THE IMPORTANCE OF MILLET IN ALTERNATIVE CROP PRODUCTION

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Abstract

Millet originates from Asia and it has been produced due to its short growing season and favourable dietary effect since the ancient times. Millet production reached its peak in the Middle Ages and it used to be the main food for humans. Later, the significance of this crop decreased and its sowing area was greatly reduced. Millet production is expected to be of great significance in the future. Millet can be used in reform nutrition, in increasing the diversity of the produced crops, as well as a secondary sown crop in areas with groundwater infiltration which dry up later due to weather extremities caused by climate change, since millet is less sensitive to these conditions. Millet could also have a role in extending the possibility of rational crop rotation.

Key words: millet, fertilisation, sowing date, plant density.

INTRODUCTION

Millet production was started in the early historical times. It is an indigenous Asian crop which was probably brought by the Celtics to Europe. After the fall of the Roman Empire, millet production started to prosper. Millet-pap used to be the main food in the Middle Ages several times.

Millet production is still significant in the hot, dry and semi-arid areas of Asia and Africa, as they are not suitable for successful wheat production (Figure 1).

The world's food supply can be significantly improved with the further use of millet, as it is cheaper than traditional proteins. The role/significance of millet in human nutrition increased again in Europe and Hungary. In Hungary, millet is mainly known as a crop for pap production purposes, while also flour and distilling industry materials are produced from its yield. Currently, millet is produced on a small area, mainly in dual production to replenish perished crop areas or to utilise areas with groundwater infiltration which dry up late (Figure 2).

The sowing area of millet could increase in the future due to its increased role in human consumption, as well as its use as birdseed and a significant export product. Millet could contribute to the development of environmental friendly production structures that are more efficient than the previous ones, as well as more favourable sowing structures.

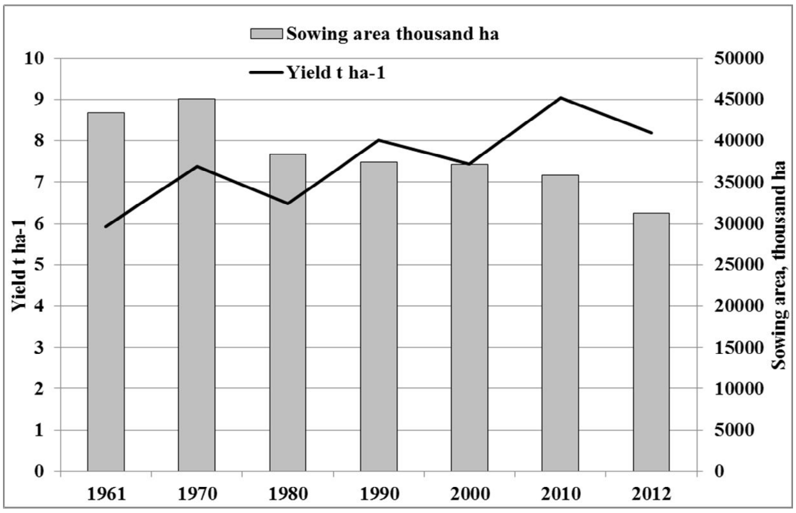

Fig. 1. Sowing area and average yield of millet in the world between 1961-2012 (FAO data)

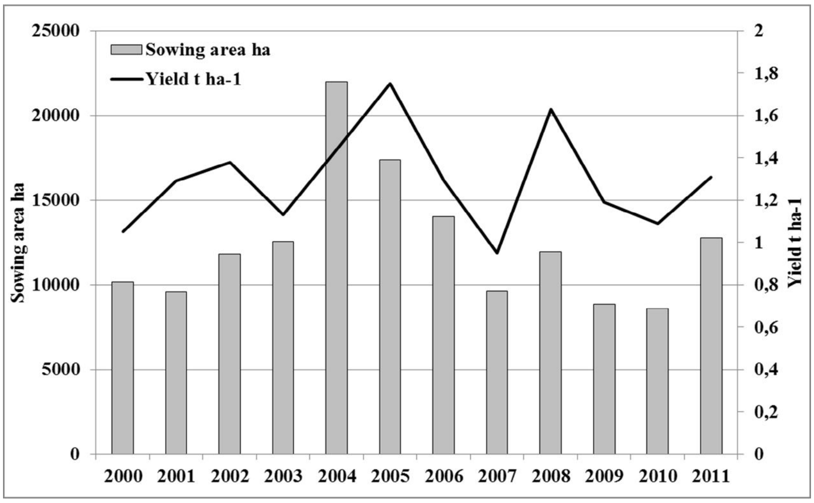

Fig. 2. Sowing area and average yield of millet in Hungary between 2000-2011 (based on the data of the Hungarian Central Statistical Office)

The significance of millet is further increased by climate change, as it needs warm weather to grow. Furthermore, millet could increase the diversity of field crop species. Based on the inflorescence of the produced millet, three variants are known (Schermann, 1967; Lazányi, 1997) as follows:

- millet with diverging panicle (*Panicum miliaceum var. effusum*)
- millet with contracted panicle (*Panicum miliaceum var. contractum*)
- millet with compact upright panicle (*Panicum miliaceum var. compactum*)

In Hungary, mainly the yellow- and red-seeded millet varieties are produced. Older varieties are the red-seeded Lovászpatona variety and the Fertődi-2 and newer ones include Biserka, Gyöngyszem, Maxi and Rumenka.

Millet prefers not too wet soils which warm up easily. The best soils for millet production are mid-heavy calcic cherozem soils. Millet prefers warm weather and its adaptability is outstanding.

A minimum of 8-10 ^{o}C is necessary for the germination of millet (Antal, 1983). The effective heat sum need of millet is 1400 ^{o}C which is provided in Hungary. Also, this value will further increase due to global warming which makes it possible to produce varieties with longer growing season and potentially higher yield potential.

According to Bittera (1930), millet is a drought-tolerant crop. The drought tolerance of millet is shown by the lower water need in the first half of its development. Millet needs half as much water as wheat, maize, oat or barley during germination (Antal, 1992).

The water utilisation of millet is good, it takes up most of the water during panicling and flowering (Varga, 1966).

Early harvested forage mix crops are proper previous crops for millet. In the case of rainy weather, millet can also be sown after winter barley and rye. However, millet cannot be sown in the same area in two subsequent years. Fertilised root crops may be sown after millet.

The specific nutrient need of millet to produce 100 kg primary and secondary yield is as follows:

- nitrogen (N) 20.0 kg t^{-1}
- phosphorus (P_2O_5) 9.0 kg t^{-1}
- potassium (K_2O) 22.0 kg t^{-1}
- chalk (CaO) 7.0 kg t^{-1}
- magnesium (MgO) 2.0 kg t^{-1}

Phosphorus and potassium are applied during the autumn ploughing, while N is applied during seedbed preparation. If millet is produced on sandy soil, all three nutrients have to be applied in the spring.

Millet can be sown from the second third of May until 10th July. Row spacing is the same as that of cereals and sowing depth is 1-2 cm.

The crop protection of millet has a rather narrow range. Weed control can be carried out in the early phase of stooling and only herbicides are worth being used against dicotyledonous weeds.

The main diseases of millet are the Barley yellow dwarf virus, bacterial stripes of millet (*Xantomonas panici Laveulescu*), millet rust (*Puccinia purpurea Cbe*), millet smut (*Sphacelotheca destruens Stev. et. Johns*) and millet fusarium (*Fusarium spp.*).

The main pests of millet are European corn borer (*Ostrinia nubilalis*), millet gall midge (*Stenodiplodes panicii L.*), frit flies (*Oscinella frit L.*) and house-sparrow (*Passer domesticus L.*).

Millet van be harvested if its panicles are starting to yellow and if the seed is in the condition of wax ripeness, while its colour is typical for each variety. Millet ripening is imbalanced and its seeds are prone to falling; therefore, its harvesting has to be started when the first seeds are ripened.

After harvesting, yield is purified and the purified seeds are dried at 40 ^{o}C until the moisture content of the seed reaches 13%. Therefore, millet seeds preserve their germination ability for two years if stored in a dry, cold and well aired place.

MATERIAL AND METHODS

The experiment focusing on the sowing date, plant density and fertilisation of millet was established at the Research Institute of Nyíregyháza of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen in 2013. The aim of the examination was to analyse the correlation between the sowing date, nutrient reaction of millet, as well as its production area and yield.

Table 1

Temperature and precipitation during the growing season of millet (Nyíregyháza, 2013)

	May	June	July	August	September
Temperature (^{o}C)	16.96	20.48	21.69	21.63	14.25
Precipitation (mm)	80.30	45.60	35.70	5.00	39.60

The first four months in 2013 were especially rainy, more than the multi-year average. The amount of precipitation was 80.3 mm even in May, while the monthly mean temperature values were below the multi-year averages in the first half of the year and even in May. In September, the monthly mean temperature was below the average which slowed down the ripening of millet.

Altogether, the weather in 2013 was extreme also during the growing season of millet.

Experiment soil

The experiment soil can be characterised by low plasticity (K_A=28), acidic character and poor water retention ability.

The soil of the experiment site consists of sand which contains little calcium, as well as calcareous loess and sand which mix with each other in various proportions. Due to the unfavourable mechanical composition, leaching is strong and the macro- and micronutrient content of these soils is low. The experiment soil is acidic and its physical soil character is sand. The water and nutrient management of the experiment soil is more favourable than that of sand drift.

Fertilisation experiment:

Control: non-fertilised plots

1. NPK 40:48:48 2. NPK 80:72:72 3. NPK 120:96:96

Variety: Biserka

Thousand grain weight: 6.7-7.0 g. Yield potential: 3.0-4.0 t ha^{-1}.

Sowing dates:

1st sowing: 12/06/2013 2nd sowing: 25/06/2013 3rd sowing: 03/07/2013

RESULTS AND DISCUSSION

The production area of millet, as well as the interactions between the applied fertiliser dose and the sowing area greatly depend on the mentioned factors. Millet reached its nearly 4 t ha^{-1} yield peak in the case of the first sowing date, 12 cm row spacing and the second fertiliser dose (Figure 3).
In the case of 24 cm row spacing (double cereal), yields above 4 t ha^{-1} were obtained at the second sowing date and even the lowest fertiliser dose. Also, the highest yield was obtained at the second sowing date in the case of 48 cm row spacing even during the control treatment (Figures 4-5).

Considering the three different production sites and the effect of fertilisation, the lowest yield was obtained at the third (latest) sowing date in all cases. As the sowing date progressed, significant yield reduction was observed, except in the case of the 24 cm row spacing. For this reason, the correlation between the three factors and yield will need to be examined also in the different crop years.

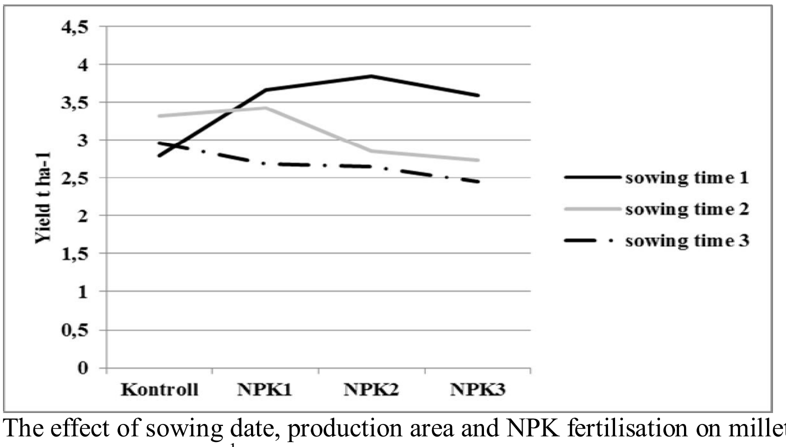

Fig. 3. The effect of sowing date, production area and NPK fertilisation on millet yield (t ha^{-1}) in the case of 12 cm row spacing

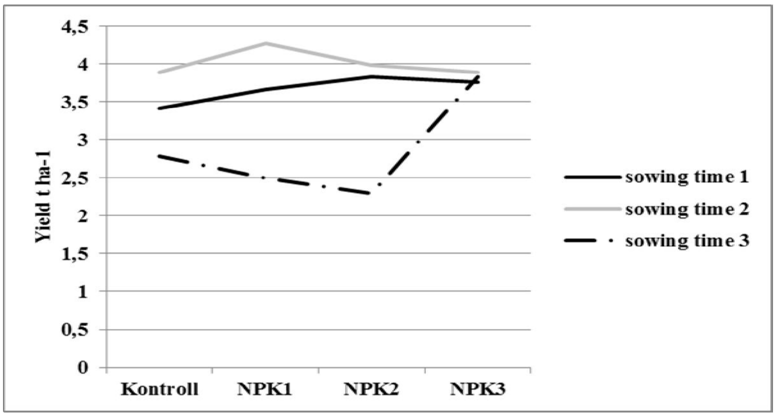

Fig. 4. The effect of sowing date, production area and NPK fertilisation on millet yield ($t\ ha^{-1}$) in the case of 24 cm row spacing

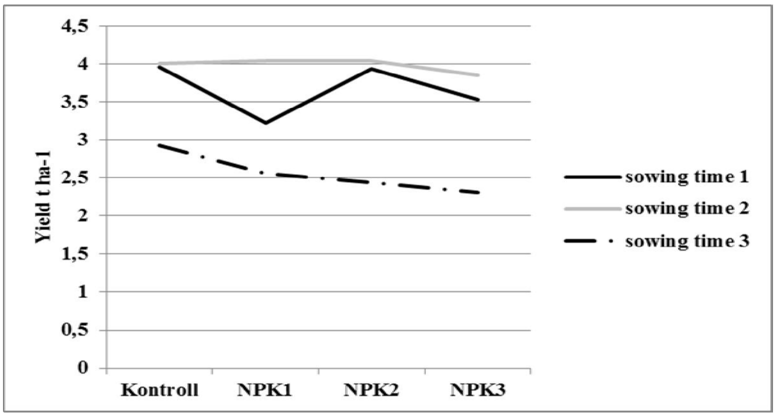

Fig. 5. The effect of sowing date, production area and NPK fertilisation on millet yield ($t\ ha^{-1}$) in the case of 48 cm row spacing

There is a close correlation between the three agrotechnical factors (production area, fertilisation, sowing date) and the element composition parameters of millet. Of the mesoelements, Ca content was above the average in the case of the 12 cm row spacing, while the Mg content was more favourable if 24 cm row spacing was used, similarly to the P content (of macroelements), which was also significantly higher in the case of the 24 cm row spacing. The extraction rate was favourable (70.5 %) in the case of the 12 cm row spacing and the protein content was also close to 10% (Table 2).

Significant yield increase was obtained as a result of fertilisation, but element contents (e.g. K and Mg content) decreased in a few cases. Also, the extraction rate and the protein content were nearly similar in the control (non-fertilised) treatment and all three fertiliser treatments. Protein contents were between 9.36% - 9.58%, while the extraction rate was between 70-71% (Table 3).

Table 2

The effect of plant density on the element composition parameters of millet

	12 cm row spacing	24 cm row spacing	48 cm row spacing
Ca	93.16	88.08	83.98
Cu	1.63	1.81	1.69
Fe	15.82	15.07	15.91
K	933.50	955.53	940.59
Mg	361.08	384.96	371.41
Mn	2.44	2.63	2.73
Mo	<0.100	<0.100	<0.100
P	973.03	1021.78	1008.44
S	1045.06	1059.24	1037.31
Zn	8.85	8.79	7.97
Protein %	9.42	9.74	9.45
Extraction rate %	69.87	70.50	70.01

There is a significant correlation between sowing date and the element composition parameters of millet. Also, the macro-, meso- and microelement contents are usually higher at the second and third sowing dates, while protein content even reaches 10.4% in the case of the third sowing date (Table 4).

It can be concluded from the obtained data that millet requires warm weather. In the case of earlier sowing date, nutrient uptake and protein production are also slower. If millet is sown at later dates, it receives the necessary heat sum during a shorter period of time.

Table 3

The effect of fertilisation on the element composition parameters of millet

	Control average	NPK1 average	NPK2 average	NPK3 average
Ca	84.40	91.46	86.29	90.64
Cu	1.81	1.68	1.73	1.64
Fe	15.21	14.79	15.33	16.37
K	986.82	914.96	947.10	912.02
Mg	394.31	358.33	375.96	357.33
Mn	2.74	2.41	3.17	2.16
Mo	<0.100	<0.100	<0.100	<0.100
P	1025.49	992.37	1012.15	973.82
S	1051.80	1034.63	1065.49	1028.78
Zn	8.67	8.60	8.83	8.20
Protein %	9.36	9.58	9.51	9.58
Extraction rate %	70.04	70.01	71.13	69.31

Table 4

The effect of sowing date on the element composition parameters of millet

	1st sowing date	2nd sowing date	3rd sowing date
Ca	90.24	81.77	92.57
Cu	1.97	1.39	1.78
Fe	11.89	14.63	19.76
K	875.60	915.66	1029.42
Mg	377.97	354.32	382.16
Mn	3.53	1.86	2.47
Mo	<0.100	<0.100	<0.100
P	527.17	907.24	1041.44
S	684.17	1031.05	1114.12
Zn	10.20	8.08	7.45
Protein %	8.85	9.28	10.40
Extraction rate %	70.08	70.31	69.98

CONCLUSIONS

Millet production is about to prosper again in Hungary and in the world. Climate change caused by global warming is also favourable for millet production. In addition to increasing yield and yield safety, the biological resources of millet, as well as the correlation of the given variety and the various agrotechnical factors have to be further developed. According to our experimental data, there is a close correlation between sowing date and yield, but it can be clearly established that too late or too early sowing dates cause significant yield reduction, considering Hungary's climate. In the future, it is necessary to further clarify the interactions between ecological, biological and agrotechnical factors in order to increase the yield safety of millet.

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