EFFECTS OF NUTRIENT SUPPLY ON THE YIELDS OF MILLET

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Abstract: *In our study we have examined the reaction of millet to different nutrient supply level. The goal of the experiment was to elaborate an efficient and economical fertilisation technology that can be recommended for millet producers or those wanting to grow this plant. Millet is among the most important cereals in the oriental parts of the world. The main millet-producing countries can all be found in Asia.. In Asia and Africa millet is one of the most important cereal plants: 400 million people consume it on a daily basis.*
The experiment was implemented in Szarvas, the Galambos experimental site of Szent István University. The soil type was phaeozem with deep-laying carbonates.
Four levels of nutrient supply was involved: 0-30-60-90 kg/ha N+PK.
Millet were sown in the springs of 2018 and 2019 in four repetitions. The size of each parcel was 18.55 m^2 and all parcels receive the same agro-technical solutions.
The largest yields were reached at the highest level of nutrient supply in both years (2.85 t/ha and 4.05 t/ha in 2018 and 2019, respectively). However, no remarkable increase could be detected regarding the average yield. Different precipitation conditions resulted alterations in the amount of yields.
Height of the plants (in 2019), relative chlorophyll content and the average number of grains per booth all reached the highest values in case of 60 kg/ha N+PK treatment. Average yield and thousand grain weight were at their peak when the highest active fertilising substances were applied.
As a summary it can be concluded that average yields increased as a result of heightened nutrient supply level, although not in an extent that would have justified the recommendation of the highest level of fertilisation. Taking into account the results received applying 30 kg/ha N, 18 kg/ha P_2O_5, 30 kg/ha K_2O or 60 kg/ha N, 36 kg/ha P_2O_5, 60 kg/ha K_2O proved to be the most economical.

Keywords: *millet, nutrient supply, yield*

INTRODUCTION

Common millet (Panicum miliaceum L.) is currently grown in a relatively small area in Hungary. It is primarily known and used as bird food. However, with the spread of alternative and healthy cuisine millet emerged as a food for human consumption. It has good nutrient values and gluten intolerant people can eat it as well.

Millet is among the most important cereals in the oriental parts of the world. The main millet-producing countries can all be found in Asia (CHRAPPÁN ET. AL. 1997, ÁBRAHÁM 2019, TÓTH 2013, VARGA 1966). In Asia and Africa millet is one of the most important cereal plants: 400 million people consume it on a daily basis (LÉDER 2010).

The production area of millet is around a few thousand hectares in Hungary. This area can only grow when weather conditions exclude the sowing of other plants. Millet can also be used as a replacement plant after frost damage (SERES 2014).

As regards of the future of Hungarian millet production an increase can be expected (LAZÁNYI 2010), since this species is a viable alternative for several other cereals. Climate change can be experienced in agriculture as well. As a consequence of aridity and the increase in the number of hot days growing cultivated plants currently covering the largest production areas becomes increasingly uncertain, especially without irrigation. Millet has come from tropical and subtropical areas (ROMHÁNYI AND GONDOLA 2011), thus it can easily adapt to these conditions. Even varieties with longer growing season and higher productivity can be used here (SERES 2014). Soils with poor characteristics can be utilised and crop rotation can become more diverse (BLASKÓ 2010).

Based on the description of Bittera (1930) millet is a drought-tolerant species. When used as a secondary crop it can develop well even in the summer period with lower water supply in the soil. From germination until the phase of stem elongation it tolerates the lack of water well. In later phases, in particular between booting and ripening its water demand increases. In case of sufficient water supply high yield can be achieved (VARGA 1966).

Millet can be grown in humus-rich sandy areas that warm up quickly or in cambisols as well. This species favours calcareous soils (CHRAPPÁN ET. AL 1997, ANTAL 1983, BITTERA 1930, ÁBRAHÁM 2019).

Millet is not demanding in the respect of previous cropping. It is usually sown in the place of died plants as main crop or in case weather prevented the sowing of any other spring crop. It is also used as secondary crop sown after an early-harvest forecrop, since it can reach full ripeness until the harvest (NAGY 2005, CHRAPPÁN ET. AL 1997, RADICS 2002, VARGA 1966).

Relatively few researches have been implemented in connection with the nutrient supply of millet in Hungary. According to the description of Bittera (1930) it is not worth directly administering either stable manure or artificial fertilisers. The former has weed-growing effect, while the latter would have no real beneficial effect due to the short growing season of millet. It is recommended to apply both kinds of fertilising for the previous cropping. Although millet has a deep-penetrating root system, its nutrient-intake capacity is still lower than that of oat or barley (VARGA 1996).

Based on the results of Nagy (2005) for producing one ton of grains and the accompanying straw matter millet takes up an average of 20 kg nitrogen, 9 kg phosphorus, 22 kg potassium, 7 kg lime and 2 kg magnesium from the soil (NAGY 2005).

In the past few years Emese Seres (SERES 2014) has conducted experiments on producing millet. During these examinations the effects of sowing date, plant density and artificial fertilising on the yield, protein content and milling output of millet have been revealed. It can be observed that the highest level of nutrients does not have considerable yield-increasing effect compared to lower nutrient levels (SERES 2014).

The growing season of millet is 70 to 130 days, depending on the given variety (RADICS 2002). Millet ripens unevenly, while its stem is still green. It shall be harvested when the boot turns to yellow. Colour of the tegument shall correspond to the standard of the given variety (CHRAPPÁN ET. AL, 1997). Following the harvest it must be dried until 10% of grain moisture (for storing) and it also must be cleaned (ÁBRAHÁM 2019). Its yield varies between 0.8 and 2.5 t/ha, largely depending on the soil type (NAGY 2005). The grain:straw proportion is 1:2 (LÁSZTITY 1997A).

MATERIAL AND METHODS

We have examined the impacts of different nutrient levels on the yield and on the most important yield generating elements of GK ALBA millet variety. The examinations were carried out in 2018 and 2019 in Szarvas.

Soil type of the experiment area: phaeozem with deep-laying carbonates. Based on the soil tests this soil is mixed clay-loam, its pH is acidic. The cultivated layer does not contain any $CaCO_3$. According to the humus content the soil provides moderate N, while its P and K supply is very good. As regards of Mg, Zn, Cu and Mn the supply is good, very good, sufficient and sufficient, respectively.

In 2018 large amount of precipitation (163.8 mm) reached the area until March as compared to both the 30-year average and 2019. However, around the sowing date and during the growing season of millet the amount of rain declined considerably – even precipitation deficit was observed. Winter period of 2019 was generally free of precipitation, but May and June brought high rainfall that coincided the growing season of millet. This impacted the yield of millet positively. Precipitation conditions in July were almost the same.

Table 1.

Nutrient levels applied in the experiment

Nutrient level	**Active substance kg/ha**
Control	0 kg/ha N, 0 kg/ha P_2O_5, 0 kg/ha K_2O
Nutrient level I	30 kg/ha N, 18 kg/ha P_2O_5, 30 kg/ha K_2O
Nutrient level II	60 kg/ha N, 36 kg/ha P_2O_5, 60 kg/ha K_2O
Nutrient level III	90 kg/ha N, 54 kg/ha P_2O_5, 90 kg/ha K_2O

Millet were sown in the springs of 2018 and 2019 in four repetitions. The size of each parcel was 18.55 m2 and all parcels receive the same agro-technical solutions.

Sowing was implemented in 12 cm row spacing by using drilling method. Approximately 3.5 million germs were used.

Due to the good plant protection resistance of millet herbicides were used only in spring in these parcels. Prior to harvest remarkable bird damage could be observed in some cases, although it usually affected only the perimeter parcels. When assessing yields I took into account the least damaged parcels to evaluate the results. Harvest was accomplished by using Sampo combine harvester, so the separate measure and assessment of parcel yields posed no problems.

During the experiment samples were taken from the parcels in order to receive data. During sampling we selected five averagely developed specimens from each parcel for measuring and sampling. Relative chlorophyll content (SPAD value) and the height of the plants were measured. We took samples from the boots and their length, the number of branches, thousand grain weight and grain number were also measured.

RESULTS AND DISCUSSION

The height of plants was measured in both years of the examination. Measurements were taken following the flowering phase when millet had already reached its maximum height. Average height had a lower value in 2018. Beside, increasing amount of nutrient supply resulted higher plants in both years with the exception of Nutrient level III in 2019. The difference between the tallest and shortest average heights was 46 cm. That means almost 40% difference. The height of plants is a determining factor, since more and bigger leaves can develop in longer stems resulting larger leaf area. This leads to more intensive assimilation and photosynthesis, therefore the plant is able to produce more organic matter.

Chlorophyll content of the plants was measured once, in 2019 by using KONICA MINOLTA SPAD-502 chlorophyll meter. The stock has left the phase of flowering, entering lactic ripeness. Results of relative chlorophyll content measurement were almost identical regarding the different nutrient levels. The highest level of chlorophyll was measured for Nutrient level II (60 kg N+PK) with the value of 31.56. Minimal (0.5%) difference was observed between the control group and Nutrient level I. SPAD value showed a decline in case of Nutrient level III. Based on the above results it can be concluded that the highest level of nutrients (90 kg N+PK) did not increase the chlorophyll content of millet. On the contrary, a decrease was detected resulting the reduction of photosynthetic activity. This decline can also be explained by the fact that at the time of the measurement plants receiving the highest nutrient level has already entered the waxy phase of ripeness which reduced the chlorophyll content.

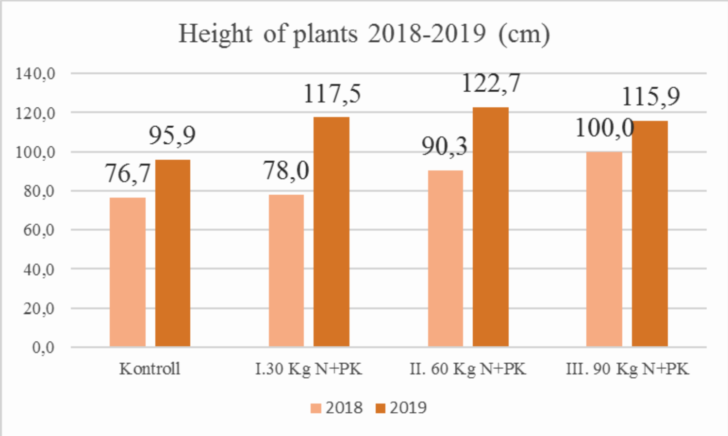

Figure 1. Height of plants 2018 and 2019 (Szarvas)

Results of thousand grain weight measurement showed great versatility among the repetitions. The lowest thousand grain weight was detected in Nutrient level I exceeding even that of the control group. This value was 8.16 g and the largest, 8.24 g in Nutrient level II and Nutrient level III, respectively.

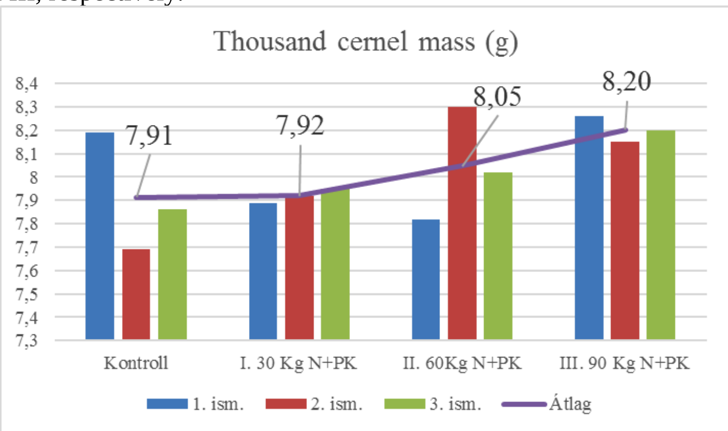

Figure 2. Thousand grain weight (Szarvas, 2019.)

The most extreme values were excluded from the experiment due to bird damage and potential sampling failures. The control group produced the lowest average weight of 7.91 g. Nutrient level I reached almost exactly the same thousand grain weight.

In case of measuring thousand grain weight values did not decline but increased in Nutrient level III. Considering the results of the repetitions it can be said that values scatter in a wide scale for each nutrient level, but generally speaking fertilisation is able to increase thousand grain weight.

We have also examined the number of grains found in a boot. As for the parcels of control group an average of 532 grains per boot was counted. The largest number was detected in Nutrient level II with 578 grains per boot. It means that the increased level of nutrient supply resulted more grains, but the highest level (III) induced a decrease in grain number. The average value was around the same in case of Nutrient levels I and III.

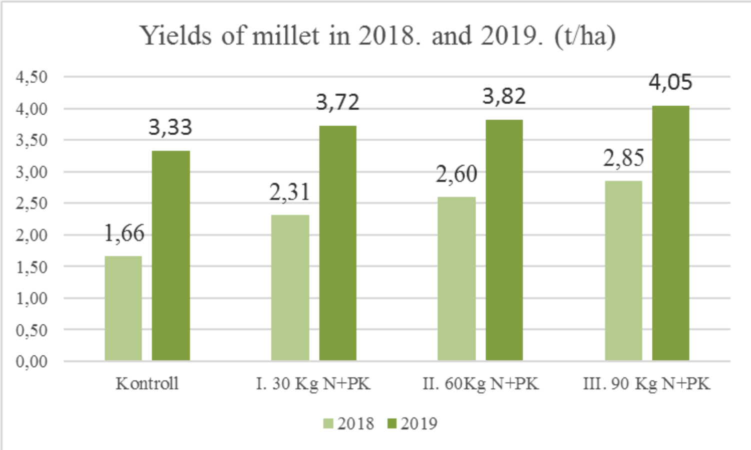

Figure 3.Average yields 2018 and 2019 (Szarvas)

Figure 3 shows the yields of the two examined years. Using artificial fertilisers in increasing levels resulted the notable rise of yields in both seasons, although remarkable differences can be observed between the two years. Average yields differ considerably when the plants are grown under the same circumstances but in different weather conditions.

Average yield of the control group was 1.66 t/ha in 2018, but in 2019 it reached twice as much (50%). When comparing different nutrient levels within the same year it can be seen that they meant an approximately 10% or less increase in the average of the harvested yield. A conclusion of this result is that millet does not react well to the increase of nutrients.

Due to the precipitation deficit the plants could not efficiently utilise the administered nutrients, but in that arid season the increased nutrient level led to larger differences among the examined groups than in the next, much more humid year. Optimal nutrient supply suppresses the fluctuations of yield in case of millet, too. This calls the attention to the fact that in arid conditions or in a drought season the relative proportion of yield loss is smaller than in case of nutrient deficit.

Based on the average yields it also can be concluded that nutrient supply increases the yield, but not in a large extent. It shall be assessed from economic aspects, too.

CONCLUSIONS

Relative chlorophyll content increased up to Nutrient level II (60 kg/ha N+PK), while it decreased by a few percent in the group receiving the highest level of nutrients. SPAD measurements provide information on chlorophyll content that correlates with the N-supply of the examined plants.

As for thousand grain weight values increased remarkably. Results for the control group and Nutrient level I were around the same, while Nutrient levels II and III (60 and 90 kg/ha N+PK) showed an increase of thousand grain weight.

In examining the number of grains in a boot the highest value was reached in Nutrient level II (60 kg/ha N+PK): an average of 572 grains in each boot. In this case the control group produced the lowest result indicating that nutrient supply exerts a significant impact on the number of grains.

Average yields were higher in 2019 due to more favourable weather conditions. In 2018 the average yield of the control group was 1.66 t/ha rising up to 2.85 t/ha by increasing the level of nutrients. In the next year (i.e. in 2019) the average yield of control parcels was 3.33 t/ha while that of Nutrient level III was 4.05 t/ha.

Heightened nutrient supply increased the yields: the examined variety produced the largest yield at the highest level of nutrient supply in both years. Large differences can be observed between the data of the two involved years due to the amount of precipitation, therefore it cannot be claimed that the highest level of nutrient supply is needed for reaching the largest income. In 2018 the increased nutrient levels resulted the drastic rise of average yields, while this tendency was much more restrained in 2019.

Based on the results of the two-year-long experiment our conclusions as regards of nutrient-replenishment is that applying 30 kg/ha N, 18 kg/ha P_2O_5, 30 kg/ha K_2O or 60 kg/ha N, 36 kg/ha P_2O_5, 60 kg/ha K_2O proved to be the most economical. By using these levels the production of millet can be reasonable either as main crop or secondary crop.

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