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# INFLUENCE OF THE FORMS AND DOSES OF MAGNESIUM ON THE UPTAKE OF NUTRIENTS BY RICE*

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Magnesium plays a vital role in the growth and development of plants. Being the only mineral constituent of the chlorophyll molecule, it is directly involved in the carbohydrate metabolism and the formation of seeds. ft is also known to have a specific role in the activation of a number of plant enzymes. Above all it is credited with the function of increasing the resistance of plants to diseases.

Loew (1903) found that magnesium enhanced the formation of proteins in plants. Blair *et al* (1939) reported that the addition of magnesium compunds resulted in a decrease in calcium content. Truog (1947,> and his associates obtained an increase in phosphorus content of plants, especially of seeds by magnesium application. A positive correlation between the absorption of magnesium and phosphorus in plants was also observed by Seo and Ichikawa (1958). The results of the experiments conducted by Varghese and Money (1965) also supported this observation. The increase in the magnesium content of plants by the application of magnesium was reported by Dewan and Hunter (1949) and Schachtschabel and Hoffman (1958). Komai and Noda (1957) found that in barley plants the interaction between magnesium and potassium was more marked than that between magnesium and calcium. The antagonistic effect between K and Mg was also reported by Scharrer and Mengal (1958), Calmes (1959) and Griffith (1959). Utagawa and Kashima (1961) found that in rice the nitrogen uptake was suppressed and grain yield reduced by applying MgO alone. When calcium absorption was high, magnesium absorption was found to be low. In the light of the above results it was felt desirable to study the effect of magnesium on the absorption of nutrients by rice under Kerala conditions and hence the present study.

## Material and Methods

The influence of the different forms and doses of magnesium on the nutrient uptake by rice was studied in a field experiment of a 9 x 4 randomised block design at the agricultural College, Vellayani. The details of the different forms and doses of magnesium were as shown in the tables of results.

The soil of the experimental plot was clay loam and acidic in reaction (pH 5.4). A basal application of N, $P_2O_5$ and $K_2O$ at the rate of 40 kg/ha in the form of urea (45% N) superphosphate (18% $P_2O_5$) and muriate of potash (50% $K_2O$) was given. A second dose of N at the rate of 10 kg/ha was applied at the time of flowering. Results were assesed by estimating nitrogen, phosphorus, potassium, calcium, magnesium and

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silicon in the plant materials collected at tillering, flowering and harvesting and in the grains.

Nitrogen was determined by the Kjeldahl method. Phosphorus, potassium calcium and magnesium were determined after wet digestion of the plant material with triple acid mixture. The fraction insoluble in this reagent was estimated as silica. In the extract phosphorus was determined volumetrically after precipitation with ammonium molybdate. Potassium was estimated volumetrically after precipitation with sodium cobaltinitrate. Calcium and magnesium were determined by the volumetric versenate method.

## Results

Results are presented in Tables 1 to 4. Application of higher levels of magnesium resulted in a decreased absorption of nitrogen and an increased uptake of magnesium at the tillering stage. The plants treated with magnesium oxide assimilated potassium to a higher level, while those supplied with magnesium silicate showed an increased absorption of silicon (Table 1). At the flowering stage (Table 2) higher levels of magnesium tended to suppress the absorption of nitrogen and calcium and promote the uptake of phosphorus and magnesium; it is also seen that the form of magnesium had no significant effect on the absorption of any of the nutrients. Results given in Table 3 indicate that at the harvesting stage the highest percentages of nitrogen and potassium were obtained in plants that received no magnesium. Further, the highest absorption of nitrogen was noted in the case of plants treated with magnesium carbonate.

The data on the composition of the grain presented in Table 4 indicate that the phosphorus content of grain under the magnesium sulphate treatment was the highest and that under the magnesium carbonate treatment was the lowest, the effect of other compounds being intermediate. Magnesium oxide appeared to induce a high accumulation of silicon in the grain. It was also seen that increasing rates of magnesium resulted in increased absorption of phosphorus and magnesium and decreased uptake of calcium and potassium.

## Discussion

It was observed that magnesium generally tended to decrease the percentage of nitrogen in the vegetative parts of the plants which is in agreement with the findings of Utagawa and Kashima (1961). However, the level of nitrogen in the grain was found to be more in the case of magnesium treated plants than in untreated plants. Among the different forms of magnesium tried, magnesium oxide was found to be the most effective in depressing the level of nitrogen in the plants and increasing its level in the grain which may be attributed to the greater solubility and quick acting nature of magnesium oxide.

One noteworthy finding with regard to the absorption of phosphorus is the rapid decrease in the percentage of phosphorus in the plants after flowering which may probably be due to the translocation of this element to the grain during its formation. It is seen that the application of magnesium enhanced the uptake of phosphorus by plants which is in agreement with the findings of Dewan and Hunter (1949),

**Summary**

A field experiment was carried out at Vellayani, Kerala, to study the effect of different forms and levels of magnesium on the composition of rice.

Magnesium application increased the percentage of nitrogen in the grain.

The phosphorus content of the plant was increased with increase in the rate of magnesium application.

Magnesium depressed the absorption of potassium by the rice plant indicating a K/Mg antagonism.

An increase in the absorption of magnesium was generally accompanied by a decrease in the uptake of calcium.

When differeat forms of magnesium were applied the magnesium oxide treated plants removed the largest amounts of nitrogen, phosphorus, potassium and silicon. Treatments with magnesium sulphate resulted in the removal of relatively high quantities of phosphorus, potassium and magnesium.

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Enzmann (1956), Sadapal and Das (1961), Truog *et al* (1947) and Varghese and Money (1965). It is possible that magnesium acts as a carrier for phosphorus in plants as suggested by Loew (1903).

At the time of harvest the level of potassium in plants receiving magnesium was significantly lower than in those receiv ing no magnesium. This might be due to the antagonistic effect of magnesium on the absorption of potassium as reported by Scbachtschabel and Hoffmann (1958), Griffith (1959) and several other works. The depressing effect of magnesium on the absorption of potassium increased with increases in the level of magnesium application especially at the harvesting stage.

The plants treated with magnesium showed a decrease in the percentage of calcium in the grain which is in conformity with the findings of Blair *et al* (1939), Schachatschabel and Hoffmann (1958). However the form of magnesium used did not appear to have any significant influence on the absorption of this element.

It is only to be expected that magnesium treated plants contain a higher percentage of this element. At higher levels of magnesium application the percentage of MgO in the plants was correspondingly higher at all the three stages of observation. These findings agree with the results obtained by Schachtschabel and Hoffmann (1958), and Schnoor (1963). Though magnesium silicate induced a relatively high level of magnesium in the plant material at the tillering and flowering stages the level of magnesium in the grain for this treatment tended to be low as compared to the treatments with the other forms of magnesium.

The application of magnesium had no consistant effect on the uptake of silicon. As might be expected the level of this element was considerably higher in plants treated with magnesium silicate.

It is important to note that a higher level of magnesium in the grain was co-existent with a corresponding increase in the percentage of nitrogen. The high contents of magnesium and nitrogen in the seed showed that magnesium enhanced the protein content of seeds. This is in agreement with the results of the pot experiments conducted by Padmaja and Varghese (1966) who found that the application of calcium oxide and/or magnesium carbonate increased the protein content of the rice grain.

The increase in the percentage of phosphorus with a more or less proportionate increase in MgO content of the plant material supports the view of Loew (1903) who stated that magnesium acts as a carrier of phosphorus and is closely related to phospho-lipid formation and to the synthesis of nucleoproteins.

The high absorption of magnesium and the consequent lowering in the uptake of potassium is indicative of a true physiological K/Mg antagonism which is in conformity with the findings of Scharrer and Mengel (1958) and Calmes (1959). A similar antagonism was also observed in the present study between calcium and magnesium though it was not so prominent. In view of its beneficial effect on the quality of the grain and straw and its influence on the absorption of nitrogen and phosphorus application of magnesium appears to be a desirable practice in the management of rice soils.

**Table 3**

Percent chemical composition of rice straw under different magnesium treatments

| Forms of magnesium | Doses of magnesium (Kg MgO/ha) | Yield of straw Kg/ha | N | $P_2O_5$ | $K_2O$ | CaO | MgO | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|
| Control | 0 | 3977 | 0.68 | 0.22 | 1.82 | 0.96 | 0.18 | 7.59 |
| Magnesium | 25 | 4398 | 0.51 | 0.26 | 1.54 | 1.04 | 0.13 | 7.75 |
| Oxide | 50 | 4530 | 0,61 | 0.31 | 1.03 | 0.93 | 0.25 | 8.94 |
| | Mean | 4464 | 0.56 | 0.29 | 1.29 | 0.98 | 0.19 | 8.34 |
| Magnesium | 25 | 4089 | 0.68 | 0.24 | 1.08 | 1.05 | 0.22 | 7.90 |
| carbonate | 50 | 4033 | 0.62 | 0.29 | 1.10 | 0.94 | 0.20 | 7.77 |
| | Mean | 4061 | 0.65 | 0.27 | 1,09 | 1.01 | 0.21 | 7.83 |
| Magnesium | 25 | 4579 | 0.59 | 0.27 | 1.33 | 1.11 | 0.16 | 8.29 |
| silicate | 50 | 3908 | 0.53 | 0.27 | 1.26 | 1.06 | 0.23 | 9.03 |
| | Mean | 4244 | 0.56 | 0.27 | 1.20 | 1.09 | 0.19 | 8.66 |
| Magnesium | 25 | 4053 | 0.58 | 0,25 | 1.31 | 0.99 | 0.24 | 8.15 |
| sulphate | 50 | 4602 | 0.57 | 0.28 | 1.37 | 0.99 | 0.27 | 7.96 |
| | Mean | 4328 | 0.57 | 0.27 | 1.34 | 0.99 | 0.26 | 8.05 |
| All forms | 25 | 4280 | 0.59 | 0.25 | 1.31 | 1.05 | 0.19 | 8.02 |
| | 50 | 4268 | 0.58 | 0.29 | 1.19 | 0.98 | 0.24 | 8.41 |
| Critical difference at 5% level | | | | | | | | |
| Between | (1) Treatments | | 0.095 | ... | 0.293 | ... | ... | ... |
| | (2) Forms | | 0.067 | ... | ... | ... | ... | ... |
| | (3) Levels | | 0.048 | ... | 0,147 | ... | ... | ... |

**Table 4**

Percent chemical composition of rice grain under different magnesium treatments

| Forms of magnesium | Doses of magnesium (Kg MgO/ha) | Yield of straw Kg/ha | N | $P_2O_5$ | $K_2O$ | CaO | MgO | $SiO_2$ |
|---|---|---|---|---|---|---|---|---|
| Control | 0 | 1737 | 1.33 | 0.77 | 0.88 | 0,16 | 0.08 | 3.85 |
| Magnesium | 25 | 1961 | 1.37 | 0.82 | 0.67 | 0.13 | 0.08 | 4.08 |
| oxide | 50 | 2013 | 1.35 | 0.79 | 0.59 | 0.12 | 0.09 | 3.99 |
| | Mean | 1987 | 1.30 | 0.80 | 0.63 | 0.12 | 0.09 | 4.04 |
| Magnesium | 25 | 1921 | 1.39 | 0.77 | 0.74 | 0.17 | 0.09 | 3.40 |
| carbonate | 50 | 1717 | 1.36 | 0.78 | 0.52 | 0 12 | 0.09 | 3.38 |
| | Mean | 1819 | 1.37 | 0.77 | 0.63 | 0.14 | 0.09 | 3.39 |
| Magnesium | 25 | 1563 | 1.29 | 0.79 | 0.70 | 0.12 | 0.07 | 2.80 |
| silicate | 50 | 1796 | 1.38 | 0.79 | 0.46 | 0.12 | 0.08 | 3.36 |
| | Mean | 1680 | 1.34 | 0.79 | 0.58 | 0.12 | 0.08 | 3.08 |
| Magnesium | 25 | 1944 | 1.34 | 0,84 | 0.52 | 0.14 | 0.08 | 3.23 |
| sulphate | 50 | 1941 | 1.34 | 0.80 | 0.66 | 0.13 | 0.10 | 3.40 |
| | Mean | 1943 | 1.34 | 0.82 | 0.59 | 0.14 | 0.09 | 3.26 |
| All forms | 25 | 1847 | 1,35 | 0.80 | 0.66 | 0.14 | 0.08 | 3.38 |
| | 50 | 1867 | 1,36 | 0.79 | 0.56 | 0.12 | 0.09 | 3.51 |
| Critical difference at 5% level | | | | | | | | |
| Between | (1) Treatments | ... | ... | 0.032 | 0.217 | 0.021 | 0.012 | 0.474 |
| | (2) Forms | ... | ... | 0.022 | ... | ... | 0.008 | 0.336 |
| | (3) Levels | ... | ... | 0.016 | 0.108 | 0.010 | 0.006 | ... |

**Table 1**

Percent chemical composition of rice plants at tillering under different magnesium treatments

| Forms of magnesium | Dose of magnesium (Kg MgO/ha) | N | $P_2O_5$ | $K_2O$ | CaO | MgO | $SiO_2$ |
|---|---|---|---|---|---|---|---|
| Control | 0 | 1.31 | 0.54 | 1.94 | 0.44 | 0,45 | 6.95 |
| Magnesium | 25 | 1.09 | 0.48 | 2.32 | 0.46 | 0.52 | 6.83 |
| oxide | 50 | 1.06 | 0.60 | 2.28 | 0.43 | 0.54 | 7.10 |
| | Mean | 1.08 | 0.54 | 2.30 | 0.44 | 0.53 | 6.96 |
| Magnesium | 25 | 1.15 | 0.61 | 1.86 | 0.45 | 0.54 | 7.66 |
| carbonate | 50 | 1.06 | 0.63 | 1.85 | 0.45 | 0.55 | 7.35 |
| | Mean | 1.10 | 0.62 | 1.85 | 0.45 | 0.55 | 7.51 |
| Magnesium | 25 | 1.19 | 0.54 | 2.06 | 0.45 | 0.58 | 8.96 |
| silicate | 50 | 1.08 | 0.60 | 2.12 | 0.45 | 0.73 | 9.94 |
| | Mean | 1.14 | 0.57 | 2.09 | 0.45 | 0.65 | 9.45 |
| Magnesium | 25 | 1.19 | 0.58 | 2.06 | 0.46 | 0.50 | 6.89 |
| sulphate | 50 | 1.19 | 0.52 | 1.89 | 0.55 | 0.65 | 6.85 |
| | Mean | 1.19 | 0.55 | 1.98 | 0.51 | 0.58 | 6.87 |
| All forms | 25 | 1.16 | 0.55 | 2.08 | 0.45 | 0.54 | 7.58 |
| | 50 | 1.10 | 0.59 | 2.03 | 0.47 | 0.62 | 7.81 |
| Critical difference at 5% level | | | | | | | |
| Between | (1) Treatments | 0.139 | ... | ... | ... | ... | 1.077 |
| | (2) Forms | ... | ... | 0.277 | ... | ... | 0.765 |
| | (3) Levels | 0.070 | ... | ... | ... | 0.079 | ... |

**Table 2**

Percent chemical composition of rice plants at flowering under different magnesium treatments

| Forms of magnesium | Doses of magnesium (Kg MgO/ha) | N | $P_2O_5$ | $K_2O$ | CaO | MgO | $SiO_2$ |
|---|---|---|---|---|---|---|---|
| Control | 0 | 1.01 | 0.46 | 1.89 | 0.47 | 0.35 | 7.10 |
| Magnesium | 25 | 0.76 | 0.49 | 1.87 | 0.45 | 0.42 | 6.94 |
| oxide | 50 | 0.81 | 0.57 | 1.63 | 0.39 | 0.49 | 6.81 |
| | Mean | 0.79 | 0.53 | 1.75 | 0.42 | 6.46 | 6.88 |
| Magnesium | 25 | 0.91 | 0.51 | 1.77 | 0.42 | 0.42 | 6.90 |
| carbonate | 50 | 0.81 | 0.54 | 1.56 | 0.38 | 0.55 | 7.67 |
| | Mean | 0.86 | 0:53 | 1.66 | 0.40 | 0.48 | 7.28 |
| Magnesium | 25 | 0.88 | 0.51 | 1.77 | 0.42 | 0.46 | 7.15 |
| silicate | 50 | 0.77 | 0.54 | 1.61 | 0.39 | 0.53 | 7.46 |
| | Mean | 0.83 | 0.52 | 1.69 | 0.40 | 0.49 | 7.30 |
| Magnesium | 25 | 0.87 | 0.53 | 1.84 | 0.41 | 0.40 | 6.69 |
| sulphate | 50 | 0.87 | 0.53 | 1.62 | 0.39 | 0.53 | 6.74 |
| | Mean | 0.87 | 0.53 | 1.73 | 0.40 | 0.47 | 6.71 |
| All forms | 25 | 0.86 | 0.51 | 1.81 | 0.43 | 0.43 | 6.92 |
| | 50 | 0.82 | 0.54 | 1.60 | 0.39 | 0.53 | 7.17 |
| Critical difference at 5% level | | | | | | | |
| Between | (1) Treatments | 0.113 | 0.053 | ... | ... | 0.074 | ... |
| | (2) Forms | ... | ... | ... | ... | ... | ... |
| | (3) Levels | 0.056 | 0.027 | ... | 0.034 | 0.037 | ... |

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