SUMMARY AND CONCLUSION

The present investigation "Studies on mineral nutrition and variability in quality characteristics of rice" embraced mainly three aspects, viz. (i) uptake of nutrients under varied levels of fertilizers and its effect on dry matter and grain yield; (ii) effect of fertilizers on the quality characteristics of rice and (iii) effect of variety and location on the quality characters of rice. The field experiment, in two consecutive kharif seasons of 1972-73 and 1973-74, was carried out at Fertilizer Research Farm, Pura, Kanpur on upland sandy loam soils to study the first two aspects. For investigation on the third aspect, grain samples of forty promising varieties of rice grown in the experiments during kharif 1972-73 at Regional Agricultural Research Stations of the province were collected. The results of the project are summarized below:

NUTRIENT UPTAKE

Percentage concentration of all the nutrients under study (i.e. N, P, K, Ca, Mg & Mn) was high at tillering stage which decreased at panicle emergence the rate of decrease of N, K, Ca and Mg being faster than that of P & Mn. While percentage of N, P and K further decreased that of Ca increased at the harvest stage. Mg also showed a gradual fall. Concentration of Mn remained almost constant throughout.
Percentage contents of N & P were higher in grains than that in straw. The reverse was true in case of other nutrients. It indicated that much of N & P was translocated to the grains from other organs of the plant during ripening period. Translocation of other nutrients was rather very limited.

Rate of increase in dry-matter being faster than that of fall in the concentration of the nutrients the total uptake of the same increased with the crop growth.

In general, total uptake of nutrients increased with each increasing level of N at all the three growth stages. In few cases, although the uptake of K was also increased with increasing levels of N but regular increase could not be recorded beyond 120 kg of N/ha during later stages. In one year, during the harvest stage, Mn also showed similar trend.

While percentage concentration of K, Mg and Mn decreased with increasing levels of N that of N and Ca showed increasing trend. The percentage of P was the highest in absence of N and the lowest at 60 kg of N/ha. It increased with increasing levels of N and reached almost the same percentage as that observed when nitrogen was not applied.

Phosphorus application increased the total uptake and percentage concentration of all the six nutrients at all the three growth stages during both the years of experimentation.
In most of the cases, a dose of 20 kg of MnSO₄/ha either increased the uptake or showed no significant effect. A dose of 40 kg MnSO₄/ha tended to show deleterious effect on the absorption of nutrients.

The percentage concentration of all the nutrients except Mn, in general, decreased with increasing levels of Mn though the effect of its first dose (20 kg MnSO₄/ha) was not very much marked. Percentage concentration of Mn, on the other hand, was increased due to its application at all the stages.

It was inferred, therefore, that higher levels of N increased the accumulation of (percentage concentration) N & Ca and application of phosphorus increased the accumulation of N, P, K, Ca, Mg & Mn.

**DRIY-MATTER AND GRAIN YIELD**

Total dry matter at all the growth stages and grain yield increased with increasing levels of N. Percentage dry-matter, on the other hand, showed decreasing trend with increasing levels of N. Dry-matter was positively correlated with the grain yield. Moreover, percentage of nitrogen in the plant at all the three stages was also positively correlated with the grain yield during both the years.

Phosphorus application increased the percentage and total dry matter at all the stages. Grain yield was also increased due to P. There has been very strong correlation between percentage of phosphorus and that of dry-
matter in the straw.

By and large, the yield of dry-matter although increased at the first dose of Mn, but it decreased when the manganese was applied at the rate of 40 kg of MnSO₄/ha. It could not affect the grain yield in the years either. Inference was, therefore, drawn that Mn was not a limiting factor for good yields.

**Harvest of Economic Products**

Nitrogen while increased the yield of protein with its each increasing level this regular increase was observed upto 120 kg of N/ha only in case of starch. At a nitrogen level of 180 kg /ha the yield of starch decreased significantly. When nitrogen was applied together with P this regular increase in starch was continued even upto the highest level of N. While the mineral matter in the straw increased with each increasing level of N it could not do so beyond 120 kg N/ha in case of grain.

Phosphorus application increased the yield of protein, starch and mineral matter in all the cases. Manganese could not affect the yield of protein. The effect of Mn on the yield of starch and mineral matter from the grains was also not significant. While no marked effect of Mn at its first dose was observed on the yield of starch and mineral matter in the straw these were adversely affected when Mn was applied @ 40 kg of MnSO₄/ha.
NUTRITIONAL REQUIREMENT OF RATNA RICE

Keeping in view the cost of fertilizer, that of additional grain yield obtained due to additional dose of fertilizer, and the present fertilizer crisis etc. the dose of 120 kg of N/ha could be safely considered as the optimum one for rice crop like 'Ratna' - under upland conditions. This dose of N was also suitable to bring the desirable qualities in rice grains. To enhance the absorption of nutrients responsible for good yields and to maintain proper balance among the quality characters a dose of almost 60 kg of P₂O₅/ha, together with 120 kg of N could also be taken as an appropriate one under the same conditions. Since Mn application could not show any beneficial effect it could not be recommended at this stage even under upland conditions. In absence of soil test recommendations for potassium, this nutrient must also be applied to high yielding varieties of rice crop. 60 kg of K₂O/ha as on an uniform application of this dose it was possible to maintain the K concentration in the plant above a critical limit.

Effect of Fertilizers on Quality Characters

Effect on physical qualities

The grains of 'Ratna' rice was graded as 'long slender' one which was not affected by fertilizer treatments. Length of grain increased with increasing level of N upto 120 kg/ha. Further increase in N could not affect the grain length. Length and breadth both reduced in absence of N.
While P application also increased the grain length it was adversely affected by Mn. N and P, alone and in combinations, increased the hulling percentage of grains. Length/breadth ratio was found to be negatively correlated with the hulling percentage. Inference could, therefore, be drawn that smaller grains with its bigger breadth would record higher hulling recovery.

**Effect on thermal qualities**

While nitrogen decreased the values of volume expansion, water uptake and kernel elongation it increased with the application of P. It led to the conclusion, therefore, that while P improved the thermal qualities it were deteriorated by the application of N.

**Effect on chemical qualities**

Alkali value decreased with increasing levels of N. P also behaved in the same way. Mn showed no regular trend. Nitrogen and phosphorus, alone and in combinations, increased the percentage of true protein. While non-protein nitrogen was also increased by N the same was decreased with the application of P. Thus, increased doses of N resulted in increased true protein production only if P was also adequately supplied together with the nitrogen. Mn decreased the percentage of protein in the rice grains.

While N decreased the starch content in the rice grains it was increased with the application of P. Manganese showed deleterious effects. On the other hand, nitrogen and phosphorus, alone and in combinations, increased
the percentage of mineral matter. An application did not show any marked effect on mineral matter.

EFFECT OF VARIETY AND LOCATION ON QUALITY CHARACTERS OF RICE

Most of the varieties studied were found to possess good physical qualities. Hot dry weather of Mathura and Jhansi reduced the grain length. Tarai conditions, on the other hand, increased the length of grains.

While highest values of volume expansion and water uptake were recorded in the samples of Mathura and Jhansi, the lowest ones were found in those of Bareilly and Rudrapur stations which were located in tarai region of the province. Kernel elongation was higher in the samples of Bareilly and Rudrapur.

Most of the varieties showed high alkali values (more than 6.0) which indicated that they could be cooked in short period. Location had no effect on any of the chemical qualities. With few exceptions, most of the varieties under study were found to contain desirable percentage of protein i.e. 6 to 7.50%. About 95% of the total nitrogen, on an average, was found in the form of true protein and the rest 5% in the form of non-protein substances. Percentage of starch varied from 76.14 to 78.86 and that of mineral matter from 1.50 to 1.89. While varieties of longer duration showed slightly higher percentage of starch than that of medium ones registered high values of mineral matter in most of the samples.
CONCLUSION

The following general conclusions which are applicable to high yielding varieties of rice like 'Ratna' could be drawn from the findings of the present investigation.

To maintain optimum concentration of N, P & K in the plant body at its tillering and panicle emergence stages; to enrich the soil to the extent that it may supply the nutrients till later growth stages; to harvest good yields rich in protein, starch and mineral matter; and to obtain good grain size with desirable quality characters it is essential that these three primary nutrients should be applied in adequate amounts. 120 kg of N/ha was found to be the optimum one. For best economic use nitrogen should be applied in splits viz. at transplanting or sowing, at tillering and at panicle emergence stages.

To enhance the uptake of nutrients and to make a balance in the quality characters of rice grains a dose of 60 kg P<sub>2</sub>O<sub>5</sub> should also be combined with 120 kg of N. For similar reasons, in absence of soil test recommendations, a general dose of 60 kg of K<sub>2</sub>O /ha may also be considered as a suitable one.

At this stage, application of Mn to high yielding varieties of rice, even under upland conditions, is not recommended for general practice. The data on quality characters of different varieties of rice as studied and reported in the present investigation must be utilized by the plant breeders in their varietal improvement programmes.

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