Allegato 6

ASSOCIAZIONE ITALIANA
DI AGROMETEOROLOGIA
XX CONVEGNO NAZIONALE

UNIVERSITÀ
DEGLI STUDI
DI MILANO

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AGRONOMIA e ARBORICOLTURA

SOCIETÀ ITALIANA
DI AGRONOMIA
XLVI CONVEGNO NAZIONALE

AIAM SIA MILANO 2017

STRATEGIE INTEGRATE PER AFFRONTARE LE SFIDE CLIMATICHE E AGRONOMICHE NELLA GESTIONE DEI SISTEMI AGROALIMENTARI

INTEGRATED STRATEGIES FOR AGRO-ECOSYSTEM MANAGEMENT TO ADDRESS CLIMATE CHANGE CHALLENGES

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A CURA DI
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Strategie integrate per affrontare le sfide climatiche e agronomiche nella gestione dei sistemi agroalimentari

Integrated strategies for agro-ecosystem management to address climate change challenges

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ISBN 9788898010707
DOI 10.6092/unibo/amsacta/5692

Grafica di copertina realizzata da Matteo Grandi

Bologna, 2017

INFLUENCE OF THERMAL GRADIENT ON THE DYNAMICS OF GROWTH AND DEVELOPMENT OF EMMER IN GARFAGNANA
INFLUENZA DEL GRADIENTE TERMICO SULLE DINAMICHE DI CRESCITA E SVILUPPO DEL FARRO IN GARFAGNANA

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Abstract

Emmer (*Triticum dicoccum* Sch.) is a traditional crop of Garfagnana (Tuscany, Central Italy), where the typical environmental characteristics and a low-input agronomic management favored the development of a local variety. The cultivation area is located at an altitude ranging from about 300 to almost 1200 m a.s.l. characterized by a significant thermal gradient affecting the biological cycle of the crop. The aim of the research, is to assess the influence of such climatic variability in Garfagnana emmer growth and development. Results showed that the altitude and temperature are the most effective variables able to regulate the crop dynamics. In particular, we found that growing degree days calculated with a base temperature of 5 °C is significantly related to the phenological phase of the crop, showing how emmer thermal demand is lower compared to modern wheat varieties. Also, dry mater accumulation and plant height showed that emmer is able to grow even under extreme and marginal conditions. Further analysis will be performed at harvest in order to investigate the productivity of the three crop biotypes (mutico, semi-aristato and aristato) under the different environmental conditions considered.

Keywords: growing degree-days; *triticum dicoccum*; mountain farming; phenology; dry biomass.
Parole chiave: sommatorie termiche; *triticum dicoccum*; agricoltura di montagna; fenologia; biomassa secca.

Introduction

In Garfagnana the cultivation of emmer (*Triticum dicoccum* Sch.) it's always been related to the food tradition, to the point that in 1996 the PGI (Protected Geographical Indication) "Farro della Garfagnana" is obtained for the local production. Health benefits of emmer, and of ancient cereals in general, are partially attributed to the phytochemical composition of ancient grains and to the presence of some elements, such as slow release carbohydrates and proteins, able to ensure a high nutritional value (Dinelli et al. 2007). Such characteristics have been lost in new cereal varieties due to the strong genetic selection driven by the obtainment of high yields and improved technological properties. This led to varieties that, in order to express their potential in terms of yield and quality, require the use of intensive agricultural systems that use large energy inputs with consequent environmental impact and high production costs. For such reasons emmer almost disappeared due to its low yields, but its cultivation is maintained in marginal and mountain areas, of limited extension and low fertility, that were not suitable for more productive cereals. Garfagnana is one of these areas, where the typical environmental characteristics and a low-input and traditional agronomic management favored the maintenance of an ancient local variety. Emmer populations cultivated in the region are genetically very variable and mainly represented by three biotypes (mutico, semi-aristato and aristato) of *Triticum dicoccum* Sch characterized by different grain properties. The crop covers a relatively small area (200 ha) but the growing conditions are also very variable. In fact, a wide range of altitude from about 300 to more than 1200 m a.s.l. determines a strong variability in the growth and development of emmer, mainly due to a significant thermal gradient affecting the biological cycle of the crop (Porter et al.,1999; Bonhomme, 2000; Dalla Marta et al., 2011; Guasconi et al., 2011). The aim of the present research is to assess the influence of such climatic variability in Garfagnana emmer growth and development under traditional low-input farming management. In fact, to the aim of preserving a broad genic pool, it is necessary to provide for seed production systems that can safeguard this important biodiversity, and for which the effect of the environment is fundamental on the maintenance of the three main biotypes.

Materials and Methods

The experiment started in October 2016 in 9 experimental fields located in Garfagnana, ranging from an altitude of 350 to almost 1200 m. Soils are from deep (100-150 cm) to moderately deep (50-100 cm) with medium to fine texture.

The agronomic technique is the one normally adopted by local farmers, very simple and low-input. Soil tillage consists of a surface ploughing (25-30 cm) in August-September followed by a harrowing just before sowing. Sowing (90-150 kg/ha of dressed grain) is carried on in late September-early October, one month earlier over 800 m of altitude, by means of seeders, centrifugal fertilizer spreaders, or more often, manually. Then, harrowing is used to bury the grains into the soil. Fertilization is not applied, only manure is exceptionally used if available in the farm. The farming system commonly adopted is a 5-6 years rotation including 2-3 years of emmer followed by 2-3 years of grass (alfalfa, clove, ryegrass, etc.) used for in-farm hay production. Summary information for the experimental fields are reported in Table 1.

DOI 10.6092/unibo/amsacta/5692

FARM N.	ALTITUDE (m)	SOWING DATE	SEED RATE (kg/ha)	SOWING METHOD	POSITION IN THE ROTATION
F1	349	10/11/16	150	rows	**E** - E - E - A -A - A - A
F2	399	10/10/16	90	rows	E - **E** - F - (F)
F3	464	15/10/16	125	broad casting	E - **E** - (E) - M - M - M
F4	516	05/11/16	140	broad casting	**E** - E - M - M - M
F5	534	20/10/16	90	rows	**E** - E - F - (F)
F6	659	20/10/16	130	broad casting	E - **E** - E - M - M - M
F7	676	20/09/16	120	broad casting	E - E - **E** - F - (F)
F8	820	05/10/16	110	broad casting	E - E - M - M - M
F9	1198	25/10/16	130	broad casting	E - **E** - E - M - M - M

Tab.1: Agronomic information of experimental fields: F=field; E= emmer; A= alfalfa; F= fallow; M = meadow.
Tab. 1: dati agronomici relativi ai campi sperimentali: F=campo; E= farro, A= erba medica; F= maggese; M= prato.

The first sampling was carried on on May 12. Four samplings of 0,25 m^2 were collected in each field and the following data are measured: phenological phase (BBCH), plant height (cm), number of leaves and, after drying for 24 hours at 105 °C dry biomass (g/m^2). Meteorological data are collected by 9 thermoigrometric stations (HOBO® PRO series Onset, USA), one specifically installed in each field the study area. Temperature data are used for calculating the degree days accumulaton with different thresholds (0, 5, 6, 7 and 8 °C) in order to find the most suitable for the determination of flowering, and to investigate the effect of the altitude on the phenology dynamics of emmer. To this aim, simple and multiple regression analysis are carried on.

Results and Discussion

The simple linear regression between the altitude of the field and the phenological stage of the sampled emmer showed that the two parameters are significantly related (R^2= 0,908). In the same way, also crop growth is strongly related with altitude (R^2= 0,534) confirming its effect on the crop growth and development (Fig. 1).

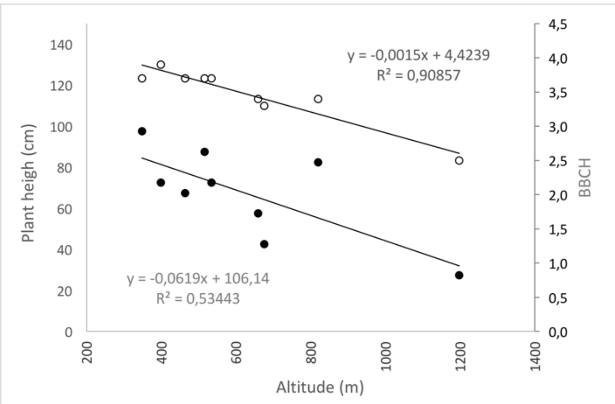

Fig.1: Linear regression between altitude (m) of the field and plant height (cm) and phenological stage (BBCH).
Fig.1: Regressione lineare tra la quota dei campi sperimentali (m) e l'altezza delle piante (cm) e la fase fenologica (BBCH).

Considering that the main variable showing a gradient with altitude is air temperature, that is also the driving variable of crop development, growing degree days (GDD) are calculated and plotted against the phenological phase measured in the different fields. In order to find the best indicator, different base temperatures are tested (GDD_0, GDD_5, GDD_6, GDD_7 and GDD_8 °C) and degree days are accumulated starting from the sowing date to the day of the sampling. The most suitable base temperature is 5 °C as demonstrated by the determination coefficient (R^2= 0,709; P<0,001) (Fig. 2).

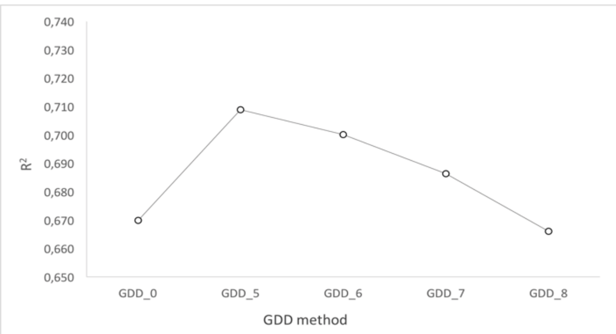

Fig.2: Trend of the determination coefficient (R^2) between emmer phenological phase and growing degree days calculated with different base temperatures.
Fig.2: Andamento del coefficiente di determinazione (R^2) tra la fase fenologica del farro e le sommatorie termiche calcolate con diverse temperature di base.

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Milano, 12-14 settembre 2017.
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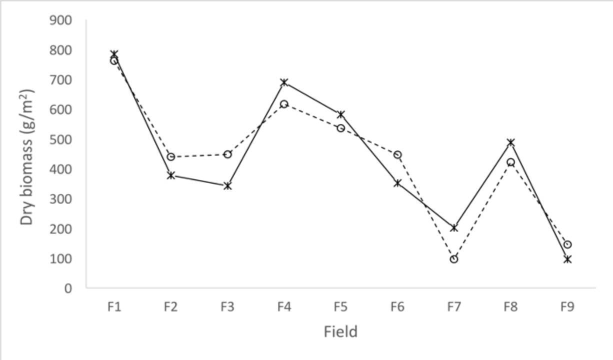

Fig.3: Dry biomass accumulation (g/m^2) observed (solid line) and estimated through the multiple linear regression equation (dotted line).
Fig.3: Biomassa secca accumulata (g/m^2) osservata (linea continua) e stimata con l'equazione di regressione multipla (linea tratteggiata).

In partiuclar, the multiple regression implemented showed an increasing effect of altitude, sowing density and GDD_5, which together explain a significant part of the plant growth variability (R^2=0,935) (Fig. 3).

Conclusions

In this research, the effect of the environment (altitude and temperature gradient) and the sowing density on the emmer growth and development is investigated. The nine fields are located at different altitudes ranging between 350 to almost 1200 m a.s.l. with a consequent variation in air temperature. Preliminary results showed that both altitude and temperature strongly affect emmer phenology. In particular, the GDD with a base temperature of 5 °C seems to be the most related to the phenology dynamics, showing the adaptation of emmer to lower temperature compared to modern wheat varieties. On the other hand, dry matter accumulation is the result of more complex interactions between environment and sowing density. In fact, both factors affect the crop tillering, but in an opposite way and with different intensity. In particular, the manual method of sowing (broad casting) provide an inhomogeneous but complete cover of the soil which probably depends more on its irregular distribution rather than on a high sowing density.

These preliminary results highlight that emmer growth and development is strongly affected by the environmental conditions, but also that the crop is well adapted to the marginal areas in which is cultivated. Further analysis will be performed in order to determine the effect of the variables considered on the final yield.

Acknowledgments

Attività in parte svolte nell'ambito del progetto misura 16.2 "FAGADOP", PSR 2014/2020 Regione Toscana. Si ringraziano la Garfagnana COOP Alta Valle del Serchio e la Fondazione Cassa di Risparmio di Firenze per il supporto fornito.

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