# Rice yield and its biological value of protein fertilized with an increased rate of mineral fertilizers

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# Rice yield and its biological value of protein fertilized with an increased rate of mineral fertilizers

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**Abstract.** The influence of fertilization (through the use of an increased rate of nitrogen-phosphor and nitrogen-phosphor-potassium fertilizers) on rice productivity and the biological value of rice protein on the alluvial meadow along Plovdiv is studied. The varieties studied are the folowing: Roza, Mariana and Krasnodar.

It is established that, up to a rate of 24 kg of nitrogen and 20 kg of phosphor per deciare, nitrogen-phosphor fertilization of rice has an opportunity to exceed nitrogen-phosphor-potassium and ensure an increase in yield reaching 41.3%.

The maximum yield coincides with a protein content resulting from nitrogen-phosphor fertilization. But with a nitrogen-phosphor-potassium fertilization, this yield will precede the maximum protein content.

Fertilization involves an impoverishment of rice protein in relation with some irreplaceable amino-acids and decreases its biological value.

The maximum biological value of rice protein precedes also the maximum yield. The maximum grain yield corresponds to the minimum biological value of protein.

An ascertainment tendency shows that rice breeding is a basic criterium for the quanlitative evaluation of new formed varieties and must be applied for the biological value of protein.

## I – Introduction

The modern methods to solve food problems (human and animal), always tend to neglect the protein concept and its substitute with a definite biological value of protein (Voazen, 1970). The circumstances demanded that the condition of maximum fertilization lies in the dynamics of yield, protein content and its biological value never coincide (Voazen, 1970, Todorov et al., 1984). This phenomenon has been noticed in maize (Todorov et al., 1978; Todorov et al., 1984), alfafa (Todorov et al., 1981), some grasses (Todorov et al., 1982; 1983) and horticultural crops (Voazen, 1970).

In Bulgaria rice is an important element of the population's diet. It is also included in different medical diets but this point is not actually covered by the study. Our aim is to determine the dependency between fertilization using mineral fertilizers, ability of varieties, yield and the protein biological value. Such information in the field of agriculture and food technology is needed for breeding new types of rice varieties.

## II – Material and methods

Field experiments to determine the effects of an increased rate of fertilization with mineral fertilizer on rice productivity and its biological value of proteins are conducted on the alluvial meadow along Plovdiv with the following agro-chemistry characteristics on an experimental part in the layer of 0-30 cm: pH 6.4 (in KC1); N - ($NO_3$ + $NH_4$) 18,2-12.4 mg/1,000 g soil; $P_2O_5$-8.9 mg/100g soil; $K_2O$-23.4 mg/100g soil; B-0.62 mg/1,000 soil; Zn-1.86 mg/1,000 g soil; Cu-6.97 mg/1 000 f soil; Mn-25.4 mg/1,000 g soil; exchange of calcium -16.4 mg/100 soil.

During the period 1966–1990, the following variants of nitrogen-phosphorous and nitrogen-phosphorous-potassium fertilizers at an increased rate for the Roza variety have been studied: 1) control; 2) 6 kg

N/deciare, 5 kg P per deciare 3); 12 kg N, 10 kg P per deciare; 4) 18 kg N, 15 kg P per deciare; 5) 24 kg N, 20 kg P per deciare; 6) 6 kg N, 5 kg K per deciaire; 7) 12 kg N, 10 kg P, 10 kg K per deciare; 8) 18 kg N, 15 kg PP, 15 kg per deciare; 9) 24 kg N, 20 kg K per deciare.

Comparative tests of Roza, Krasnodar and Mariana varieties are conducted during the period 1991–1993 at the background of priority indexes in relation to yield-nitrogen-phosphorous fertilization and its variants: 1) control (without fertilizer; 2) 12 kg N, 10 kg P per deciaire; 3) 18 kg N, 15 kg P per deciaire; 4) 24 kg N, 20 kg P per deciare.

Both for phosphorus and potassium, fertilization was carried out entirely at pre-planting with superphosphate and potassium sulphate. Nitrogen is at 6 kg per deciare and at a higher rate, half of it being applied at pre-planting and the other half at tillering stage. Nitrogen fertilizer in the form of ammonium sulphate is applied at pre-planting and ammonium nitrate as a feeding.

An experiment by block method in four replications for a plot of 10 $m^2$ is carried out. The seeding rate is 650 germinated plants for 1 $m^2$ and at the time of vegetation commonly accepted methods of cultivation in the region is used (Milev et al., 1971).

The methods used for agricultural soil assessment in an experimental site are: to define simultaneously ammonium and nitrate nitrogen (Stanchev et al., 1968); the $P_2O_5$ and $K_2O$ content – aceton-lactaten method (Ivanov, 1984), and for microelements – colorimetrical assessment (Sandev, 1979).

The protein content of grain is defined by the Keldal method and its amino-acid composition with automatic analyzer type Hd-1200 E from acid hydrolisis received by processing samples with 6n-HC1 in welded ampulla at 105°C for 24 h.

A biological value of rice protein is defined by the Oser and Mitchell method (Sandev, 1979) on the basis of irreplaceable amino-acids content, using egg albumen as initial protein.

## III – Results and discussion

Within the limits of the variants studied, increasing the rate of nitrogen-phosphorous and nitrogen-phosphorous-potassium fertilizers showed a positive influence over rice productivity *(figure 1)*. Depending on the nutritive regime of the soil, yields can be increased on the average from 30% *(figure 1)* to 41.3% (*figure 5)*. A very high yield growth shows fertilization with nitrogen-phosphor at the rate of 12 kg nitrogen and 10 kg phosphor per deciare which is afterwards maintained within 3 to 5%. The type of soil used for potassium fertilizer at the background of nitrogen fertilizer appears to be of no importance and its high rate of fertilizer leads to yield reduction.

Regarding the quantity of yield, besides fertilizer rate, the varietal capability plays an essential part *(figure 5)*. Among the varieties studied: Roza has shown the strongest reaction to fertilization, followed by Krasnodarski and Mariana. For the Roza variety, maximum yield is obtained at the rate of 18 kg nitrogen, 15 kg phosphorous per deciare, and for the other varieties at the highest rate of fertilizer.

A protein content of grain at nitrogen-phosphor fertilization follows pace of yield (*figure 1)* and its growth is the highest at the biggest rate of fertilization. At a nitrogen-phosphor fertilization, this maximum does not coincide, preceded from maximum yield to the maximum content of crude protein available. Using potassium fertilizer at the background of nitrogen-phosphor fertilizer leads to a rise in the protein content of grains up to an average of 3.6–4.5%.

Changes in yield and its protein content occur under fertilization having an impact on the amino-acid composition of grain resulting in a whole reduction of irreplaceable amino-acids (Rizin, Agrinin, Treonin, Varin, Levsin, Izolesin), an average of 5—24%, and an increase in the Metionin content (11–78%), and in Tirozin (5.3–10.5%) (*figure 2)*. The increased protein content is described as the chemical deleting of irreplaceable amino-acids of protein content. The complete impoverishment of irreplaceable amino-acids of protein in rice exists (*figure 3)* and leads to decreasing its biological value. The only exception is amino-acid Metionin which influences potassium at the background of nitrogen-phosphor fertilization and can enrich rice protein from 3.9 to 41.7%.

This shows that protein content of a very high yield is obtained with a very low content of Rizin limiting amino-acid. That is why nourishing food is actually the subject of various studies (Voazen, 1970) allowing to evaluate yield and protein content. Therefore, mineral fertilizers must serve to improve, or at least maintain the quality of protein.

According to these considerations, we made an evaluation of the biological value of protein in rice on the basis of its content in irreplaceable amino-acids: rizin, histidin, agrinin, treonin, metionin, levtsin, izolevtsin, valin, phenilalanin *(figure 4)*. The highest biological value of protein has been obtained from rice coming from non-fertilized fields. An increased rate of fertilization with nitrogen-phosphor fertilizer leads to a yield decrease regarding the biological value of protein. The highest yield is obtained with the lowest biological value of protein. Dependency is evident with a nitrogen-phosphor-potassium fertilization. The exception, observed at the highest fertilizer rate for this type of fertilizer, is due to an interruption in deleting the amino-acid composition of rice protein and as a result, its hinder yield increment. A similar phenomenon is observed for maize (Todorov et al., 1978; 1984).

This is expressed by the method of Oser (through the EAA index) as well as by the method of Mitchell (through the so-called chemical indicator): absolute quantities of biological value of rice protein show one and the same tendency.

Besides the types and rate of fertilizer for the formation of the biological value of rice protein, variety pecularity is also important *(figure 5)*. Among studied varieties – cultivated without fertilizer – the highest biological value of rice protein (63.12 EAA index) is found for Roza followed by Mariana (56.77 EAA) and the lowest for Krasnodarski.

But, under fertilized conditions, only the Mariana variety shows that fertilization is likely to increase the biological value of rice protein. For this variety, with a growth of rate fertilizer up to 18 kg nitrogen and 15 kg phosphor per deciare, an increase of the biological value of rice protein is observed as well as a highest absolute quantity at a rate of 12 kg nitrogen and 10 kg phosphorous per deciare. Independently of that, this maximum yield variety is with the lowest biological value of rice protein, the difference compared to other varieties' wide range of fertilization will ensure an increase in the biological of rice protein, and makes it valuable; e.g., for food technology as well as for breeding as an initial material to establish new varieties with a possibility for increasing productivity and improving quality.

As for Mariana, it is a new variety obtained by another cultural method and on the whole its biological value reduction cannot be attributed only to mineral fertilizer. Special criteria are applied for evaluating new rice varieties aiming at breeding to form varieties having a moderate growth of yield and a higher threshold regarding basic nutrients.

## IV – Conclusion

At the rate of 24 kg nitrogen and 20 kg phosphor per deciare, nitrogen-phosphor fertilization of rice exceeds the possibility of nitrogen-phosphor-potassium to ensure 41.3% yield increase. Through nitrogen-phosphor fertilization, maximum yield can be obtained, with a protein content coinciding with the yield. But by fertilization with nitrogen-phosphor-potassium this yield precedes the maximmum protein content.

The influence of fertilization results in an impoverishment of rice protein in relation to some irreplaceable amino-acids which reduces its biological value.

A maximum in biological value of rice protein precedes also a maximum yield. The maximum grain yield corresponds to the minimal biological value of protein.

An ascertainment tendency shows that rice breeding is a basic criterium for the quanlitative evaluation of new formed varieties and must be applied for the biological value of protein.

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**Figure 1.** Dependency between the growing rate of fertilizer, yield of rice and its protein content (average for the period 1988–1990).
A = nitrogen-phospohorous; B. Nitrogen-phosphor-potassium fertilizer.
Variants: 1) non-fertilized (control) ; 2) 6 kg N,5 kg P per deciare 3) 12 kg N, 10 kg P per deciare 4) 18 kg N, 15 kg P per deciare; 5) 24 kg N; 20 kg P per deciare ; 6) 6 kg N, 5 kg P, 5 kg K per deciare ; 7) 12 kg N, 10 kg P, 10 kg P, 10 kg K per deciare ; 8) 18 kg N, 15 kg, P, 15 kg K per deciare ; 9) 24 kg N, 20 kg P, 20 kg K per deciare.

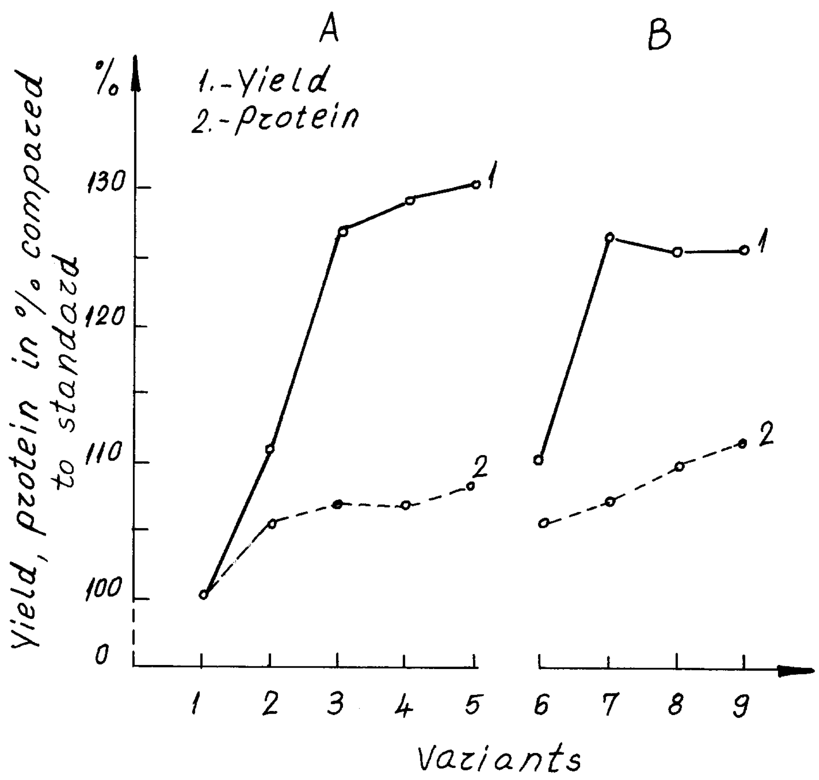

**Figure 2.** Dependency between growing rate of fertilizer, yield of rice and amino-acid composition of grain. Average for the period 1988–1990.
A = nitrogen-phosphorous fertilizer; B = Nitrogen-phosphor-potassium fertilizer. Variants as indicated in *figure 1*.

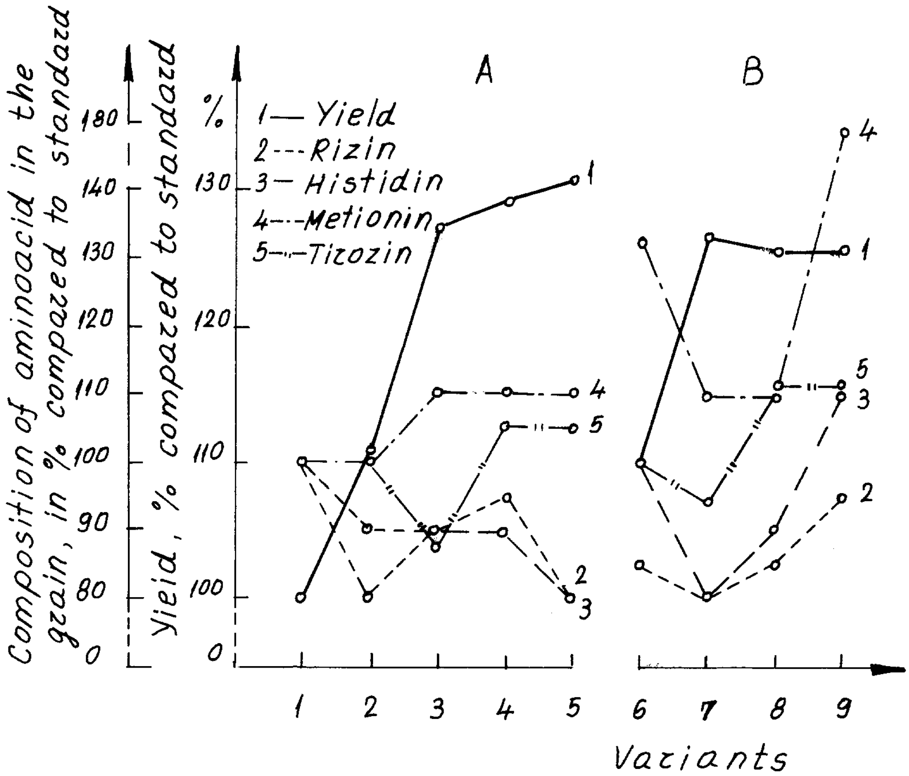


**Figure 3.** Dependency between growing rate fo fertilizer, yield of rice and ammino acid composition of protein. Average for the period 1988-1990. A = nitrogen-phosphor fertilizer; B = Nitrogen-phosphor-potassium fertilizer. Variants as indicated in *figure 1*.

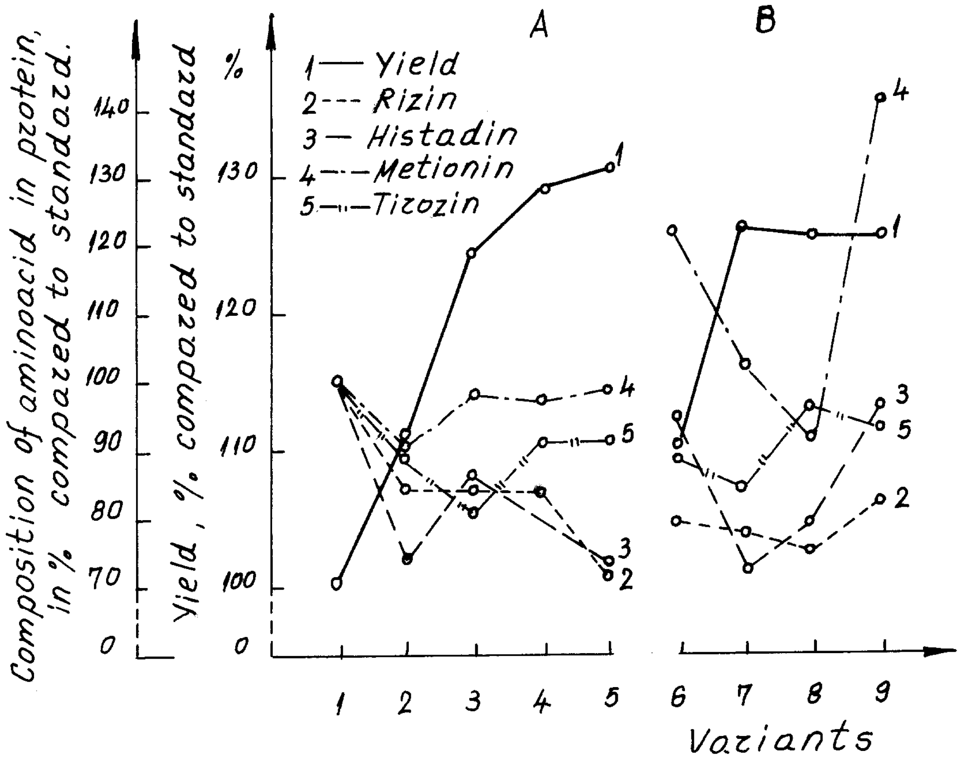

**Figure 4.** Dependecy between growing rate of fertilizer, yield of rice and its biological value of protein (EAA index). Average for the period 1988–1990. A = nitrogen-phosphor fertilizer; B = nitrogen-phosphor-potassium fertilizer. Variants as indicated in *figure 1*.

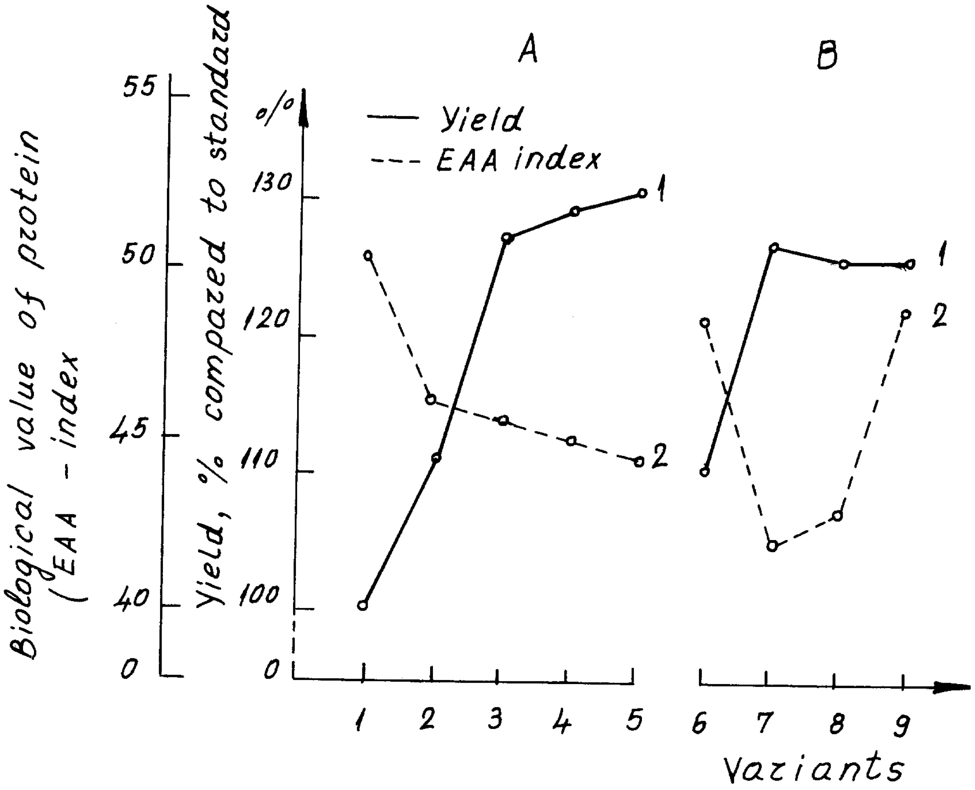


**Figure 5.** Dependency between growing rate of fertilizer, variety ability, rice yield and biological value of protein (average for the period 1991–1993).
Variants: 1) non-fertilized (control) **;** 2) 12 kg N, 10 kg P per deciare; 3) 18 kg N, 15 kg P per deciare; 4) 24 kg N, 20 kg per deciare.