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NEW METHOD TO DETERMINE FAO NUMBER OF MAIZE (*ZEA MAYS* L.)

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FAO numbers are generally calculated from the grain moisture at harvest, which has decreased substantially in recent decades. In many countries maize is now harvested with a grain moisture of around 20 %. However, the lower the grain moisture at harvest, the smaller the difference in grain moisture between the maturity groups and/or individual hybrids. The reliability of grain moisture measurements has not improved parallel to the decline in the differences between hybrids, making it difficult to determine the maturity dates of the hybrids reliably. A new method has been elaborated to solve this problem and has been successfully used for the last two years in official trials in Hungary. The new method has several advantages: (a) more maturity parameters are taken into consideration, so the evaluation of more data improves reliability, (b) regression between the maturity parameters and the FAO number is calculated using several standards, thus reducing the effect of the G × E interaction and the experimental error. As a result, the annual fluctuation in the FAO number for each 1 % grain moisture is reduced.

Key words: maturity, maize, FAO number, vegetation period

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INTRODUCTION

Based on experiments carried out in several countries, FAO recommended a uniform method for the determination of maturity date (JUGENHEIMER, 1958). According to this recommendation, the FAO numbers of new hybrids are determined by comparing them with standard varieties. The designated standards, however, no longer exist and each country has replaced them with hybrids of their own. For this and various other reasons, it is purely by chance if the FAO numbers determined for any hybrid in different countries prove to be the same.

Due to the increase in drying costs, there is a real demand for maize hybrids with fast drying down, which can be harvested with a low grain moisture content. In order to exploit the genetic potential latent in the hybrids and to achieve the lowest possible grain moisture, maize is harvested at an ever later date except on areas where winter wheat is to be sown. The results of earlier experiments (CAVALIERI *et al.*, 1985; CRANE *et al.*, 1959; CROSS and KABIR, 1989; HALLAUER and RUSSELL, 1961) indicated that drying down continued, to an extent depending on the genotype, even after physiological maturity, thus proving the advantage of late harvesting.

The demand for a lower grain moisture content at harvest is also reflected in official trials, in changes in the grain moisture data and in the methods used to calculate FAO numbers. In Hungary the FAO numbers were calculated on the basis of the number of days required to reach a grain moisture content of 34–36 % in the sixties, 28–30 % in the seventies, and 28 % or later 25 % in the 80s. In the 90s the FAO number was often calculated on the basis of grain moisture contents of less than 20 % (NEDUCZÁNÉ, 1997; MARTON *et al.*, 1999), by comparison with known varieties which were the standards for the maturity group in question and for the one later group.

In recent years there has been a tendency for the difference in grain moisture between the maturity groups to decrease. In the 1980s the mean grain moisture at harvest was 21.77 % in the earliest group (FAO 200) and 28.33 % in the latest (FAO 500), giving a difference of 6.46 %. In the 90s the grain moisture of the earliest group dropped to 20.1 % and that of the latest group to 24.43 %, giving a difference of only 4.33 % (MARTON *et al.*, 1999). This means that a 1 % difference in grain moisture was equivalent to a difference of over 60 in the FAO number, which was hardly acceptable to experts because of the difficulty of measuring grain moisture accurately and because of the economic weight of a 1 % difference in grain moisture. By comparison, the Minnesota Relative Maturity (MRM) grouping (PETERSON and HICKS, 1973), which formed 8 maturity groups within the maturity range covered by the FAO 200–500 groups, tolerates a difference of ±4 % from the standard within each group. In this system, the grain moisture range within each group is wider than for the whole variety collection using the Hungarian method of calculating FAO numbers.

Later harvest at lower grain moisture content is required if drying costs are to be reduced. However, the lower the grain moisture at harvest, the smaller the difference in grain moisture between the maturity groups.

Data also indicate that under certain conditions, if the autumn is wet, the grain moisture content of hybrids in the early maturity group may increase during October by as much as 5–8 %, while that of hybrids in the latest maturity group may decline to a similar extent (Fig. 1). In this case the difference in grain moisture content, which was 13 % in September, may drop to only 3 % in the course of October.

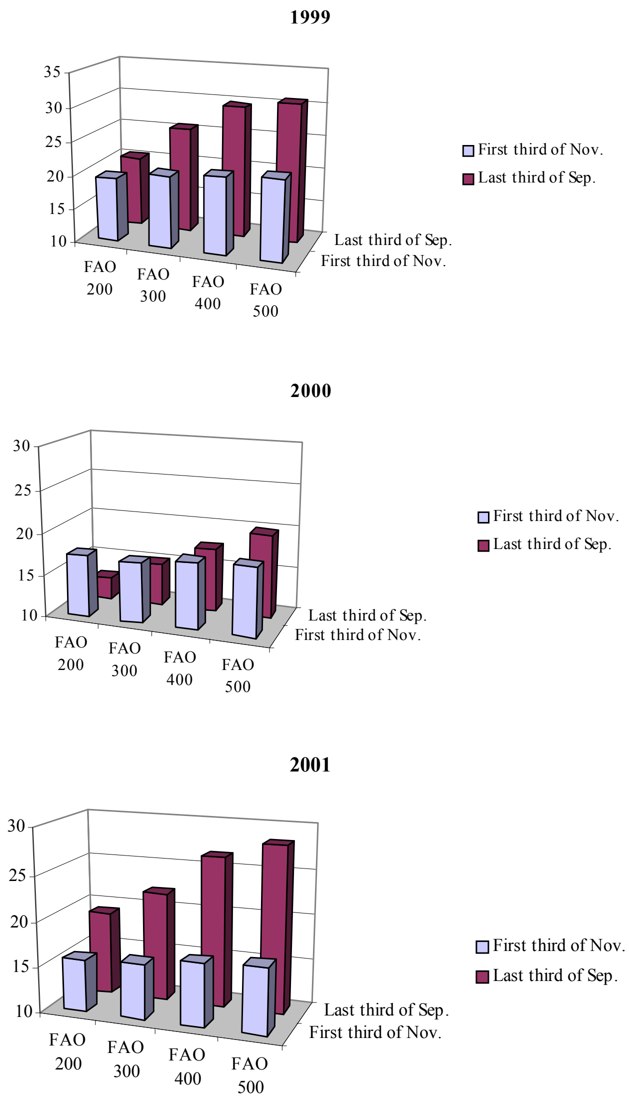


Fig. 1. Grain moisture content of maize hybrids in the last third of September and the first third of November, Martonvásár, 1999–2001

Parallel to the decrease in the differences between the hybrids, the reliability with which grain moisture content can be measured has not improved, thus making the determination of maturity groups extremely uncertain.

The estimation of FAO numbers is further complicated by the fact that for each maturity group the FAO number for unit grain moisture was based on two mean data: the grain moisture of the two maturity group standards. This quotient differed considerably from year to year and from one maturity group to the other.

The present paper summarises proposals which could solve this problem and allow the FAO number of hybrids to be calculated with greater accuracy.

MATERIALS AND METHODS

It is proposed that the calculation of FAO numbers should be based on the following: (1) Number of days from sowing to 50 % silking; (2) Grain moisture when the average grain moisture of maturity group standards is 25 %; (3) Grain moisture when the average grain moisture of maturity group standards is 20 %; (4) Grain moisture at harvest.

The grain moisture of the standards was determined by regular weekly sampling. When the grain moisture of the standards used in the experiment averaged first 25 %, then 20 %, the grain moisture of all the hybrids in the experiment was determined.

Table 1. Maturity parameters of the standards

Standards	Accepted FAO number	Days to silking	25 % grain moisture (%)	20 % grain moisture (%)	Grain moisture at harvest (%)
St1	340	66.0	25.0	18.7	18.4
St2	380	70.0	28.5	19.6	19.4
St3	370	67.0	29.1	20.2	20.1
St4	350	66.0	27.6	19.8	19.7
Mean		67.25	27.55	19.57	19.4

The steps in the calculation for each maturity group and each experiment are as follows: (a) all the standards sown in the experiment are also treated as maturity group standards; (b) the standard mean is calculated for each maturity parameter; (c) each maturity parameter for each hybrid is expressed as a % of the standard mean; (d) the mean of the relative values of the maturity parameters is calculated as the arithmetic mean of the four relative values; (e) the a and b constants of the $y = a + b*x$ equation are calculated by linear regression between the mean of the relative values of the maturity parameters of the standards (x) and the known FAO number of the standards (y)

the FAO number of any hybrid included in an experiment with the above standards can then be calculated from the equation $y = a + b*x$, where x = the mean of the relative values of the maturity date parameters, and y = the FAO number.

RESULTS AND DISCUSSION

Example of the calculation:

The maturity parameters of the standards in the given experiment and the mean of each parameter are summarised in Table 1.

The maturity parameters of all the standards expressed as a percentage of the standard mean are presented in Table 2.

Table 2. Maturity parameters of the standards as a percentage of the standard mean

Standard	Accept FAO number (y)	Days to silking	25 % grain moisture (%)	20 % grain moisture (%)	Grain moisture at harvest (%)	Mean of relative maturity parameters (x)	Calculated FAO number (based on y'= 4,2721x-67.211)
St1	340	98.14	90.74	95.53	94.85	94.82	337
St2	380	104.09	103.45	100.13	100.00	101.92	368
St3	370	99.63	105.63	103.19	103.61	103.01	373
St4	350	98.14	100.18	101.15	101.55	100.25	361

Linear regression analysis was then carried out between the mean of the relative values of the maturity parameters of the standards (x) and the accepted FAO number (y). The result of linear regression in this example was: $y = 4.2721x - 67.211$. In order to determine the FAO numbers of new hybrids using this equation, the maturity parameters of the new hybrids (Table 3) were first expressed as a percentage of the standard mean (Table 4).

Table 3. Maturity parameters of new hybrids

Hybrids	Days to silking	25 % grain moisture (%)	20 % grain moisture (%)	Grain moisture at harvest (%)
HIB5	61	23.9	20.0	19.9
HIB6	64	23.3	19.4	19.2
HIB7	73	29.2	22.3	21.2

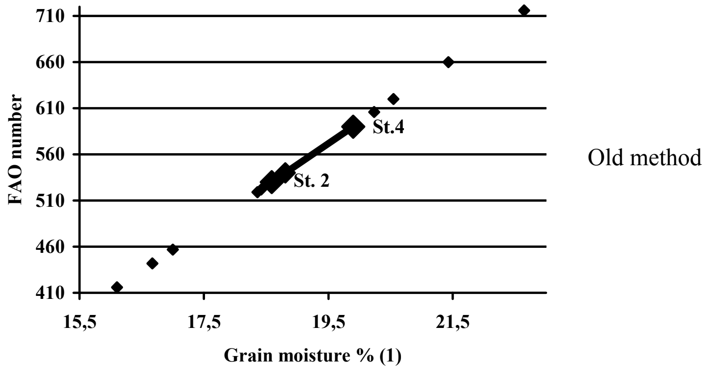
The number obtained as the mean of the relative maturity parameters was substituted for x in the equation, and the y value represented the FAO number of the hybrid.

Table 4. Maturity parameters of the new hybrids as a percentage of the standard mean

Hybrids	Days to silking	25 % grain moisture (%)	20 % grain moisture (%)	Grain moisture at harvest (%)	Mean of relative maturity parameters (x)	Calculated FAO number
HIB5	90.71	86.75	102.17	102.58	95.55	341
HIB6	95.17	84.57	99.11	98.97	94.45	336
HIB7	108.55	105.99	113.92	109.28	109.43	400

*Based on the equation: y = 4.2721x – 67.211

Using the above method, FAO numbers were calculated from the results of the official variety trials carried out in 2000, which were then compared with the FAO numbers obtained using the traditional method. The results obtained for 2nd and 3rd year hybrids in the FAO 500 group and for 2nd year hybrids in the FAO 300 group are presented below.



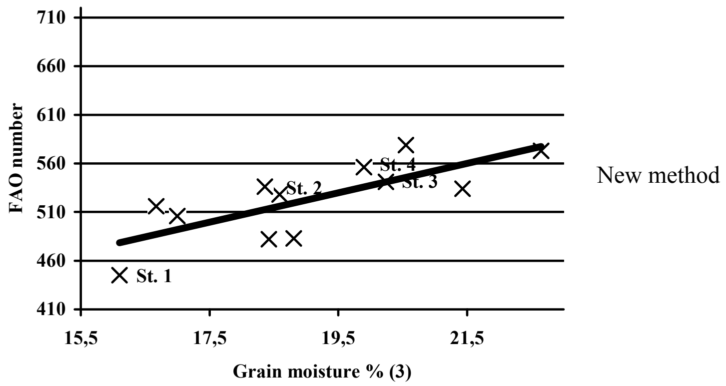


Fig. 2. Relationship between grain moisture and FAO number, National Institute for Agricultural Quality Control, 2000 FAO 500

In the FAO 500 group, the FAO numbers of the hybrids calculated using the old method ranged from 416 to 716. Only for one hybrid (Hybrid 7) was the FAO number between those of the two maturity group standards (Standard 2 and Standard 4) (Fig. 3), while the remainder had to be determined by extrapolation. In biology, extrapolation must always be treated with reservation, and this is particularly true of FAO numbers in the range of 700. By contrast, when the FAO numbers were calculated using the new method, they all came within the range (450–590) covered by the previously determined FAO numbers of the standards (Fig. 2).

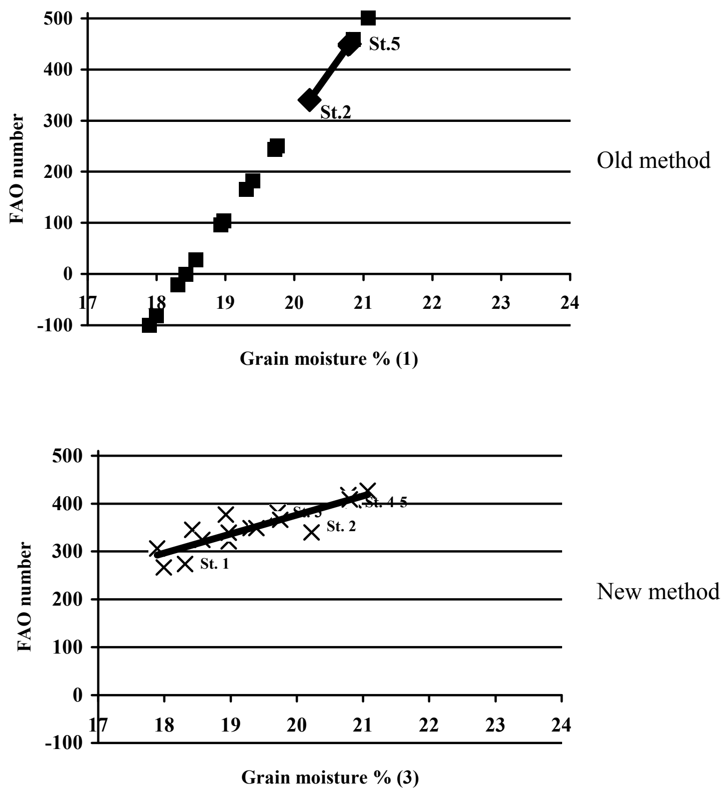


Fig. 3. Relationship between grain moisture and FAO number. National Institute for Agricultural Quality Control, 2000, FAO 300

Only two hybrids (Hybrid 1: 573 and Hybrid 6: 579) had values outside the range calculated for the FAO numbers of the standards using the new method (445–556), and even these were within the limits determined for the maturity group (500–599).

A similar situation was found in the FAO 300 group. The old method of calculation was founded on the difference in grain moisture between the two maturity group standards. Since in this group the difference between the two maturity group standards was less than 1 % (20.8%–20.22%), while the $LSD_{5\%}$ value was 2.33 %, the FAO number for each 1 % difference in grain moisture was 189. Consequently, the FAO numbers calculated using this method exhibited very great deviation (–100 to +500). By contrast, the vast majority of the FAO numbers calculated using the new method were within the limits for the maturity group (300–399) (Fig. 3), while only two hybrids (Hybrid 3: 427 and Hybrid 8: 418) fell outside the FAO number range of the standards. As in these two examples, the new method of calculating

FAO numbers also gave better results in the other maturity groups.

The advantages of the new method can be summarised as follows:

More maturity parameters are taken into consideration, thus improving reliability. In addition to grain moisture at harvest, two additional grain moisture contents, measured in a relatively high grain moisture range, and the flowering date are also included. In a series of experiments carried out in several European countries for a number of years, DERIEUX and BONHOMME (1982) established the fact that the reliability of maturity group determinations is improved by measuring grain moisture at several dates and by taking the date of silking into account.

Regression between the maturity parameters and the FAO number is calculated using several standards, thus reducing the effect of the genotype × environment interaction and the experimental error.

As a result, the fluctuation in the FAO number for each 1 % grain moisture between years and between experiments is reduced. A further advantage is that breeders can calculate the FAO numbers of their hybrids more accurately from their own results and can thus enter them for trials in the appropriate maturity group. In 2000 the method was adopted as an official method by the National Institute for Agricultural Quality Control (SZIEBERTH, 2000).

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NOVI METOD ZA ODREĐIVANJE FAO GRUPE ZRENJA KUKURUZA (*ZEA MAYS* L.)

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Izvod

FAO brojevi, koji označavaju grupu zrenja kod kukuruza , generalno se izčunavaju na osnovu sadržaja vlage pri berbi, koja se značajno smanjila u poslednjim dekadama. U mnogim zemljama kukuruz se bere sa sadržajem vlage u zrnu oko 20%. Smanjenjem sadržaja vlage u zrnu pri berbi smauje se razlika u sadržaju vlage između grupa zrenja i/ili između pojedinih hibrida. Pouzdanost merenja sadržaja vlage u zrnu nije poboljšavana paralelno sa smanjenjem razlika između hibrida što otežava određivanja datuma sazrevanja hibrida. Novi metod za rešeje ovoga problema je testiran iuspešno korišćen poslednje dve godine u oficijelnim eksperimentima u Mađarskoj. Novi metod ima nekoliko prednosti: (a) Korišćenje većeg broja parametara zrelosti što daje pouzdanije rezultate ocenjivanja; (b) Regresija između parametara zrelosti i FAO brojeva se izračunava korišćenjem nekoliko standarda tako da se smanjuje efekat Gx E interakcije i eksperimentalna greška. Kao rezultat se javlja godišnje smanjenje fluktuacija FAO brojeva i za 1% vlage.

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