P 15: Breeding of a high yielding chamomile variety (*Matricaria recutita* L.) with improved traits for machine harvesting

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Abstract

A more productive variety of chamomile (*Matricaria recutita* L.), which is more efficient in machine processing with consistent quality traits, will benefit the viability of german products in the global market. Breeding of an enhanced chamomile variety is part of a german multi-network project called KAMEL whose research aims on *Matricaria recutita* L., *Valeriana officinalis* L. and *Melissa officinalis* L. The agronomic and qualitative improvement of these speciality crops are the basis for further economic prosperity of medicinal and aromatic plant cultivation in Germany.

The main breeding goals of a new variety of chamomile are the increase of blossom product yield (*Matricariae flos*) to 6 dt/ha in up to three harvest stages through a homogenous flower horizon (pick height), an even flowering time, large flower heads and a high regeneration rate after each harvest stage. The upgrade of the content of essential oil content to a minimum of 0.8 % with its compostion according to Ph. Eur. and a chamazulene content of min. 25 % are further objectives of the breeding process. In addition to these quality traits, high tolerances against common fungal diseases are of particular interest. Development of an innovative chamomile variety is realized over nine years in three stages (2010 - 2019).

Keywords: medicinal and aromatic plants, chamomile, breeding, yield, quality, machine processing

Introduction

Chamomile (*Matricaria recutita* L.) is one of the most common medicinal plants worldwide. Its origin is the Near East and south and east Europe. It is to be found almost all over Europe, Asia Minor, North and South America, New Zealand and Australia (Franke et al. 2005). Chamomile has been used in herbal remedies for thousands of years, known in ancient Egypt, Greece, and Rome (Singh et al. 2011). Besides as a raw product for food industries it is one of the most important crops for pharmaceutical and cosmetic purposes in Germany (Wagner et al. 2005). The history of chamomile breeding in Germany started around the 1950´s with the development of the "Quedlinburger Großblütige" and the "Erfurter Kleinblütige" populations as commercial-used varieties (Hoppe et al. 2012). After this initiation, systematic breeding of chamomile in Germany started a rapid development with a widespread outcome. However, in other countries mainly in east Europe further breeding has resulted in improved populations and registered varieties.

Currently a large number of different varieties with agricultural use are known worldwide, which are mostly old cultivars, landraces or mixed populations without a current right protection. Only a few registered cultivars with high contents of α-bisabolol and chamazulene e.g. `Manzana´ (1986) and `Mabamille´ (1995) are dominating the german medicinal and aromatic plant cultivation.

The tetraploid variety `Bodegold´ (1962) which was bred in the 1950s in Quedlinburg is widespread too (Otto et al. 2015) not least because of its exemplary sensoric qualities. Other, mainly tetraploid (4x) and also diploid (2x) varieties are available in a large scale. In general they reveal deficits in agronomic traits regarding their harvest-ability. Parameters like an inhomogenous pick height or an uneven flowering time still need to be improved. Also their yield capability under machine harvest conditions is still unexhausted.

The aim of the project is breeding an open pollinating variety (non-hybrid) or a synthetic line (artificial population emerging of selected component lines) which is capable to exceed yield performance of current german cultivars (4.5 dt/ha) by use of machine processed harvesting.

Improved agronomic traits like a homogenous and small pick height, and even flowering time, large flower heads and a high regeneration after each harvest stage is intended. Another aim is the refinement of chamomile flower contents of essential oil to a minimum of 0.8 % and the consolidation of the content of matrizin/chamazulene to a minimum of 25 %. The general compostion of compounds must accomplish to Ph. Eur. Also breeding lines which are tolerant against common fungal diseases are intended to be found.

Material and methods

The breeding process is built of three stages which are arranged consecutively. (i) Characterizing known lines and development of source material (2010-2012), (ii) Development of different breeding lines and test of their combination ability (2014-2016), (iii) Selection of breeding lines (for cultivar registration), seed propagation of priority crossings and component lines, field trials under conditions of practice (2017-2019).

In the first stage, source material of 30 different origins was characterized in two years autumn and spring sown trials (Table 1). Yield performance was tested as hand-picking harvest within a plot-in-plot area of 1 m^2. Most important criteria of the evaluation were yield under hand-pick conditions, yield-distribution over different harvest stages, the arrangement of flowers at the plant (different pick heights of 6 cm from above, 15 cm, and under 15 cm), the flower size, pickability and flowering period as well as the content of quality determining constituents and the resistance against different diseases and pests. Of 30 characterized origins, eight lines were valued to be founder lines of single plant selections. Of these donors, isolated self-pollinated seeds were generated in the third year (I1).

Tab 1 Donor material for breeding a new chamomile (Matricaria recutita L.) variety

cultivar/commercial variety	origin	ploidy level	cultivar/commercial variety	origin	ploidy level
Argenmilla	RA	2x	Origin of USA	US	2x
Aromi	IT	4x	Origin of India	IN	2x
Bodegold	DE	4x / 2x	Origin of Croatia	HR	2x
Bohemia	CZ	4x	Lazur	BG	4x
Bona	SK	2x	Lutea	SK	4x
Camoflora	DE	2x	Mabamille	DE	4x
Chamomilla organic B&T		4x	Manzana	DE	4x
Flortis company	IT	4x	Margaritar	RO	4x
GARAFARM company	HU	4x	Novbona	SK	2x
Golden Line company	IT	4x	PNOS Polen	PL	4x
Kiepenkerl company	DE	4x	Promyk	PL	2x
Ferme de Saint Marthe	FR	4x	Robumille Akk34	DE	4x
Germania	DE	2x	Robumille Typ046	DE	4x
Goral	SK	4x	wild type fr. Dover	GB	2x
Origin of Russia	RU	2x	Zloty Lan	PL	4x

In the second stage, self-pollinated I1-seeds of 60 selected lines were tested in field trials. Further limitation in this progeny was carried out to 30 lines and single plant selections were made for I2-seed production and analytics. The resulting set of I2-progeny was tested in 2015 in a large field trial with yield analysis (hand pick) and for reselection of single plants to strengthen homogeneity in relevant genotypes and to produce I3-seeds. In the next step, single plant progenies (I3-seeds) were chosen for test-crossings to evaluate the combination-ability in specific maturing- and height-groups. In addition, the component lines of test-crossings will be selected again to homogeneity and going to be multiplicated (I4-seeds) in 2016.

In the third stage (2017-2019) the hybridization-products will be tested in large scale field trials and will be evaluated for their combination ability. Component lines will be multiplicated and homogeneity of these parental lines will be improved. The project leads to the selection of poten-

tial candidates for cultivar registration. Field trials under conditions of practice are planned for validation.

Results

At the beginning of the first three-year stage of the project, 30 origins were characterized. Apparently none of these genotypes accomplished the breeding goals in every respect. This supports the necessity of an intercross- breeding scheme. Eight lines of the source material were scored as valuable. In the next step, overall 600 to 1000 plants of this valuable material were grown for selection. Overall 200 Single plants were selected to harvest a sample for analytics (first pick) and to generate self-pollinated I_1-seeds (second pick of isolated flowers). The breeding goal regarding essential oil content with 0.8 % were found in twelve single plant selections out of three different origins. The requested chamazulene content (min. 25 %) was found in 42 % of all analyzed samples. 83 % of all samples reached or surpassed the minimum content of Apigenin of 0.25 % of dry matter.
In the second stage, 60 I1-lines were tested in a plot-designed field trial resulting in a selection of 50 % of these lines for characterization and to generate isolated I2-seeds. Accordingly to their valuable components and performance they were grouped in yield-types (Y), essential-oil types (O), types with optimal pick-height (P) and types with resistances to common chamomile diseases (R). Whereas 19 single plant selections were identified as (Y)-types with general growth above average and a high flower yield. Seven lines (Y+O) could be exposed with high flower yield in combination with high contents of essential oil of 0.83 - 1.05 %. Other seven selected lines (P) provide the intended flower pick- height of 6 cm – 8 cm. The pick-height of other 24 lines (P) was in the range of 12 cm. The weather conditions in 2014 lead to a drastic infestation with powdery and downy mildew and facilitate the selection of resistant genotypes within the set. Nine selections (R) were free of any symptoms in this year. Monitoring of diseases is included in the further breeding process. The homogeneity of single breeding lines was still insufficient at this point. In 2015 a field trial with 50 selected I2-candidate lines of the different types (Y, O, and P) was carried out. It was aimed at the improvement of the homogenous growth through further single-plant selection within the breeding lines.The generation of I3-seeds as well as the selection of candidates for test-crosses were completed. In 2016 the I2-generation will be tested for agronomic parameters especially yield components in a single-trial. At the same time the I3-lines will be evaluated for all important breeding parameters. Besides these two trials, isolated nine test-crosses of selected lines are underway with simultaneous maintaining of their components at 49 isolated locations.

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