# Fibre sorghum: influence of the harvesting methods on plant moisture and fibre content

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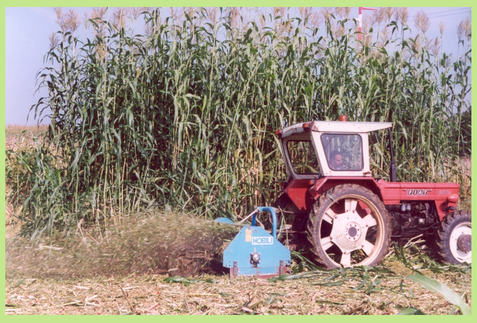
Sorghum fibre can be used to obtain paper, ethanol and electricity. Many experimental contributions established an excellent adaptability of fibre sorghum hybrids in both Italian and European environment (Peyre, 1979; Mariani *et al*., 1989; Jacquin and Labalette, 1998; Belocchi *et al*., 1999; Quaranta *et. al*., 1999). On the contrary, some aspects related to harvesting methods based on mechanization need further investigations (Recchia *et al*., 1999; Monteleone *et al*., 2000).
Aim of this research was to study the possibility of an adequate mechanization of harvesting operation in fibre sorghum hybrid cultures. Machinery, developed for other crops, were employed to compare three different harvesting methods: a) whole stem harvesting (by mower); b) whole stem harvesting (by mower) plus stem conditioning (by Cambridge roll); c) stem chopping (by chopper).



## MATERIALS AND METHODS

Field experiments were carried out in 2001 and 2002 at the Inviolatella farm of Cereal Research Institute of Rome (41°58' N, 12°28' E) on deep soils having an outright clayey texture.
Two different fibre sorghum hybrids, H 133 (medium-maturing) and H 132 (late- maturing), were tested. In 2001 sowing time was May, 15; in 2002 two sowing dates were chosen: April, 23 (early sown) and May, 20. Sorghum hybrids were sowed in two adjacent large-plots (750 $m^2$ each ). Each one was divided into nine sub-plots of 80 $m^2$ in order to test, by three replicates, the three harvesting methods scheduled.

Table 1 - Rome, Inviolatella farm, 2001 and 2002: trials management.

| | 2001 | 2002 | |
|---|---|---|---|
| Preceding crop | soft wheat | maize | barley |
| Fertilization | | | |
| N (kg $ha^{-1}$) | 150 | 150 | |
| $P_2O_5$ (kg $ha^{-1}$) | 80 | 80 | |
| Sowing | 15 May | 23 April | 20 May |
| Emergence | 22 May | 10 May | 28 May |
| Thinning | 7 June | - | 13 June |
| Weeds control | terbuthylazine | terbuthylazine | |
| Water supplies | | | |
| date | 18 July | 8 July | 11 July |
| $m^3$ $ha^{-2}$ | 800 | 800 | 800 |

Table 1 reports general information on trials management. Each sorghum hybrid was harvested 14 days after flowering. Three different mechanical harvesting methods were tested: a) whole stem harvesting (by mower); b) whole stem harvesting (by mower) plus stem conditioning (by Cambridge roll); c) stem chopping (by chopper).
Before mechanical harvesting, three significant samples of each genotype, of at least 1.5 $m^2$ , were harvested by hand. On these plants, stem height at last blade joint, stem diameter, yield of aboveground fresh and dry biomass were measured.
After mechanical harvesting, biomass sample were taken and scanned by NIRSystem 6500 (near-infrared reflectance spectrophotometer) to determine the concentrations of NDF (neutral detergent fibre), ADF (acid detergent fibre) and ADL (acid detergent lignin). In this work we present only 2001 results because the 2002 data now being drawn up.
Biomasses, mechanically harvested, were left in the field for drying. Samples were weekly collected from each plot, weighed, dried at 105°C for 36 h in a forced-air oven, and re-weighed to establish moisture content.

## WEATHER CONDITIONS

Figure 1 shows the decadal maximum and minimum temperatures and rainfall from April to October for the two-year trial (2000 and 2001) and for the 27-year average (1974-2000).

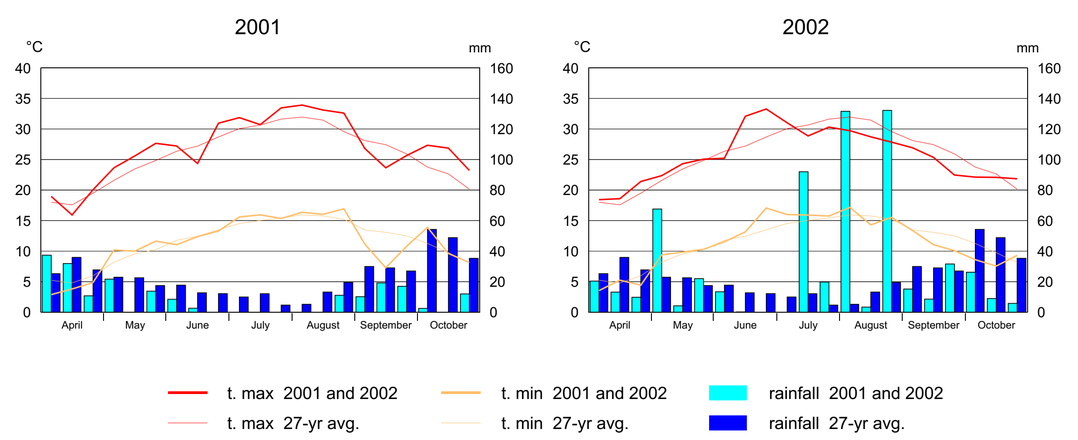



Figure 1 - Rome, Inviolatella Farm. Decadal maximum and minimum temperature (°C) and rainfall (mm) from April to October for 2001, 2002 and 27-yr average (1974-2000).

During 2001, precipitations above 10 mm were absent from sowing up to the first September fortnight. The summer temperatures were above the seasonal average, except a short period in the second July fortnight. October was also characterised by higher temperatures with respect to the average and rainfall was poor.
In 2002 weather conditions were completely different: during the summer months, except for June characterized by no rainfall and very high temperatures, abundant and unusual rainfall occurred and temperatures were above the seasonal average. October was colder and less rainy than the seasonal average.

## RESULTS AND DISCUSSION

The different weather conditions of the two growing season significantly affected sorghum yield. In 2001 the stem height and the yield of the two hybrids were rather low (table 2) since weather conditions were definitively unfavourable. The average stem height and diameter were 376 cm and 19.3 mm, respectively; the aboveground fresh biomass was 100.0 t/ha and dry matter was 33.1 t/ha. As expected, the late-maturing hybrid H 132 was lightly more productive than the early one H 133.

Table 2 - Plant height (at the last blade joint), bottom stem diameter, fresh yield (aboveground biomass and stems+sheaths) and dry matter (DM) yield (aboveground biomass)

| Year | Sowing date | Hybrid | Plant height cm | Bottom stem diameter mm | Fresh yield aboveground biomass t $ha^{-1}$ | Fresh yield stems+sheaths t $ha^{-1}$ | DM yield aboveground biomass t $ha^{-1}$ |
|---|---|---|---|---|---|---|---|
| 2001 | 15 May | H 133 | 368 | 18.5 | 86.4 | 69.3 | 29.3 |
| | | H 132 | 383 | 20.1 | 113.6 | 96.6 | 37.0 |
| | | **Mean** | **376** | **19.3** | **100.0** | **83.0** | **33.1** |
| 2002 | 23 April | H 133 | 316 | 18.9 | 99.7 | 78.3 | 28.8 |
| | | H 132 | 447 | 20.3 | 115.5 | 95.1 | 39.6 |
| | | **Mean** | **382** | **19.6** | **107.6** | **86.7** | **34.2** |
| 2002 | 20 May | H 133 | 434 | 20.3 | 124.8 | 101.7 | 43.8 |
| | | H 132 | 473 | 22.7 | 144.0 | 124.9 | 49.6 |
| | | **Mean** | **454** | **21.5** | **134.4** | **113.3** | **46.7** |

In 2002 the average yield measured in the early sowing was similar to yield of the previous year. The best performance of morphological and productive parameters occurred for the sowing of May 2002 (table 2): stem height was 454 cm, diameter was 21.5 mm, the aboveground fresh biomass was 134.4 t/ha and dry matter was 46.7 t/ha.

Figure 2 and 3 show, for 2001 and 2002 respectively, the moisture content of the biomasses, drying in the field, in relation to the two hybrids and the three different harvesting methods.

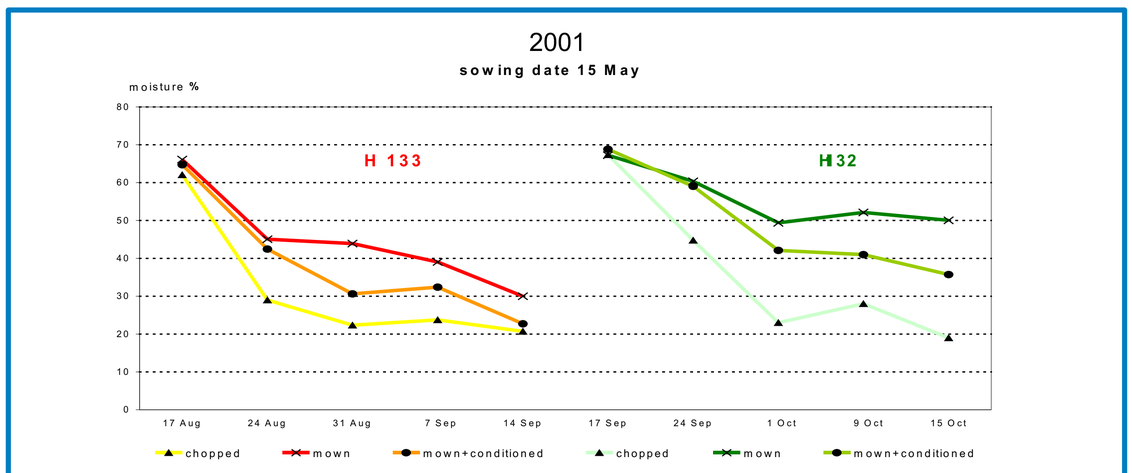



Figure 2 – Rome, 2001 - Moisture content (%) of the biomasses drying in the field.

In the year 2001 characterized by dry weather, by the stem chopping, a 20% of moisture was calculated for both hybrids in the chopped biomasses within two weeks indicating an adequate biomass drying. By using the others two harvesting methods (mower and mower plus roll) the medium-maturing hybrid H133 achieved 20-30% of moisture content after further two weeks; on the contrary, the moisture content of late-maturing hybrid H132 was about 50% when it was mown, and about 40% when mown and rolled.
The H133 hybrid, tested in the early sowing in 2002, showed (figure 3a) a fast decrease of moisture content (20% after two weeks) independent of harvesting methods. This was probably due to the scarce rainfall of the second decade of August. The abundant and unusual rainfall occurred in the third decade of August increased again the moisture content up to harvesting values. H 132, harvested one month later respect to H 133, reached about 30% of moisture content only with chopping method.
The results of the trial sown in May (figure 3 b) were strictly influenced by the environmental conditions (temperatures and rainfall) of 2002 (figure 1). The moisture level of chopped H133 was always over 40%; the mown and mown plus rolled biomasses moisture was about 60-70% at all the sampling time. Late-maturing hybrid H 132 was harvested at the end of September. The moisture content of chopped H132 biomass was 30% two weeks after harvesting, strongly favoured by the really scarce rainfall of October; on the contrary the mowed and mowed plus rolled H 132 biomasses moisture content decreased only up to about 50%.

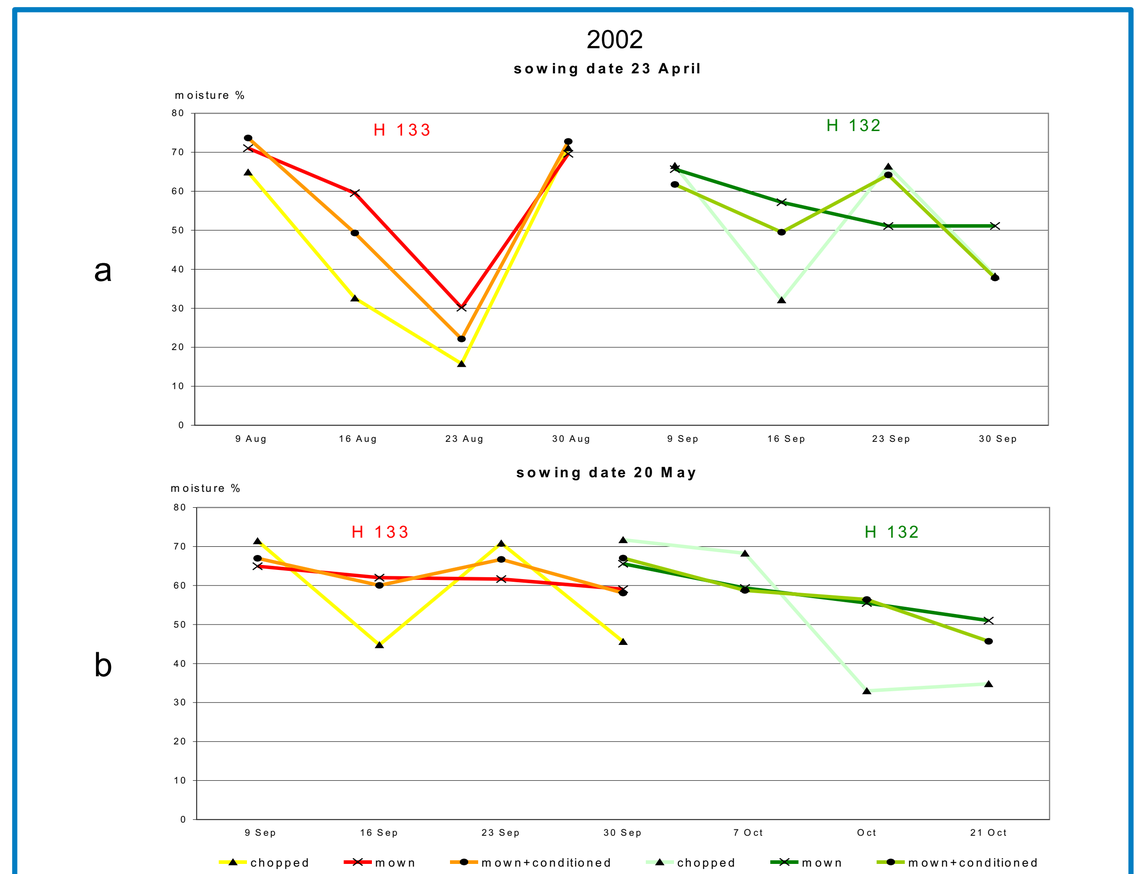



Figure 3 – Rome, 2002 - Sowing date 23 April (a) and 20 May (b). Moisture content (%) of the biomasses drying in the field.

In table 3 are reported the values of the cell wall components of the two fibre sorghum hybrids and the three harvesting methods recorded in 2001 trial. The mean value for NDF, ADF and ADL content (expressed as percentage of dry matter) are 61.58, 38.49 and 3.11, respectively. Differently from ADL, neither NDF, nor ADF contents display significant statistical diversity between hybrids and their interactions with the different harvesting conditions. The harvesting conditions seems to cause significant differences in NDF and ADF content especially between the cutting and the other two treatments.

Table 3 - Rome, 2001. Concentrations of NDF (neutral detergent fibre), ADF (acid detergent fibre) and ADL (acid detergent lignin) for two hybrids and three harvesting methods.

| Hybrid | Harvesting method | NDF % | ADF % | ADL % |
|---|---|---|---|---|
| H 133 | | 61.90 | 38.59 | 3.24 *a* |
| H 132 | | 61.26 | 38.39 | 2.99 *b* |
| | chopped | 62.99 *a* | 40.34 *a* | 3.15 |
| | mowed | 61.09 *b* | 37.15 *b* | 2.95 |
| | mowed+rolled | 60.66 *b* | 37.98 *b* | 3.23 |
| H 133 | chopped | 63.17 | 41.46 | 3.20 *a* |
| | mowed | 61.92 | 37.57 | 3.25 *a* |
| | mowed+rolled | 60.60 | 36.73 | 3.26 *a* |
| H 132 | chopped | 62.80 | 39.22 | 3.10 *a* |
| | mowed | 60.26 | 36.72 | 2.65 *b* |
| | mowed+rolled | 60.71 | 39.24 | 3.21 *a* |
| **Mean** | | **61.58** | **38.49** | **3.11** |

Within each column for each treatment, means followed by different letter are significantly different at the 0.05 level of probability by Duncan's Multiple Range Test.

## CONCLUSIONS

Although the trials were carried out in two years characterized by unusual climatic conditions (rainfall considerably scarce in 2001, while strongly abundant in 2002), from our data we can make some general conclusions. One or two weeks of field drying after harvesting seems to be enough to reduce the biomasses moisture content up to 20-30%, especially for the medium maturing hybrid H133. The late maturing hybrid H132, harvested at the beginning of autumnal season, runs the risk of an unsuitable field drying.
The stem chopping seems to be the harvesting method to obtain the faster moisture loss, but also the method that make easier a novel assumption of water depending on the seasonal rainfall.
The development of special devices for fibre sorghum harvesting is necessary: it obviously depends on the industrial interest to an expanded use of this annual crop for pulp production.

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