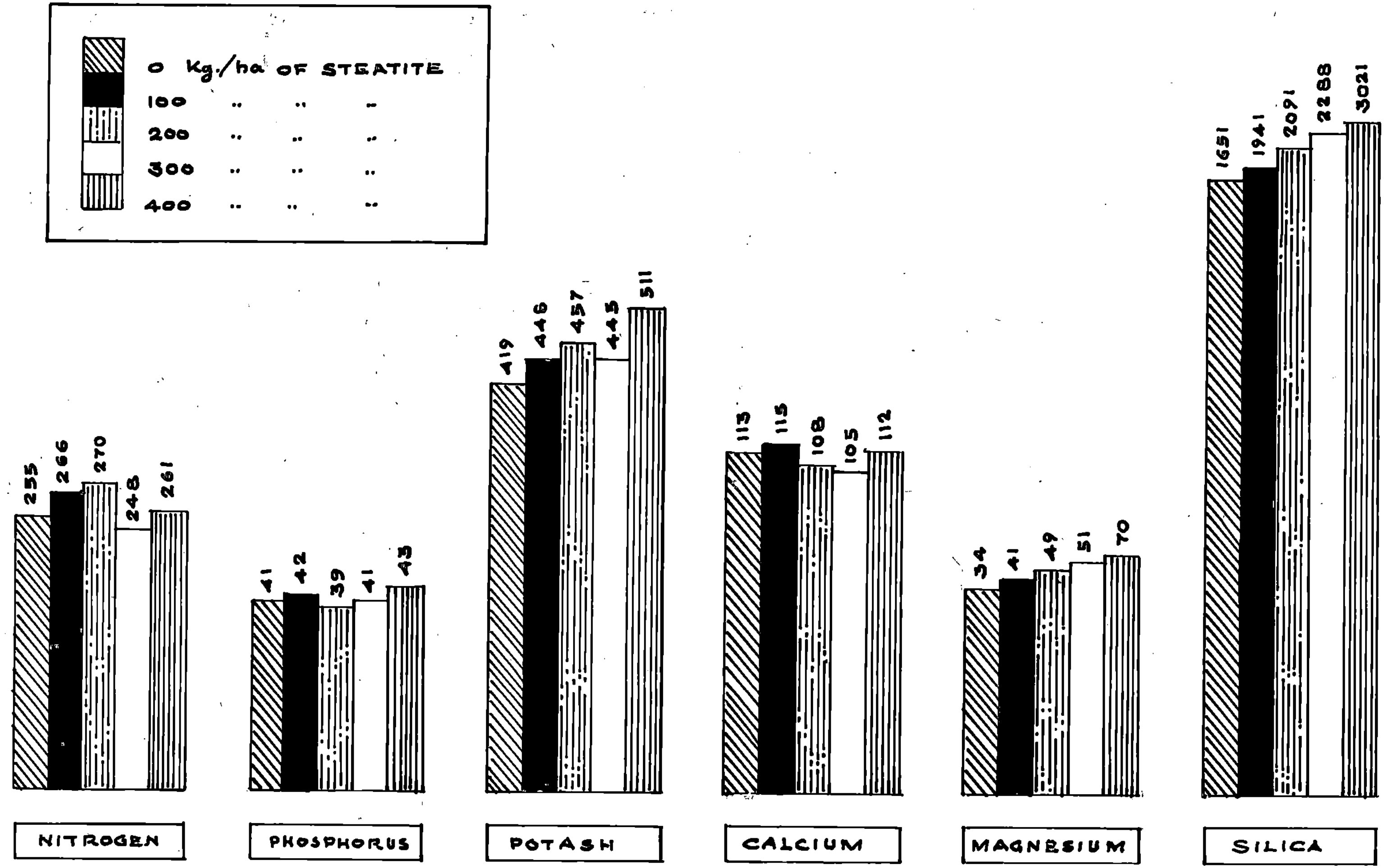


FIG: IV. UPTAKE OF NUTRIENTS AT VARYING LEVELS OF STEATITE IN GRAMS PER PLOT of soil under Kuttanad conditions.

5:20. Physical properties of soil

No change in the physical properties such as apparent specific gravity, absolute specific gravity, water holding capacity, per cent pore space, volume expansion etc. of the soils were obtained in the post-harvest soil samples as a result of magnesium silicate application.

5:21. Uptake of plant nutrients.

The results of the uptake of nitrogen, phosphorus, potash, calcium, magnesium and silica showed that nitrogen, phosphorus, potash and calcium did not show a straight line relationship with the varying levels of magnesium silicate treatment. But the magnesium and silica uptake showed a linear relationship with the varying levels of magnesium silicate treatment. This is indicative of the fact that the influence of magnesium silicate on the uptake of nitrogen, phosphorus, potash and calcium is only partial. The non-linear uptake of these nutrients might have been due to the combined effect of various physico-chemical and microbiological factors existing in Kuttanad soils.

It is notable that magnesium and silica, showed a straightline relationship in the uptake at varying levels of treatment. This may be because of the direct involvement of the treatment material which contain about 29 per cent of MgO and 55 per cent of SiO_2. The addition of steatite (magnesium silicate) might have increased the availability of these nutrients (magnesium and silica) to the crop.

SUMMARY AND CONCLUSIONS

CHAPTER VI

SUMMARY AND CONCLUSIONS

A field experiment was conducted at Kavalikari padom, Changanacherry, Kuttanad tract to investigate the effect of 'Steatite' (Magnesium silicate) on the growth and yield characters of rice in Kuttanad soils. The samples of grain and straw from the experiment were analysed for the contents of N, P, K, Ca, Mg and Si; and the uptake of nutrients per plot computed. The influence of the treatment material on the grain shattering character of Jyothi variety; incidence of pests and diseases etc. were also examined. The results from the study are summarised below:-

Steatite application at 200 kg/ha increased tillering at 30 days after planting, 60 days after planting and at harvest. The increase was statistically significant at five per cent level over control. The other levels of treatments also resulted in increased tillering though not statistically significant.

The percentage of productive tillers also was increased by the application of steatite.

Plant height showed an increasing trend consequent to the application of steatite. At the harvest stage, treatments of 100 kg/ha, 200 kg/ha, and 400 kg/ha levels showed statistically significant increase in plant height.

Length of panicle was not influenced by the treatments at any level. The grain-straw ratio was also not influenced by any level of the treatment.

The yield of grain and straw was increased by the application steatite at all levels over control. The increase recorded for the 400 kg/ha level was statistically significant also. The thousand grain weight ~~was~~ also increased significantly at five per cent level in all the treatments over control and that the maximum weight of 25.21 g was recorded for the highest level of steatite, viz., 400 kg/ha.

As regards the nutrient content of both grain and straw, it was observed that N, P, K and Ca decreased significantly consequent to the application of steatite. But Mg and Si recorded a linear increase with increasing levels of treatment. The increase was statistically significant also at five per cent level.

The protein content of the grain was reduced from 7.56 per cent to 6.38 per cent due to the application of steatite at 0 kg/ha and 400 kg/ha respectively.

The uptake of nitrogen by rice plant was highest (270 g/plot) at 200 kg level of the treatment, and lowest value of 255 g/plot was for the control. The uptake of phosphorus showed a non-linear variation with different levels of treatment, the variation being from 39 g/plot in 200 kg level treatment to 43 g/plot in the 400 kg/ha of steatite treated plots. The uptake of potash was also non-linear with a variation of 419 g/plot and 511 g/plot for the zero kg and

400 kg/ha treatments respectively. The variation of calcium uptake was from 105 g to 115 g/plot in the case of 300 kg/ha and 100 kg/ha levels of steatite thereby presenting a non-linear variation with the different levels of treatment.

But in the case of magnesium uptake there existed a linear relationship with the increased levels of treatment. the range of variation was 34 to 70 kg/plot depending on the level of treatment zero kg and 400 kg/ha respectively. The uptake of silica showed a linear increase from 1651 g/plot in the case of control plot to 3021 g/plot for the 400 kg/ha treatment.

A non-significant decrease in grain shattering was noted in the treatment of 400 kg/ha of steatite. This is an indication of possible reduction in grain shattering in Jyothi by the application of steatite at still higher levels.

No beneficial effects could be obtained by the treatment with regard to the resistance of Jyothi variety of rice to pests and diseases.

Analysis of pre-planting and post-harvest soil samples did not show any marked variation in physical or chemical properties of the soil due to steatite application.

The following conclusions could be arrived at from the present study:-

(1) Application of steatite (100 mesh) increased tillering in Jyothi variety of rice under Kuttanad conditions.

(2) The percentage of productive tillers increased by the treatment.

(3) Increased height of plants was also recorded in the steatite treated plots.

(4) Both grain and straw yields were increased significantly by the application of steatite at 400 kg/ha.

(5) Thousand grain weight increased significantly due to steatite application at all levels.

(6) Application of steatite resulted in decreased percentage of N, P, K and Ca in both grain and straw.

(7) Mg and Si content of plant parts was increased significantly by the application of steatite.

(8) The uptake of N, P, K and Ca was not linear with the varying levels of treatment, but Mg and Si uptake was linear with increase in the levels of treatment.

(9) A non-significant reduction in grain shattering was noted in the 400 kg/ha treatment level of steatite.

(10) No significant effect of steatite application was observed pertaining to the incidence of pests and diseases and also to the change in physical and chemical properties of soil.

APPENDICES

APPENDIX I

Summary of Analysis of varience tables for tillering of rice at 30 days after planting.

Source	df	M.S.	F.ratio
Total	24		
Block	4	4.324	1.63
Treatment	4	5.667	2.13
Error	16	2.659	

APPENDIX II

Summary of Analysis of varience tables for tillering of rice at 60 days after planting.

Source	df	M.S.	F.ratio
Total	24		
Block	4	4.288	1.89
Treatment	4	6.341	2.79
Error	16		

APPENDIX III

Summary of Analysis of variance tables for tillering of rice at the time of harvest

Source	df	M.S.	F.ratio
Total	24		
Block	4	4.219	1.86
Treatment	4	6.224	2.74
Error	16		

APPENDIX IV

Summary of analysis of variance tables for height of rice plants at 30 days after planting

Source	df	M.S.	F.ratio
Total	24		
Block	4	19.525	1.51
Treatment	4	10.675	0.82
Error	16		

APPENDIX V

Summary of analysis of variance tables for height of rice plants at 60 days after planting

Source	df	M.S.	F.ratio
Total	24		
Block	4	11.853	0.74
Treatment	4	81.338	5.12
Error	16		

APPENDIX VI

Summary of analysis of variance tables for height of rice plants at harvest

Source	df	M.S.	F.ratio
Total	24		
Block	4	23035.14	0.97
Treatment	4	22954.14	0.97
Error	16		

APPENDIX VII

Summary of analysis of variance tables for the yield of rice grain

Source	df	M.S.	F.ratio
Total	24		
Block	4	2.615	1.030
Treatment	4	7.597	3.004
Error	16		

APPENDIX VIII

Summary of analysis of variance tables for the yield of rice straw

Source	df	M.S.	F.ratio
Total	24		
Block	4	6.275	0.798
Treatment	4	15.300	1.940
Error	16		

APPENDIX IX

Summary of analysis of variance tables for the thousand grain weight of paddy

Source	df	M.S.	F.ratio
Total	24		
Block	4	0.242	0.657
Treatment	4	1.836	4.973*
Error	16		

*Significant at 0.05 level

APPENDIX X

Summary of analysis of variance tables for the magnesium content of rice grain

Source	df	M.S.	F.ratio
Total	24		
Block	4	0.00031	4.27*
Treatment	4	0.00065	8.96*
Error			

*Significant at 0.05 level

APPENDIX XI

Summary of analysis of variance tables for the silica content of rice grain

Source	df	M.S.	F.ratio
Total	24		
Block	4	0.0094	0.905
Treatment	4	2.1789	208.320**
Error	16		

**Significant at 0.01 level

BIBLIOGRAPHY

BIBLIOGRAPHY

Akhramako, A.J. (1934). Influence of silicic acid upon the utilization of phosphoric acid by the plants from various sources. Bibliography on the literature on minor elements. 1: Educational Bureau Inc. 120, Broadway, New York.

Albrecht, W.A. and Smith, G.E. (1952). Soil acidity as calcium (fertility) deficiency. Indian Sci. Soil Sci. Comm. II and Comm. IV. Trans. 1: 119-135.

Alexander, M.T. and Durairaj. (1968). Influence of soil reaction on certain soil properties and availability of major nutrients in Kerala Soils. Agri. Res. J. Kerala. 6: 15-18.

Anonymous (1963). Annual Report of the International Rice Research Institute, Philippines. pp. 99-100.

Anonymous (1975). Annual Report of the Central Rice Research Station, Pattambi. 14: 14-15.

Azuma, Okuda and Takahashi, E. (1961). Silicon supply period in the growth of a rice plant and its nutrient uptake. Chem. abst. 11913, 58: 1963.

Balakrishna Kurup, T.K. (1967). Fertility investigation on rice soils of Kuttanad. M.Sc. Thesis submitted to the University of Kerala.

Bear, F.E. and Toth, S.J. (1948). Influence of calcium on availability of other cations. Soil Sci. 65: 69-74.

Birch, H.F. (1948). Soil phosphate - A review of literature. The Planters Chronicle XI. 113: 23, 574-78.

Basak, M.N., Chaudhuri, S.B. and Bhattacharya, R. (1961). Effect of fertilizers on the nutritive value of rice grain. Indian J. Agric. Sci. 31(2):

*Bastisse, E.M. (1951). Silica in plants. Bibliography of the literature on the minor elements. Part 3. Educational Bureau Inc. 120. Broadway, New York.

Bastisse, E.M. (1952). Silico phosphate potassium fertilizing. Ann. Agron. 3: 111-123.

Bhat, K.K.S. (1964). The effect of liming on the availability of N and P in some acid soils of South India. Dissertation submitted to the University of Madras for M.Sc.(Ag.)

*Brenchley, W.M., Mankel, E.J. and Warrington, K. (1927). The interaction between silicon and other nutrients in plants. Ann. Appl. Biol. 14: 45-82.

Brown, D.D. (1928). The effect of different proportion of calcium nitrate and potassium dihydrogen phosphate on growth of wheat in sand culture. Soil Sci. 26: 441-446.

Chakraborthy, M., Chakravarthy, B. and Mukherjee, S.K. (1961). Liming in crop production in India. Indian Soc. Soil Sci. Bul.7.

Chandler, M.V. (1941). Phosphorus absorption by five Alabama soils by reaction, base saturation and free sesquioxides. J. Amer. Soc. Agron. 33: 1-2.

Cheng, A., Kuang, Lu; Tonby Kurtzo and Roger, H.Bray (1952). Analytical Chemistry. 20: 1640-41.

Cheong, Y?W.A. (1970). Residual effect of calcium silicate application on sugarcane growth. Annual report. Mauritius sugar industry Res. Inst. 71: 63-68. Abst. in Soils and Fert. 35(6): 1043.

Clarke, F.W. (1924). Data of geochemistry. Bull. U.S. Geol. Surv. No.770-80.

Conner, S.D. (1962). Factors affecting the availability of aluminium in soils. J. Amer. Soc. Agron. 25: 735-38.

Cook, J.H. and Yoshida, S. (1970). Soil Sci. Pl. Nutr. 16(5): 212-214.

Datta, N.P., Shind, J.E., Kamath, N.B. and Datta, S.K. (1962). Effect of sodium silicate on the uptake of soil and fertilizer 'P' by wheat, rice and Berseem. Indian J. Agric. Sci. 32(3): 219-227.

Davis, L.E. (1935). Sorption of phosphates by non-calcareous Hawaiian soils. Soil Sci. 40: 129-150.

Davis, P.L. and Brewer, C.A. (1940). The influence of liming on the absorption of P and N by water legumes. J. Amer. Soc. Agron. 32: 419-435.

*Dolman, J.D. and Boal. (1967). A study of organic soils (Histosols) in the tide water region of North California. Tech. Bull. N.C. agric. Exp. Stn. 181, pp. 52.

Donahue, R.S. (1958). An introduction to soils and plant growth. Prentice Hall Inc. New York.

Donskikh, I.N. (1966). Forms and mobility of nitrogen in the main types of peat soils of north-western RSFSR. Zap. Leninger. Sel-Khoz. Inst. 105(1): 86-92.

Dunn, L.E. (1943). Effect of lime on the availability of nutrients in certain soils of Western Washington. Soil Sci. 56: 297-316.

Duprez, P. (1970). The influence of silica on grain growth. Proc. 44th Congr. S. Afr. Sug. Tech. Ass. pp. 183-188.

Fox, R.L., Silva, J.A., Youngo, O.R., Plucknett, D.L. and Sherman, G.P. (1967). Proc. Soil Sci. Amer. 31: 775.

Fritz Wagna. (1940). The importance of silicic acid in the growth of some cultivated plants, their nutrient relation and their susceptibility to mildew fungus. Chem. Abst. 34: 4114.

Gangopadhyay, S. and Chathopadhyay, S.B. (1975). Total silica and brown spot development of rice under varying levels of N. Curr. Sci. 44: 3792-94.

Gansman, W. (1962). The influence of silicic acid on the uptake of phosphoric acid and other nutrients. Chem. Abst. 50: 5772.

Gile, P.L. and Smith, J.E. (1925). Colloidal silica and efficiency of phosphate. J. Agric. Res. 31: 247-251.

Gomez, K.A. (1972). Techniques for field experiments with rice. International Rice Research Institute, Losbanos, Philippines.

Gopalaswami, V. (1958). Studies on the fertility status of some peaty, marshy and swampy soils. M.Sc. Thesis. Indian Agri. Research Inst.

Gopalaswami, V. (1961). Studies on the soils of Kuttanad. Part III. The nature of clay minerals present. Agri. Res. J. Kerala 1: 65-69.

Goto, S. (1967). Characteristics of swampy paddy fields with special reference to those of Sasayama basin. Mem. Hyago Univ. Agric. No.19. Agron. Ser.7. pp.81.

Gurnel Sing and Mann, M.S. (1962). Effect of sodium silicate, farm yard manure and castor cake on the maize crop. 1. Influence on soil property. Indian J. Agron. VI(4): 289.

Halias, P. and Parish, D.H. (1963). Silica in soils, plants and animals. Advances in Agron. 19: 107-149.

Hashimoto, S. and Kawaguchi, K. (1955). Magnesium in barley plants on magnesium deficient soils. Soil Plant food. 1: 9-10.

Heslop, J.M. (1951). A study of infertility of two acid soils. Soil Sci. 72: ~~69~~ 67-80.

Hiroda, K. and Takata, H. (1957). Efficiency of calcium silicate on the paddy rice field in black soil. Field crop Abst.(2): 167-68.

*Imaizumi, K. and Yoshida, S. (1958). Edaphological studies on the silicon supplying power of paddy soils. Bull. Nat. Inst. Agric. Sci. Ser. Tokyo. 8: 261-304.

*Ishaburo Nagai. (1959). Japonica rice - its breeding and culture. Yokendo Ltd., Tokyo pp.575.

*Ishibashi, H. (1937). Effect of silica on the growth of soils of various depths. J. Sci. Soil Tokyo. 11: 539-49.

*Ishibashi, H. and Hajima. (1937). Effect of Si on the growth of cultivated plants. Chem. Abst. 31: 1845.

*Ishibashi, H. and Kawano, N. (1957). The effect of silica on the growth of rice plants in water culture. Bul. Fac. Agric. Yamaguchi University 8: 689-692.

Islam, A. and Saha, R.C. (1969). Effect of silica on the chemical composition of rice plant. Pl. Soil XXX: 446-58 Abst. in Soils and Fert. 33(1): 684.

*Iyer Narayana, K.A. (1928). Dept. Agr. Travancore Bull. 123, 126, 130.

*Isawa, G. and Kume, I. (1959). Influence of silica on the growth of rice plant in relation to the nitrogen levels. Hyogo. U. Agri. Sci. Rpt. Ser. Agr. Chem. 4: 13-17.

Jackson, M.L. (1967). Soil Chemical analysis. Constable and Co. Ltd., 10, Orange Street, W.C. 2. London pp.148-51.

Joffee, J.S. (1949). Pedology. Pedology Publ., New Burnswick, New Jersey. 459-523.

Jones, L.P.H., Milne, A.A. and Wadham, S.M. (1963). Studies of silica in oat plant II. Distribution of silica in plant. Plant and Soil, 18: 358-371.

Jones, L.P.H. and Handreck, K.A. (1965). Studies of silica in oat plant. Plant and Soil. 23: 79-95.

Kadrekar, S.B. (1973). The study of acid soils of Maharashtra state with special reference to their potash content. Paper presented in the symposium on acid sulphate and other acid soils of India held at Trivandrum. February 1973.

*Kawaguchi, K. and Hattovi, T. (1958). A study of available silica in paddy soils. J. Sci. Soil Tokyo. 30: 371-73.

Keen, A. and Raczkowski. (1921). The relationship between clay content and certain physical properties of soils. J. Agric. Sci. 11: 441-449.

Khanna, S.S. and Mahajan, K.K. (1971). A study of the behaviour of added phosphates in soils of variable physico-chemical properties. Proc. International Symposium on soil fertility evaluation. Indian Soc. Soil Sci. (1971). 725-736.

Kiso, M. (1958). Physiological and ecological studies of rice plant in well drained and ill-drained field. 4. Difference in quality and ripening rice grains as affected by fertilizers. Proc. Crop Sci. Soc. Japan. 26: 1958.

Kipps, E.M. (1947). The calcium magnesium ratio in relation to growth of lucerne. J. Coun. Sci. Indust. Res. (Australia). 20: 176-89.

Kobayashi, H., Kawaguchi, Y. and Ota, M. (1956). The effect of slag on paddy rice. Soil Plant Food. 1: 45-6.

Kumaran Nayar, P. (1966). Status of available silica in the rice soils of Kerala State: Thesis submitted to the University of Kerala for M.Sc.(Ag.) degree.

Kurup, T.K.B. and Iyer, R.S. (1973). Seasonal variations in soil reaction and soluble salt content of Kuttanad rice soils, Kerala State. Kerala Agri. Res. J. 11(1): 57-60.

*Kyogoto (1960). Magnesium and silicate for paddy rice. Agri. Horti. 35: 1933-36.

Lanning, F.C., Ponnaiya, B.W.X. and Crumpton, C.F. (1958). The chemical nature of silica in plant. Plant Physiology. 33: 339-343.

Lanning, F.C. (1963). Silica in rice. J. Agri. Food Chem. 11:5.

Lanning, F.C. (1966). Relation of silica in wheat to disease and pest resistance. J. Agric. Fd. Chem. 14: 350-352.

Lawes, W.P. (1951). Water soluble silicate application to a calcareous soil and its effect on the soil properties and nutrient uptake by plants. Proc. Soil Sci. Soc. Amer. 15: 85-92.

Lemmermann, O. and Wiesmann, H. (1922). The yield increasing action of silicic acid in the presence of insufficient phosphoric acid for plant nutrition. Bibliography of the literature on minor elements. Educational Bureau Inc. 120, Broadway, New York.

Lesztak, V. and Darab, K. (1967). Soils of Hansag region and their physical properties. Agrokem. Talajt. 13: 19-28.

Lian, S. (1963). Silica in soils, plants and animals quoted by Jone, L.P.H. and Handrock, K.A. (1967). Advances in Agronomy 19: 107-149.

Liebig (1840). "Quoted by Pierre and Norman, Soil and Fertilizer phosphorus 1953".

*Manabe, T. and Itose, S. (1966). Relationship between Si uptake by rice plants and mineral composition of paddy fields. Bull. Kagawa Agric. Expt. Station. 17: 17-20.

Mc Keague, J.A. and Cline, M.G. (1963). Silica in soil. Advances in Agronomy. 15: 339-396.

Menon, K.P.R. and Sankaranarayanan, N.P. (1957). General characteristics of Indian black soils. Black soils of tinnis district. Indian J. Agric. Sci. 27: 259-265.

Milton Fireman and Wadbigh, C.H. (1951). A statistical study of relationship between pH and exchangeable sodium percentage of western soils. Soil Sci. 71: 251-260.

*Mitchell, R.L. and Muir, A. (1937). Base exchange capacity and clay content of soils. Nature, London. 139: 552.

Mitsuit, S. and Takahashi, Y. (1963). Nutrition study of the Si in graminaceous crops. J. Sci. Soil Tokyo. 21: 86-117.

*Miyoshi, H. and Ishii, H. (1960a). Effect of silicic acid and silicic slag on paddy rice. III. Effect of silicic acid on the N. metabolism of paddy rice. J. Sci. Soil Tokyo. 31: 111-15.

*Miyoshi, H. and Ishii, H. (1960b). Effect of silicic acid and silicic slag on paddy rice. IV. Effect of silicic acid on P. metabolism of paddy rice. J. Sci. Soil Tokyo. 31: 146-48.

*Miyoshi, H. and Ishii, H. (1960c). Effect of silicic acid and silicic slag on paddy rice VII. Relationship between increase of grain yield by application of silicic slag on the growth form of rice plant. J. Sci. Soil Tokyo. 31: 495-497.

Money, N.S. (1961). Studies on the soils of Kuttanad. Part I. Toxic factors. Agri. Res. J. Kerala. 1: 52-58.

Money, N.S. (1964). Paper read at the conference of State Agricultural Chemists.

Money, N.S. and Sukumaran, K.M. (1973). Chemical, Microbiological and Agronomic aspects of the acid saline waterlogged soils of Kerala. Tech. Bull. 1. Directorate of Extension Education, K.A.U.

Nair, S.P. (1965). Phosphorus uptake by plants and readily extractable phosphorus in some rice soils of Kerala in relation to their important chemical characteristics. Thesis submitted to the University of Kerala for M.Sc.(Ag.) degree.

Narayanan Nambiar, P.S. (1947). Base exchange studies in Travancore rice soils and utilisation of bye-products from salt factories of Travancore. M.Sc. Thesis, University of Travancore.

Nung Nei-Thimy and Ponnamperuma, F.N. (1965). Effect of calcium carbonate, manganese dioxide, ferric hydroxide and prolonged flooding on chemical and electrochemical changes and growth of rice in a flooded acid sulphate soil. Soil Sci. 102: 29-41.

Obata, S. (1959). Quoted by Lian, S. Silica fertilization of rice. The fertility of paddy soils and fertilizer application for rice. Compiled by Food and Technology Centre for the Asian and Pacific region.

*Okamoto, Y. (1957). Effect of silica supplied at various stages of growth. Proc. Crop. Sci. Soc. Japan. 25: 11-16

*Okamoto, Y. (1959). Physiological studies on the effect of Si supplied at the various stages of growth. Proc. Crop. Sci. Soc. Japan. 26: 11-16.

*Okamoto, Y. (1970). Physiological studies on the effect of silicic acid upon rice plants. II. Effect of various amounts of silicic acid supply on the growth and formation of organs and tissues of the plant. Proc. Crop Sci. Soc. Japan. 39: 139-43.

*Okawa and Kinsaku (1936). The physiological action of silicic acid on plants. Bibliography of literature on minor elements. Vol. I. Educational Bureau Inc. 120. Broadway, New York.

*Okawa and Kinsaku (1937). The physiological action of silicic acid on plants. J. Sci. Soil manure Japan. 33: 1123.

*Okuda, A. and Takahashi, E. (1961). Silicon supply period in the growth of rice plant and its nutrient uptake. Chem. Abst. 31: 11913.

Onodera, J. (1927). Chemical studies on rice blast disease. J. Sci. Agri. Sci. 108: 106.

Padmaja, P. (1964). The effect of calcium, magnesium and silicon on productive factors and quality of rice. Thesis submitted to the University of Kerala for M.Sc.(Ag.) degree.

Padmaja, P. and Varughese, E.J. (1966). The effect of Ca, Mg and Si on productive factors and yield of rice. Agri. Res. J. Kerala 4: 31-38.

Park, Y.D. (1976). Effect of wallstonite as a silica fertilizer source in rice plants grown in alkali soils of Korea (Unpublished).

*Pearsall, W.H. (1950). The investigations of wet soil and its agricultural implications. Emp. Journ. Expt. Agri. 18(72): 289-298.

Piper, C.S. (1950). Soil and Plant analysis. Inter Science Publishers, New York.

Piper, C.S. (1966). Soil and Plant analysis. Hans Publishers, Bombay.

Pisciotta, F. (1913). Lime magnesia ratio in the cultivation of grain. Bibliography on the literature on minor elements. Educational Bureau Inc. 120, Broadway, New York.

Raychaudhuri, S.P. and Mukerjee, M.K. (1941). Studies on Indian red soils. II. Fixation of phosphates. Indian J. Agric. Sci. 11: 205-219.

Rodrigo, D.M. (1962). The variation of chemical and physiological characteristics of paddy soils on submergence. Experiment II. Trop. Agricult. 118: 139-218.

Russel, E.W. (1933). "The significance of certain single value constants". J. Agric. Sci. 23: 261-310.

Russel, E.W. (1961). Soil conditions and plant growth, 9th Ed. Longmans, Green and Co., New York.

Sadanandan, A.K. and Varughese, E.J. (1965). Role of silica in the uptake of nutrients by the rice plant in the lateritic soils of Kerala. Thesis submitted to the University of Kerala for M.Sc.(Ag.) Degree.

Sadanandan, A.K. and Varughese, E.J. (1969). Role of Si in the uptake of nutrients by rice plant in the lateritic soils of Kerala. Agri. Res. J. Kerala. 7: 91-96.

Schachfschabel, P. (1971). Causes and nature of soil acidity. Soil and Fert. 35(2): 116.

Schollenberger + Dreibelbis (1922). Silica and silicates in relation to plant growth and composition. Soil Sci. 14: 347.

Shed, O.M. (1922). Effect of certain calcium compounds and other substances on the yield and calcium content of some crops. Soil Sci. 14: 4, 293.

Silva, J.A. (1971). Possible mechanism of crop response to silicate application. Int. Symp. Soil Fert. evaluation Proc. 1: 805-814.

Snedecor, George, W. and Cochran, William, G. (1967). Statistical methods. Oxford and I.B.H. Publishing Co., Calcutta-16, 6th Ed.

Sreedevi Amma, K. and Aiyer, R.S. (1973). Potassium status of some rice soils of Kerala State. Thesis submitted to the University for M.Sc.(Ag.) Degree.

Sreenivasan, A. (1936). Investigations on the role of Si on plant nutrition IV. Effect of silicate fertilization on the growth of rice plant. Proc. Indian Acad. Sci. 3(B): 302-309.

Sternut, D. and Piot, R. (1958). Magnesium an essential element in plant nutrition. Field crop abst. 597. 897-920. 1959.

Stephenson, R.C. (1921). The effect of OM in soil reaction II. Soil Sci. 12: 145-162.

Stephenson, R.E. (1926). "Replaceable bases in orgon soils". Soil Sci. 24: 57. 1927.

Subbiah, B.V. and Asija, G.L. (1956). A rapid procedure for estimation of available nitrogen in soils. Current Science. 29: 259-260.

Subramony (1960). Sulphur bacterial cycle-probable mechanism of toxicity in acid soils of Kerala. Sci. and Cult. 2: 637-638.

Takahashi, R. (1961). Study on silicon as a promoter of rice crop. J. Sci. Soil. Tokyo. 22: 31-34.

*Takijima, Y., Shiojima, M. and Konno, K. (1959). Studies on the soils of peaty paddy fields. XI. Effect of 'Si' in the growth of rice plant and its nutrient absorption. J. Sci. Soil Tokyo. 30: 181-84.

Takijima, Y., Wijayaratna, H.M.S. and Seneviratne, C.J. (1970). Nutrient deficiency and physiological disease of low land rice in Ceylon. 3. Effect of silicate fertilization and dolomite for increasing rice yields. Soil Sci. Pl. Nutr. 16: 11-16.

*Tanaka, A. and Park, Y.D. (1966). Significance in the absorption and distribution of Si in the growth of rice plants. Soil Sci. Plant Nutr. 12(5): 23-28.

Ueda, K. and Kimura, S. (1959). Studies on old paddy soils. II. Effect of weathered serpentine and log iron on rice yields. J. Sci. Soil Tokyo. 30: 154-56.

*Ueda, K. and Yamaoka, M. (1959). Studies on old paddy soils. VII. Examination of a method for determining available silicate in soil. J. Sci. Soil Tokyo. 30: 393-96.

*Utagawa, I. and Kiyoto, K. (1963). The physiological function of silicic acid applied to rice and wheat. Bull. Fac. Agric. Kagoshima Univ. 13: 116-165.

Valmis, J. and Williams, D.E. (1967). Pl. Soil. Quoted by Jones, L.P.H. and Hendricks, K.A. Advances in Agronomy. 19: 107-148.

Varghese, M.P. (1972). Studies on the lime potential and aluminium hydroxide potential of acid soils of Kerala State. M.Sc.(Ag.) Thesis submitted to the University of Kerala.

Varghese, M.P. and Aiyer, R.S. (1973). Studies on lime potential and aluminium hydroxide potential of the acid soils of Kerala State. Paper presented in the Symp. on acid sulphate and other acid soils of India held at Trivandrum in Feb. 1973.

Varghese Thomas. (1963). The influence of Ca and Mg in increasing the efficiency of fertilizers for rice and Ca, Mg status of some typical rice soils. Thesis submitted to the University of Kerala for M.Sc.(Ag.) Degree.

Venugopal, V.K. (1969). Cation exchange studies in Kerala soils. Thesis submitted to the University of Kerala for M.Sc.(Ag.) Degree.

Vijayakumar, K. Kosly (1977). Use of indigenous source of magnesium silicate as a soil amendment. Thesis submitted to the Kerala Agricultural University, for M.Sc.(Ag.) Degree.

Volk, R., Khan, R.P. and Weintraub, R.L. (1957). Silicon content of rice plant as a factor influencing its resistance to infection by Pyricularia oryzae. Phytopathology. 47: 35.

Votkevich, S.V. (1936). The effect of silicic acid on plant development. Bibliography of literature on minor elements. Educational Bureau Inc. 120, Broadway, New York.

*Wagawa and Ken-Ichi-Kashima. (1963). Studies on the physiological factors of silicic acid applied to rice and wheat. Bul. Fac. Agric. Kagoshima University. 13.

Walkley, A. and Black, I.A. (1934). Soil Sci. 37: 29-38. Quoted by Piper (1950).

Winifred, S., Brenchly, C.S. and Marshal, E.J. (1927). The interrelationship between silicon and other elements in plant nutrition. Annals of applied Biology. 14.

*Wolff, E. and Kreuzhage, C. (1884). Land Versuchsslationnen. 30: 161. as quoted by Hall and Morrison. 1906.

*Wu, C.T. and Lian, S. (1965). Quoted by Lian, S. Silica fertilization of rice. The fertility of paddy soils and fertilizer application for rice. Compiled by Food and Technology Centre for the Asian and Pacific region.

Yoshida, S. (1959). Role of silicon in rice nutrition. Soil Pl. Fd. 5: No.3.

Yoshida, O., Onishi, K. and Kitagishi, L. (1962). Chemical forms, mobility and deposition of silica in rice plant. Soil Sci. Pl. Nutri. 8(3): 15-21.

*Yoshida, S. (1975). The physiology of silica in rice. Tech. Bul. 25: 27. ASPAC Food and Fertilizer Technology Centre.

Zeid, F.A. and Kuhn, H. (1971). Effect of silicic acid on the straw strength of cereals. Sudorwft Land Wirtschaftchiche forschung. 26(1): 105-112. Abst. in Soils and Fert. 35(2): 1987.

*Originals not seen

ABSTRACT

Utility of an indigenous source of magnesium silicate for rice in Kuttanad soils

A field experiment was conducted at Kavalikari padom, Changanacherry, Kuttanad tract, to investigate the effect of 'Steatite' (Magnesium silicate) on the growth and yield characters of rice in Kuttanad soils. The samples of grain and straw from the experiment were analysed for the contents of N, P, K, Ca, Mg and Si; and the uptake of nutrients per plot computed. The influence of the treatments on the grain shattering character of Jyothi variety; incidence of pests and diseases etc., were also studied. The following results were obtained.

Steatite application increased tillering and plant height.

The yield of grain and straw showed increase. The increase was statistically significant at five per cent level in the case of 400 kg/ha treatment. The thousand grain weight increased significantly in all the four levels of treatments over control.

The treatments resulted in decreasing the N, P, K and Ca content of grain and straw, while Mg and Si content increased with increasing levels of the treatment.

The protein content of grain did not show any increase by steatite application.

The uptake of N, P, K and Ca was not linear with the varying levels of treatment, but Mg and Si uptake was linear with increase in the levels of treatment.

No significant effect of steatite application has been observed pertaining to the incidence of pests and diseases and also to the change in physical and chemical properties of soil.