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Biomass and energy production of catch crops in areas with deficiency of precipitation during summer period in central Bohemia

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ABSTRACT

The biomass production dynamics of catch crops, volunteers and weeds in dependence on precipitation and air temperature, was studied in central Bohemia from 2004 to 2006. The cover of individual components of the growth was monitored during the same period. Also measured were energy and efficiency of utilization of global radiation by catch crops and volunteers. The catch crops included the following species: *Brassica napus*, *Lolium multiflorum*, *Lolium perenne*, *Phacelia tanacetifolia*, *Sinapis alba*, *Trifolium incarnatum*, *Raphanus sativus* var. *oleiformis* and *Trifolium subterraneum*. The highest biomass production and the highest cover of catch crops were observed in treatments with *S. alba* (1382.0 kg ha^{-1}, 47.8%). The average biomass production (sum of catch crops, volunteers and weeds) was highest in treatments with *S. alba*, *R. sativus*, and *P. tanacetifolia* and lowest in treatments with *B. napus*, *L. multiflorum* and *L. perenne*. It was demonstrated that an increase in the percentage share of volunteers caused a decrease in the biomass production of catch crops. The average energy production ranged from 0.31 to 2.37 MJ m^{-2} in treatments with catch crops, and from 0.25 to 0.89 MJ m^{-2} in treatments with cereal volunteers. The highest effectivity of global radiation utilization, was determined in treatments with *S. alba* (0.11–0.47%). Based on regression analysis the closest dependence between biomass production from all treatments on the experimental site and precipitation was observed from 1st May till the time of sowing and the average air temperatures from the sowing period till the time of the last biomass production assessment.

1. Introduction

Production of intercrops is one of the main factors which lead to stabilization of circulation of organic matter in arable land. Input of organic matter to the soil is associated with the increase in soil fertility and soil aggregate stability etc. [1]. Catch crops biomass energy can contribute to the increase in the share between the gained and inserted energy in agricultural systems because the additional energy input grows within the framework of agricultural progression [2]. Vos and van der Putten [3] comment that a regression, forced through the origin, gave a common slope of 1.12 g dry matter of the catch crops accumulated per MJ intercepted global radiation, irrespective of season, species, sowing date or nitrogen treatment. The catch crops have a positive effect on the soil fertility, elimination of erosion and on limiting the loss

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of nutrients [4,5]. They are also very acceptable as breakers of crop rotations [6] and they can increase the yield of the main crop [7]. Catch crops also eliminate the occurrence of diseases and pests [8,9] and contribute to weed regulation [10–12]. The progress of catch crops is decided by the amount of precipitation, water in the soil supply and the time of sowing [13,14]. Methods of soil cultivation before the catch crops sowing determine the quantity of volunteers and weeds. Shallow stubble ploughing and elimination of soil reversion leads to higher development of volunteer [15]. Volunteer's development can lead to the suppression of a catch crop and its biomass production [16]. Garbe and Heitefuss [17] point out that a cereal's volunteers can be suppressed by growing catch crops. The volunteer is undesirable from the phytosanitary aspect, as a host of pests and diseases [18]. However they also have a positive impact on biomass production, fixation of light energy and nutrients, elimination of soil erosion, etc. Beaudoin *et al.* [19] state that the average dry volunteers' biomass production of *Pisum sativum*, *Hordeum vulgare* and *Brassica napus* was 0.9 Mg ha^{-1} and volunteers took up as much N as catch crops. Catch crops biomass production is dependent on soil and climatic characteristics of the geographic location. Gregorová [20] documented a positive correlation between shoot biomass production of *Phacelia tanacetifolia*, precipitation and average daily air temperature from July until August. Total catch crops dry biomass production is dependent on the duration of the vegetation period on the site.

The aim of this study was to determine the values of the dry shoot biomass production and energy of different crops in dependence on the abiotic factors of the environment and development of volunteers and weeds as the base for stabilization of the organic matter cycle and energy flows in arable land systems. Specific objectives of this research include:

- Determination of the catch crops, volunteers and weeds dynamics of the above-ground biomass production in areas with low precipitation
- Determination of the catch crops and volunteers energy production at the end of the vegetation period. Measuring their effectiveness in utilization of global energy.
- Determination of the dependence of catch crops' biomass production on precipitation during the vegetative period and on temperature during the vegetative growth period
- Determination of the mutual interdependence between the catch crops biomass production and the development of weeds and volunteers.

2. Materials and methods

The experiment was established in central Bohemia (GSP coordinates: 50°04′34.45"N, 14°09′22.351"E – WGS 84) on an experimental plot in Červený Újezd at an elevation of 398 m above sea-level, with an average yearly temperature of 7.9 °C and yearly precipitation of 525.8 mm. According to the latest climatic regionalization of the Czech Republic [21] the locality falls into Class III, which is characterized by an average duration of the main vegetative period within the range of 160–177 days, the average annual totals of precipitation below 580 mm and the rainless period of more than 22 days. Average soil texture of the experimental plots was as follows: soil particles smaller than 0.01 mm: 53.21%, 0.01–0.05 mm: 38.54%, 0.05–0.1 mm: 2.32% and 0.1–2 mm: 5.93%.

Eight plant species cultivated as stubble catch crops were observed within the framework of experiments from 2004 to 2006. They were *B. napus* L. (Bristol variety), *Lolium multiflorum* Lamk. (Lonar), *Lolium perenne* L. (Prolog), *P. tanacetifolia* Bentham (Větrovská), *Sinapis alba* L. (Veronika) and *Trifolium incarnatum* L. (Kardinál). The species *Raphanus sativus* L. var. *oleiformis* Pers. (Ikarus) and *Trifolium subterraneum* L. (new cultivation) were evaluated within the period of years 2005–2006. The area of the experimental plot was 30 m^2 (3 × 10 m). Each of the variants had four replicates (random blocks). The catch crop sowing followed the *Triticum aestivum* L. (Alana variety) harvest.

Straw was crushed and dispersed over the field during harvest. Harvesting dates were on 9.8.2004, 19.8.2005 and 24.8.2006. In 2004 stubble ploughing was carried out to a depth of 0.12 m because of the very dry soil. In 2005 and 2006 the field was prepared by a rotary tiller to a depth of 0.08 m because of high soil moisture. Catch crops were sowed (13.8.2004, 24.8.2005 and 30.8.2006) immediately after stubble ploughing. This was followed by harrowing of the field plots. The catch crops sowing rates are shown in Table 1.

2.1. Dry shoot biomass production and degree of coverage of catch crops

Dry shoot biomass production (kg ha^{-1}) and degree of coverage (%) by catch crops, cereal volunteers and weeds were assessed on 1.10., 26.10., and 8.11. in 2004, on 14.9., 4.10., and 20.10. in 2005 and 26.9., 11.10., and 1.11. in 2006. Four variants were established in two replicates per variant. Each variant had 0.1 m^2. Plants were cut near the surface. Degree of coverage was determined by a random method using frames of 0.25 m^2, also in two replicates on the experimental site.

2.2. Energy content in above-ground biomass of catch crops and volunteers

An average biomass of catch crops from each plot was sampled to determine the content of energy at the final evaluation of the experiment (8.11.2004, 20.10.2005, and 1.11.2006). The energy of volunteers' biomass was determined in 4 average samples from each treatment. The calorific value in the dry biomass of catch crops and volunteers was measured by the automatic adiabatic calorimeter system IKA C 5000

Table 1 – Catch crop sowing rates in 2004–2006.

Catch crop	Seeding rate (kg ha^{-1})	Catch crop	Seeding rate (kg ha^{-1})
Brassica napus	10	*Sinapis alba*	20
Lolium multiflorum	40	*Raphanus sativus*	25
Lolium perenne	20	*Trifolium incarnatum*	25
Phacelia tanacetifolia	10	*Trifolium subterraneum*	30