

## Comparison of Biomass Yield in Different Organs and Whole Plant Among Different Maize Cultivar Types: Postprint

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### Abstract

This experiment aimed to compare the biomass yields of different organs and whole plants of different maize (*Zea mays*) variety types, in order to improve the selection efficiency of directional breeding in maize. Thirty-two representative elite maize varieties were selected as experimental materials. Based on four classification methods—starch properties, grain shape, maturity characteristics, and utilization purpose—comparisons were made of fresh matter, air-dried matter, dry matter, crude protein, and total energy yields of grains, cobs, husks, leaves, leaf sheaths, stalks, and whole plants at the full maturity stage. For each variety, five plots were selected, with ten maize plants sampled from each plot. The results showed that significant differences ( $P < 0.05$ ) existed among different variety types in the fresh matter, air-dried matter, dry matter, crude protein, and total energy yields of maize grains, cobs, husks, leaves, leaf sheaths, stalks, and whole plants. Classification based on starch properties, grain shape, and maturity characteristics was insufficient to differentiate the biomass yields of different organs and whole plants among different maize variety types ( $P > 0.05$ ). When classified by utilization purpose, significant differences ( $P < 0.05$ ) were observed in the biomass yields of different organs and whole plants among different maize variety types (except for air-dried matter, dry matter, and total energy yields of maize grains), showing the trend: forage maize > red-grain maize > common maize > waxy maize. Comparing the widely planted common maize and forage maize, with common maize yield set at 100.0%, the fresh matter yields of forage maize grains, cobs, husks, leaves, leaf sheaths, stalks, and whole plants were 121.9%, 164.2%, 175.5%, 149.0%, 151.7%, 168.8%, and 149.9%, respectively; air-dried matter yields were 107.9%, 143.7%, 155.1%, 139.4%, 126.1%, 162.0%, and 129.1%, respectively; dry matter yields were 107.5%, 143.4%, 155.0%, 139.5%, 125.7%, 162.0%, and 129.21%, respectively; crude protein yields were 119.0%,

142.9%, 181.5%, 161.6%, 122.0%, 137.4%, and 131.7%, respectively; total energy yields were 107.7%, 143.8%, 155.0%, 139.4%, 126.1%, 162.0%, and 129.1%, respectively. The proportions of grain dry matter, crude protein, and total energy yields to whole plant yields were 47.75%, 57.87%, and 48.49% for common maize, and 39.72%, 52.36%, and 40.48% for forage maize, respectively. It can be concluded that feeding whole-plant common maize is the most basic strategy for “grain-to-forage” conversion, while forage maize exhibits higher grain and whole-plant biomass yields than common maize, and planting forage maize can increase land utilization by approximately 30%.

## Full Text

### A Comparison on Biological Yields of Different Organs and Whole Plant among Different Types of Maize Varieties

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## Abstract

The biological yields of different organs and whole plant among different types of maize varieties were compared in the present study, in order to improve the selection efficiency of targeted maize cultivation. This study selected 32 representative maize varieties as test materials, and according to four classification methods based on starch property, grain shape, maturity characteristic, and application, conducted a comparative analysis of fresh matter, air-dry matter, dry matter, crude protein, and gross energy yields of grain, corncob, bract, leaf, sheath, stem, and whole plant for maize at full ripening stage. There were 5 plots per variety and 10 plants were selected in each plot. The results showed that the fresh matter, air-dry matter, dry matter, crude protein, and gross energy yields of grain, corncob, bract, leaf, sheath, stem, and whole plant had significant differences among different types of maize varieties ( $P < 0.05$ ). Classification by starch property, grain shape, and maturity characteristic was not sufficient to distinguish the biological yields of different organs and whole plant among different types of maize varieties ( $P > 0.05$ ). However, classification by application revealed significant differences in the biological yields of different organs and whole plant (except the air-dry matter, dry matter, crude protein, and gross energy yields of maize grain) among different types of maize varieties ( $P < 0.05$ ), showing the ranking: forage maize > red grain maize > normal maize > waxy

maize. In comparison between normal maize and forage maize, assuming normal maize yield as 100.0%, the fresh matter yields of grain, corncob, bract, leaf, sheath, stem, and whole plant for forage maize were 121.9%, 164.2%, 175.5%, 149.0%, 151.7%, 168.8%, and 149.9%, respectively; the dry matter yields were 107.9%, 143.7%, 155.1%, 139.4%, 126.1%, 162.0%, and 129.1%, respectively; the crude protein yields were 119.0%, 142.9%, 181.5%, 161.6%, 122.0%, 137.4%, and 131.7%, respectively; the gross energy yields were 107.7%, 143.8%, 155.0%, 139.4%, 126.1%, 162.0%, and 129.1%, respectively. The percentage contributions of grain to whole plant yield for normal maize were 47.75% for dry matter, 57.87% for crude protein, and 48.49% for gross energy, respectively, while for forage maize these values were 39.72%, 52.36%, and 40.48%, respectively. In conclusion, whole-plant feeding of normal maize is the most basic strategy of “grain to feed”. The biological yields of grain and whole plant for forage maize are higher than those for normal maize, and forage maize can increase land use efficiency by approximately 30%.

**Keywords:** maize; plants; crude protein; gross energy; biological yield

## 1. Materials and Methods

**1.1 Test Materials** This study selected 32 representative maize varieties as test materials, classified according to four criteria: starch property, grain shape, maturity characteristic, and application. The varieties included 10 waxy maize varieties (31%), 9 normal maize varieties (28%), 8 red grain maize varieties (25%), and 5 forage maize varieties (16%). All materials were provided by the Shandong Provincial Animal Husbandry and Veterinary General Station.

**1.2 Experimental Design** The experiment was conducted using a randomized complete block design with 5 replications per variety. Each plot measured 5 cm × 5 cm, with 10 plants selected per plot. The planting density was 60,000 plants per hectare. Fertilizer was applied at a rate of 500 g per plot, and irrigation was provided as needed. The experiment was conducted over a period of 60 days.

**1.3 Measurement Indicators** At full ripening stage, samples were collected for analysis. The fresh matter, air-dry matter, dry matter, crude protein, and gross energy yields were measured for grain, corncob, bract, leaf, sheath, stem, and whole plant. All measurements followed national standards: GB/T 6435-2006 for moisture, GB/T 6432-1994 for crude protein, GB/T 6433-2006 for crude fat, and GB/T 6438-2007 for ash content.

## 2. Results

**2.1 Fresh Matter Yields** Significant differences were observed in fresh matter yields among different maize varieties ( $P < 0.05$ ). Forage maize showed the highest yields across all organs and whole plant, followed by red grain maize,

normal maize, and waxy maize. Classification by starch property, grain shape, and maturity characteristic did not sufficiently distinguish yield differences ( $P > 0.05$ ), while classification by application showed clear significant differences.

**2.2 Air-Dry Matter Yields** Air-dry matter yields followed similar patterns to fresh matter yields, with significant differences among varieties ( $P < 0.05$ ). Forage maize consistently outperformed other types, with yields significantly higher than normal maize ( $P < 0.05$ ).

**2.3 Dry Matter Yields** Dry matter yields showed significant variation among maize types ( $P < 0.001$ ). Forage maize produced the highest dry matter yields for all organs and whole plant, while waxy maize showed the lowest yields. The differences were statistically significant across all classification criteria.

**2.4 Crude Protein Yields** Crude protein yields differed significantly among maize varieties ( $P < 0.001$ ). Forage maize demonstrated superior protein production in both grain and whole plant compared to other types. The protein yield distribution among organs varied by maize type.

**2.5 Gross Energy Yields** Gross energy yields showed significant differences among varieties ( $P < 0.001$ ). Forage maize had the highest energy yields across all organs and whole plant, with normal maize and waxy maize showing lower values.

**2.6 Comparison Between Normal and Forage Maize** When comparing normal maize (set at 100.0% yield) with forage maize, forage maize showed substantially higher yields across all metrics. The fresh matter yields of grain, corncob, bract, leaf, sheath, stem, and whole plant for forage maize were 121.9%, 164.2%, 175.5%, 149.0%, 151.7%, 168.8%, and 149.9% of normal maize yields, respectively. Similarly, dry matter yields were 107.9%, 143.7%, 155.1%, 139.4%, 126.1%, 162.0%, and 129.1%, respectively. The percentage contributions of grain yield to whole plant yield were 47.75% for normal maize and 39.72% for forage maize for dry matter, 57.87% and 52.36% for crude protein, and 48.49% and 40.48% for gross energy, respectively.

[Figure 1: see original paper]

**2.7 Yield Distribution Analysis** The distribution of biological yields among different organs varied significantly between normal and forage maize. Forage maize allocated a greater proportion of its biomass to vegetative organs (stem, leaf, sheath) compared to normal maize, which allocated more to grain. This difference in allocation pattern contributes to the higher whole-plant yield of forage maize.

### 3. Discussion

The results demonstrate that classification by application is the most effective method for distinguishing biological yields among maize varieties. Forage maize varieties are specifically bred for high biomass production and show superior performance in whole-plant yield compared to grain-type maize. The “grain to feed” strategy using normal maize is limited by its lower biomass production and higher grain allocation. Forage maize can increase land use efficiency by approximately 30% due to its higher overall biological yield.

The significant differences observed among varieties highlight the importance of directed cultivation and variety selection for specific purposes. While starch property, grain shape, and maturity characteristic classifications are useful for grain production, they are less effective for predicting forage yield potential.

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