New field pea selections for inland Morocco

CONTEXT

Conservation Agriculture in particular, and sustainable agriculture in general, are not compatible with the extensive monoculture and the repeated cropping of wheat that are widespread in rainfed areas of the Mediterranean region. **Including legumes in crop rotations** would be particularly valuable, because greater cultivation and utilization of these crops can contribute to climate change mitigation, lower energy consumption, increased soil fertility, more resilient cropping systems, greater feed and food security, and healthier food and living environments (Figure 1). **These crops, however, are little cultivated in Europe and North Africa** because of their wide profitability gap relative to wheat and other major cereals, which profited of much greater crop improvement research and usually greater supporting measures than legumes. This is why **legume yield improvement was one of the objectives of the project CAMA.**

CAMA identified field pea as a major target of its plant breeding effort, because this crop is:

(1) widely adapted to soil, climate and management conditions of the Mediterranean region, and fairly drought tolerant (because of its winter-spring cycle and early maturity);

(2) well-known by farmers of the Mediterranean region;

(3) flexible and diversified for crop use (feed or food grain; fodder; protein concentrates and isolates);

(4) more competitive against weeds than other grain legumes;

(5) not targeted by the international research centre ICARDA with a Mediterranean mandate, and promising on the basis of prior knowledge and available germplasm and genomic resources (also thanks to earlier projects, e.g., REFORMA).
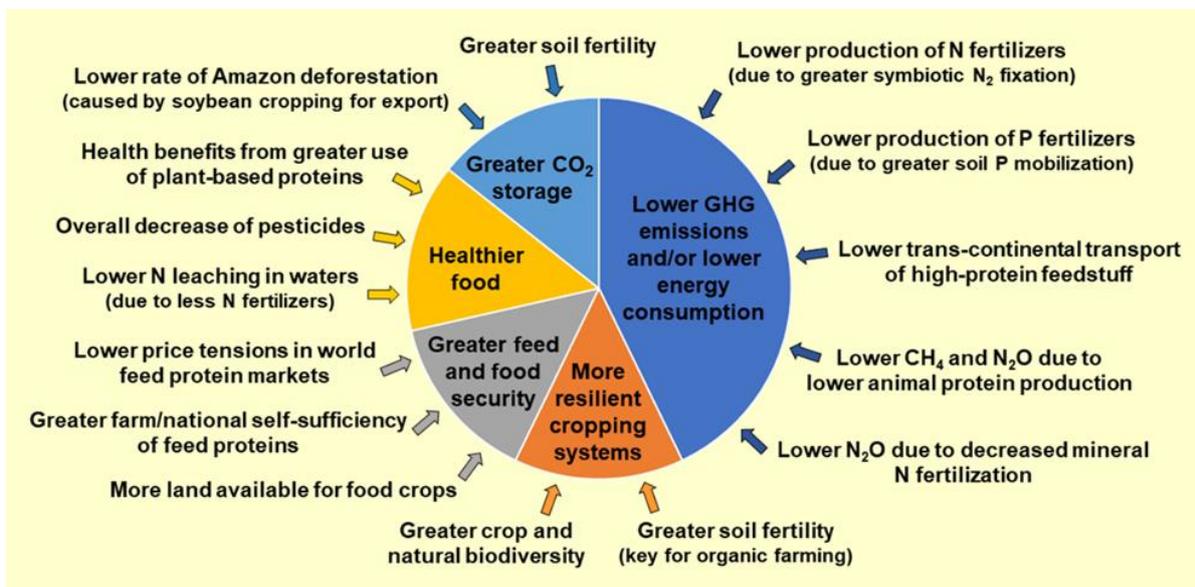

Fig 1. Advantages associated with greater cultivation and utilization of legume crops

New field pea selections for inland Morocco

WORK DONE IN CAMA

CAMA devised pea improvement research for different climatically-contrasting Mediterranean regions, namely, Central and Southern Italy, coastal Algeria, and inland Morocco. One aim was producing new cultivars with higher grain yield for each of these regions. A second aim was comparing the ordinary phenotypic selection of inbred lines with two innovative selection methods: a biotechnology-based one, i.e., the genomic selection of inbred lines (which could reduce the cost and the time needed for variety selection), and an agroecology-based one, i.e., the selection of evolutionary populations (which are genetically heterogeneous, unlike the inbred lines, and are characterized by very low selection cost).

All the selections originated from connected crosses between three international semi-dwarf, semi-leafless cultivars that displayed high and stable grain yield across climatically-contrasting Italian environments in earlier work. Genomic selection for inland Morocco was carried out by the model developed by Annicchiarico et al. (2020), which was based on pea plant responses in Morocco (Marchouch) and managed severe drought in Italy and genotyping-by-sequencing marker data. The evolutionary population originated from three generations of stratified mass selection under managed severe drought in Italy followed by natural selection under field conditions for three years in Morocco.

The selections were evaluated in field experiments under autumn sowing in inland Morocco (Marchouch) for two cropping years, i.e., 2021-22 and 2022-23 (Figure2).

Fig. 2. Overview of the evaluation experiment in Marchouch in 2021-22 during the crop cycle and at crop harvest

RESULTS

Results for grain and straw production and onset of flowering over two years of phenotypically-selected and genomically-selected inbred lines and the evolutionary population for inland Morocco are given in Table 1. This table also includes results relative to the parent cultivars, and the LSD value for each trait which indicates the threshold of difference beyond which the values of two materials are statistically different with a probability of error ≤ 5%. **The key findings are the following:**

- The **genomically-selected line AI_S144**, featuring **extreme earliness, exhibited the highest grain yield**, with a yield advantage of 19% compared to the top-yielding parent Kaspa. However, it should be noted that **Kaspa had higher straw yield** than AI_S144.

- The **phenotypically-selected line KI_41** ranked **second for grain yield**. Compared with AI_S144, this tended to display higher yield in the first, less favorable year, and lower yield in the second year.

- The **grain yield of the evolutionary population was similar to the mean yield of the selected** inbred lines (1.400 vs. 1.415 t/ha). However, this population exhibited **higher yield stability** than most inbred lines in the sample of drought-prone evaluation sites of the project (which included also environments of Algeria and Italy.

Table 1. Grain yield and other traits assessed in a two-year field evaluation in Central Italy, and grain yield under managed moderate drought, for a subset of well-performing inbred lines issued by phenotypic selection (PS) or genomic selection (GS), one evolutionary population and three elite parent cultivars of the selected material

Genotype	Material	Grain yield (t/ha)	Straw yield (t/ha)	Onset of flowering (dd from March 1)
Selections for Morocco				
AI_S144	GS line	1.922	5.250	17.8
KI_41	PS line	1.700	5.539	19.0
KA_L10	GS line	1.645	5.272	20.2
KA_S127	GS line	1.411	5.428	20.5
KI_S184	GS line	1.344	4.905	19.8
AI_41	PS line	1.317	5.667	22.0
AI_S260	GS line	1.267	4.233	18.7
KI_S94	GS line	1.111	5.067	21.7
KA_S7	PS line	1.023	5.439	21.5
Evolutionary population	Population	1.400	4.603	19.5
Parent cultivars				
Attika	Commercial cultivar	1.372	5.066	20.2
Isard	Commercial cultivar	1.250	5.194	22.5
Kaspa	Commercial cultivar	1.611	6.916	20.2
LSD for genotype (P<0.05)		0.439	1.083	3.4

New field pea selections for inland Morocco

The **evolutionary population also showed relatively better adaptation than any inbred lines to the new growing condition of intercropping with barley**, which was investigated as well in a specific experiment. In this experiment, pea was at competitive disadvantage (with average grain yield proportion in the mixture of 0.339). There was no correlation observed for pea genotype yield response across pure stand and mixed stand conditions (r = 0.10), with a slight trend suggesting relatively better yield response in intercropping of taller pea genotypes.

CONCLUSIONS AND RECOMMENDATIONS

The project CAMA succeeded in **generating a few potential varieties which, for the main Moroccan target region (Marchouch), represent a clear improvement in terms of grain yield.**

The **line KA_L10**, which was top-ranking for farmers' acceptability, is undergoing the third year of evaluation in national trials. Other best-yielding lines are undergoing evaluation in various sites, with the aim to register one or two more lines.

The **evolutionary population could be suitable for cultivation in low-input or drought-prone environments**, particularly those featuring highly variable climatic conditions across years (as increasingly occurring due to the climate change). Because of its genetic heterogeneity, this material cannot be registered as a commercial variety. We envisage multiplication of this population for extensive distribution to farmers by informal seed systems.

CAMA produced also **important scientific information for crop improvement of pea** and other inbred grain legumes. It demonstrated the **value of genomic selection**, which generated inbred lines with agronomic value similar to that of phenotypic selection in a shorter period of time, and highlighted the adaptability and high yield stability of an **innovative and low-cost variety type such as the evolutionary population**.

References

Annicchiarico, P., N. Nazzicari, M. Laouar, I. Thami-Alami, M. Romani, L. Pecetti (2020). Development and proof-of-concept application of genome-enabled selection for pea grain yield under severe terminal

Contact of authors

Imane Thami Alami, INRA, imane.thamialami@inra.ma

Paolo Annicchiarico, CREA, paolo.annicchiarico@crea.gov.it

PARTNERS INVOLVED