AgrEcoMed

FOSTERING AGROECOLOGICAL TRANSITION

"New AGRoecological approach for soil fertility and biodiversity restoration to improve ECOnomic and social resilience of MEDiterranean farming systems"

Deliverable 1.2
Demonstration fields

This project is part of the PRIMA Programme supported by the European Union, having received funding from it under grant agreement PRIMA21_00018

PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION
IN THE MEDITERRANEAN AREA

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Acronym and abbreviations

VRT	Variable rate
RIA	Research and Innovation Action
CA	Conventional agriculture
AA	Agroecological approach
WP	Work package

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Executive summary

The AgrEcoMed project, funded under the European Union’s Horizon 2020 research and innovation program PRIMA and Grant Agreement PRIMA21_00018 is a research project aimed to fill the research gaps for implementing a biodiversity-based strategy for primary crops as cereal farming systems through an Agroecological approach adapted to environments in Mediterranean countries, efficient use of natural resources, reduction of pollution, circular economy. Such a goal will be achieved through innovative approaches to support the sustainable production of staple foods in the scenario of present and future climate changes. To this end, the project activities will be carried out through on-farm experimentations, focus groups, pilot actions, and demonstrative action. This document is Deliverable 1.2, “Demonstration fields”, of the AgrEcoMed project, which aims to describe the demonstration fields of best practices of new crop rotation and innovative farming techniques with an agroecological imprint. The experimental fields will be open to visitors from their start (about 12 months after the start of the project) until the closure of field activities (31 months).

Keywords: PRIMA, AgrEcoMed, on-farm demonstration, dissemination, agroecological practices, sustainable agriculture

1. Project basis

AgrEcoMed is a 36-month Research and Innovation Action (RIA) project under Grant Agreement No PRIMA21_00018 aiming to fill the research gaps for implementing a biodiversity-based strategy for primary crops as cereal farming systems through an Agroecological approach adapted to environments in Mediterranean countries, efficient use of natural resources, reduction of pollution, circular economy. The effective start of the project is 23/05/2022 and the project ends 36 months later, on 31/05/2025. The AgrEcoMed consortium consists of 8 partners from 4 countries (including two EU and non-EU countries). The project is coordinated by the University of Basilicata (UNIBAS, Italy). The list of Project Participants is included in the Grant Agreement, in the Consortium Agreement, and presented in Table 1. The project has an overall budget of 1,308,051.15 €. The budget detailed per beneficiary and the corresponding EU contribution of each beneficiary is detailed in Annex 2 to the Grant Agreement – Estimated budget of the action.

Table 1. Partners of the AgrEcoMed project and representatives.

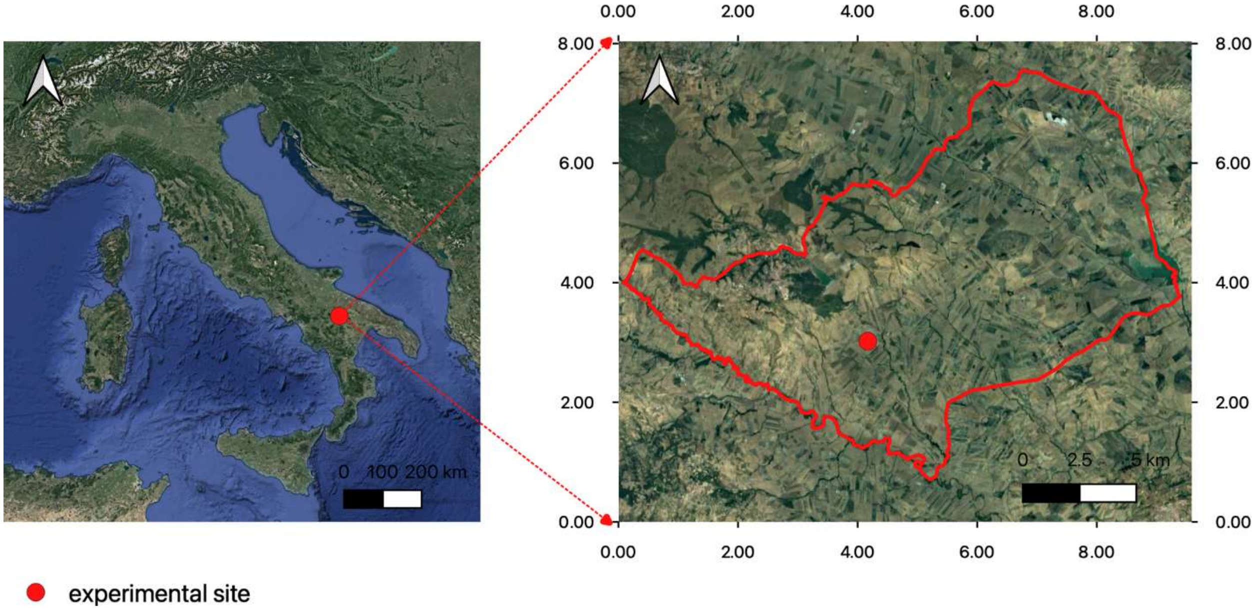
Participant No *	PI name	Organization	Short name	Country	Type of institution
P1	Michele Perniola	University of Basilicata	UNIBAS	Italy	Higher Education Institution
P2	Luigi Roselli	University of Bari	UniBa	Italy	Higher Education Institution
P3	Maria Assunta D’Oronzio	Council for Agricultural Research and Economics	CREA	Italy	Public Research organization
P4	Ines Yacoubi	Centre of Biotechnology of Sfax	CBS	Tunisia	Public organization
P5	Hanine Hafida	University Sultan Moulay Slimane Beni Mellal	USMS	Morocco	Higher Education Institution
P6	Said Ennahli	National School of Agriculture	ENAM	Morocco	Public Research Organisation
P7	Julio Berbel	Universidad de Córdoba	UCO	Spain	Higher Education Institution
P8	Neus Sanjuan Pellicer	Universitat Politècnica de València	UPV	Spain	Higher Education Institution

2. Demonstration fields

A 3-year field trial (2022-2023-2024) will be conducted in the real setting farm in the Mediterranean area, comparing the cropping system practiced (conventional agriculture CA) with an alternation one in which, in addition to the introduction of new alternative crops, the cultivation technique will be set based on agroecological principles, the agronomic correctness of the individual cultivation technique interventions (rotation, tillage, fertilization, defense, etc.) and the consistency that the specific methods of farm management demonstrate they possess concerning environmental, social, cultural, economic conditions, etc. of the cultivation site (AA). In the above-said farms, “conventional agriculture” (CA) will be compared with the proposed “agroecological approach (AA). On the same rotating plots cultivated in the farm, part of the surface will be used to test the management regime on an agroecological basis (AA). Specifically, wheat and legumes will follow the same rotation scheme already in place on the farm, but the newly established varieties grown on the farm will be compared with the alternative varieties. The rotation scheme will instead be expanded (to increase the degree of biodiversity) by introducing and allocating part of the area for the cultivation of a brassica crop and a medicinal plant. In this rotation, wheat maintains the role of the main crop (given its suitability to the cultivation area), the leguminous for the balance of nutrients in the soil, the grass for improving and refining crops against weeds, the brassica crop for the soil pathogens control and finally the medicinal crop for triggering green chemistry chains with the possibility of producing extracts also useful for the agricultural sector itself in a circular economy perspective. Following the rotation scheme, the 5 crops in the rotation will all be present in each of the three years of experimentation. To make the management of rotation more ecological, in compliance with the knowledge acquired in the agronomic research, the tillage plan in the AA rotation will provide for plowing at 30 cm on legumes and medicinal crops (to better contain both weeds and the pathogens on these two crops which are more sensitive) and the minimum tillage on wheat and brassicas (where the control of weeds and pathogens is easier). This is to contain the carbon footprint on the one hand due to fuel consumption and to take advantage of the positive effect of plowing on the control of pathogens, weeds, and the physical characteristics of the soil, also for successive crops in rotation. The plant nutrition will be ensured by calculating the plant needs according to the crop potential uptake, the spatial variability and availability of the soil, and crop status due to the climatic trend of the cultivation period. On this basis, the DSS for the fertilization plan will be customized and used for the variable rate distribution of fertilizers through the "precision farming" technique. In the calculation of nutrients, the contribution deriving from the burying of crop residues from previous years will be considered (and this will allow for reducing the fertilizer doses), and organ-mineral fertilizers from the composting of crop residues and urban waste will be used, with a view to of circular economy and low environmental impact. The crop residues will be managed both through the burying and possible shredding in the field, and, based on the physicochemical characteristics and the isoumic coefficient, to start the farm composting processes to obtain a more stable and more effective fertilizer-soil conditioner (ENAM). In particular, we will study the possibility of using medicinal crop residues to obtain macerates which are also useful for the control of some plant pathogens. The crop residues will also constitute the substrate for their enhancement through the bioconversion operated by the Diptera Hermetia Illucens (WP3, task2, UNIBAS). Also, plant health and performance will be assessed to evaluate the benefits of these treatments. An environmental analysis of the processes that allow the self-production of fertilizers and/or amendments for agricultural soil will be carried out, starting from the residues of crop cycles or other organic waste. These processes will be carried out on locally selected farms in participating countries. Weeds and pathogens control in the AA rotation will be carried out based on monitoring the damage threshold; commercially available low-impact bio-molecules will be used and will be compared to the traditional one.

2.1 Experimental site description

The site is within L'azienda Soc. Coop. Agricola La Generale [latitude: 40.82460° N, longitude: 6.09348° N.] located in C.da Pezzalonga c.p.24, 85013 Genzano di Lucania, Potenza, the Basilicata region of southern Italy. The territory of the municipality of Genzano di Lucania has an area of 208.92 km^2 and a population density of 27.23 inhabitants/km^2.



Source (Denora et al., 2022)

Figure 1. Location of demonstration fields.

The experimental site is characterized by hot summers followed by cold winters and with rainfall concentrated in the autumn-winter seasons. The mean annual precipitation is nearly 610 mm (Table 2). The average annual temperature is 19.2°C. The maximum average of the hottest month (July) reaches 28.1°C, and that of the coldest month (January) is 3.3°C.

Table 2. Climatic parameters for Genzano di Lucania, Basilicata region, Southern Italy.

Month	Precipitation (mm/month)	Wet days	Tmp. min. (°C)	Tmp. max. (°C)	Tmp. mean. (°C)	Rel. Hum. (%)	Sunshine (%)	Wind (2m) (m/s)
Jan	59	11.5	3.3	9.7	6.5	76.3	42.1	3.1
Feb	55	11.1	3.5	10.4	6.9	73.8	42.8	3.2
Mar	52	11.2	4.8	12.6	8.7	71.2	44.8	3.2
Apr	49	10.3	7.4	16.2	11.8	69	49.4	3.1
May	40	7.8	11.4	21	16.2	68.1	56.1	2.6
Jun	35	6.7	15	25.1	20	65.1	61.4	2.5
Jul	23	4	17.5	28.1	22.8	61.7	69.9	2.5
Aug	33	5.6	17.8	28	22.9	63.6	69.9	2.4
Sep	51	7.1	15.1	24.5	19.8	66.1	63.5	2.2
Oct	67	9.7	11.3	19.4	15.3	71.2	55.5	2.4
Nov	72	11	7.4	14.8	11.1	75.7	47.1	2.8
Dec	71	12.1	4.5	10.9	7.7	77.3	40.8	3.1

The average relative content of particles of various sizes in the soil is 39.3% for clay, 25.9% for silt, and 34.9% for sand. Therefore, the soil of Genzano di L. is classified as clay loam and is moderately calcareous with a moderate alkaline pH being more than 8.2 (Figure 2). The textural class of top and subsoil using the triangular diagram is shown in Figure 3. The average soil Electrical conductivity (EC) 1:2.5 is 0.26 mS/cm. The average available water content is 100 mm. The average field capacity of the soil is **35**% while the wilting point is 22%. The average humidity is 30%. Elevations range from 347 to 365 meters above sea level (Figure 4). The average nitrogen content is 1.2 g/kg while organic carbon is 1.2%.

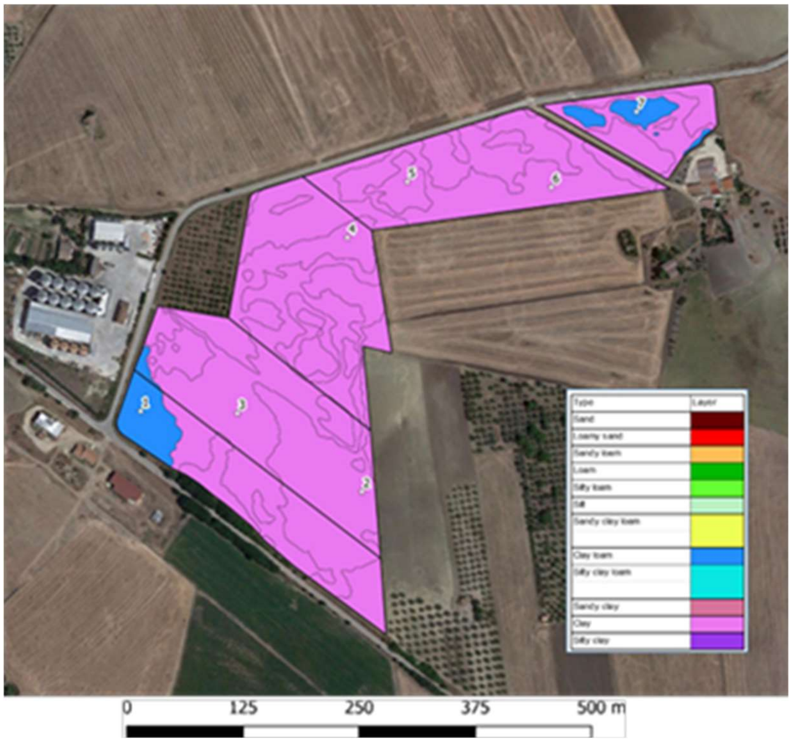


Figure 2. Soil texture of demonstration fields.

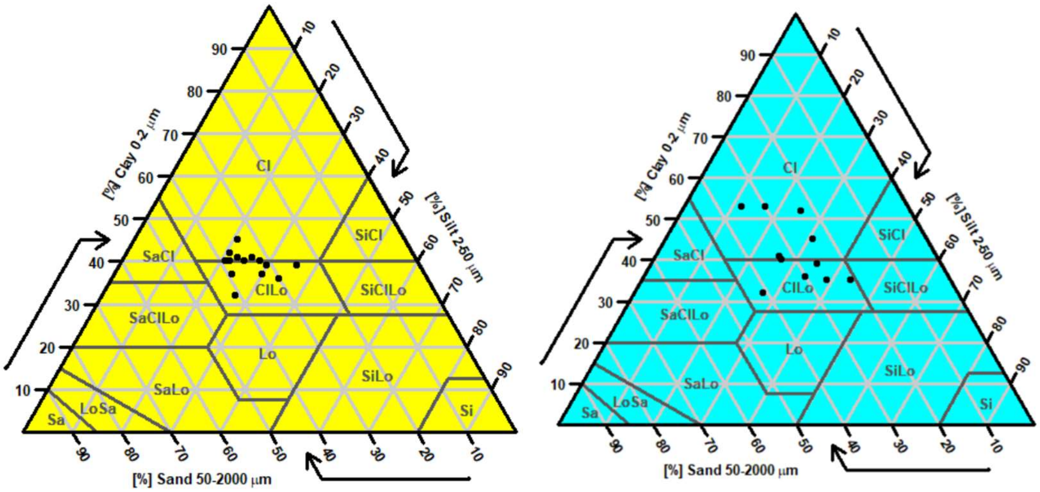


Figure 3. The triangular diagram of the basic soil textural classes of topsoil (yellow/left) and subsoil (blue/right).

Figure 4. The altitude map of demonstration fields.

2.2 Experimental design and management

The demonstration fields are organized in different demonstration plots (Figure 5) hereafter identified as mono-cropping, legumes, intercropping, cereals, and medicinal. The trial will be conducted under rain-fed conditions using a randomized block design. Field operations included primary and secondary tillage, fertilizer application, planting, harvesting, and post-harvest straw management for all plots.

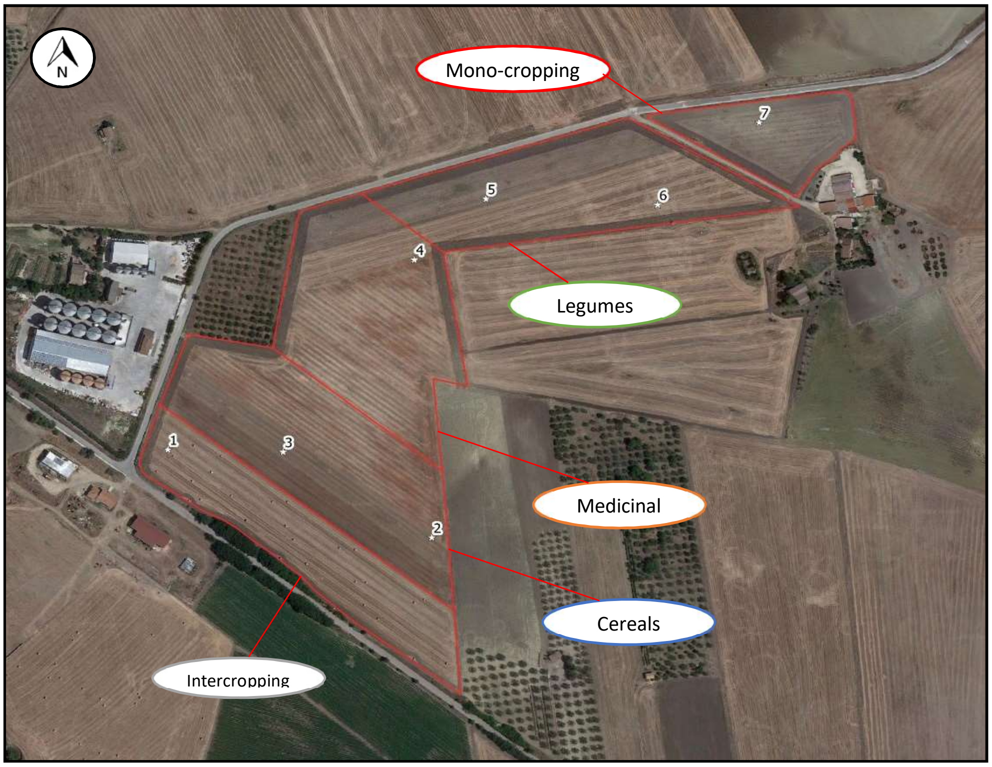


Figure 5. The layout of demonstration fields.

Table 3. Demonstration plots, size, and crops selected.

Plot names	Area [ha]	Crops
Mono-cropping	1.04	Wheat (cv. Tirex)
Legumes	2.73	Protein pea (cv. Aviron), Chickpea (cv. Pascià), Chickpea (cv. Sultano), Lentil (cv. Eston), Lentil (cv. Laird)
Intercropping	2.1	Wheat (cv. Tirex), Vetch (cv. Ereica), Trifolium incarnatum (cv. Kardinal)
Cereals	3.04	Wheat (cv. Tirex), Wheat (cv. Svevo), Wheat (cv. Marco Aurelio); Wheat (cv. Senatore Capelli)
Medicinal	2.91	Rapeseed (cv. SY Harnas), Coriander (Coriandrum sativum), Mugworts (Artemisia)

Table 4. Cropping strategies.

No	Cropping strategy	Plot location
1	Wheat mono-cropping (cv. Tirex) - seeding rate at 250 kg/ha	Mono-cropping
2	High input wheat mono-cropping (cv. Tirex) - seeding rate at 250 kg/ha	Cereals
3	Wheat (cv. Tirex) - seeding rate at 250 kg/ha	Cereals
4	Wheat with Trichoderma technology/strains - seeding rate at 250 kg/ha	Cereals
5	Wheat (cv. Tirex) - seeding rate at 250 kg/ha - with compost	Cereals
6	Wheat (cv. Svevo) - seeding rate at 250 kg/ha - with compost	Cereals
7	Wheat (cv. Tirex, M. Aurelio, Svevo, and Cappelli) - seeding rate at 250 kg/ha - with inorganic soil conditioner (Bioreactive)	Cereals
8	Wheat (cv. Tirex, M. Aurelio, Svevo, and Cappelli) - seeding rate at 250 kg/ha - without inorganic soil conditioner (Bioreactive)	Cereals
9	Wheat (cv. Tirex) - seeding rate at 250 kg/ha - with only biostimulants (BlueN)	Cereals
10	Wheat (cv. Tirex) - seeding rate at 250 kg/ha - with only fertilization	Cereals
11	Wheat (cv. Tirex) - seeding rate at 250 kg/ha - with fertilization and biostimulants (BlueN)	Cereals
12	Wheat (cv. Tirex) - seeding rate at 250 kg/ha	Intercropping
13	Wheat (cv. Tirex) - seeding rate at 150 kg/ha	Intercropping
14	Wheat (cv. Tirex) - seeding rate at 150 kg/ha (cv. Tirex) with Vetch (*Vicia sativa* L.) seeding rate at 80 kg/ha	Intercropping
15	Wheat (cv Tirex) seeding rate at 150 kg/ha with Clover (trefoil) seeding rate at 35 kg/ha	Intercropping
16	Protein pea (cv. Aviron) - seeding rate at 180 kg/ha	Legumes
17	Chickpea (cv. Pascià) - seeding rate at 230 kg/ha	Legumes
18	Chickpea (cv. Sultano) - seeding rate at 200 kg/ha	Legumes
19	Lentil (cv. Eston) - seeding rate at 220 kg/ha	Legumes
20	Lentil (cv. Laird) - seeding rate at 100 kg/ha	Legumes
21	Rapeseed (cv. SY Harnas) - seeding rate at 3.5 kg/ha	Medicinal
22	Coriander (Coriandrum sativum) - seeding rate at 20 kg/ha	Medicinal
23	Mugworts (Artemisia) - seedling rate at 22.7 and 44.45 seedling/ha	Medicinal

2.2.1 Mono-cropping demonstration fields

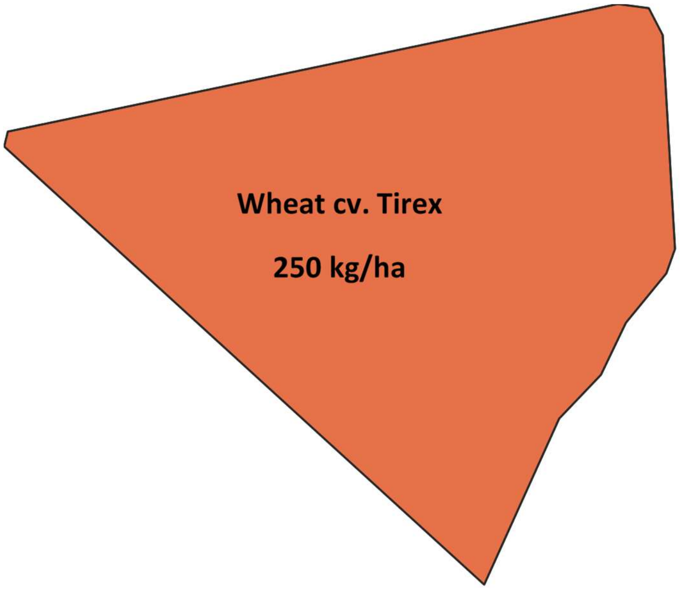


Figure 6. The layout of mono-cropping demostration fields.

Mono-cropping or continuous monoculture is the agricultural practice of growing a single crop year after year on the same land. Wheat, corn, and soybeans are three common crops often grown using mono-cropping techniques. By growing just one crop species in a field at a time, monocultures enable farmers to use machinery, increasing the efficiency of activities like planting and harvesting. Moreover, it saves time and reduces the demand for manual labor, is easier to manage, and enables high production efficiency, resulting in high yields. Winter wheat monoculture is recommended due to its economic impact (Bouatrous et al., 2022). Wheat-based monoculture is common in the Mediterranean region. It is applied commonly in several parts of Mediterranean countries such as Morocco, Syria, and Turkey. Crops produced on monoculture plantations are often subsidized by the government. Despite the economic and yield advantages, cultivating cereals in monoculture systems impoverishes both organic matter and microbiological life in the soil (Woźniak, 2020), increases the risk of disease and pest outbreaks, increased weed infestation contributing to the decrease in grain yield and quality and soil fertility (Bouatrous et al., 2022). Monoculture cereal systems could reduce productivity in dry areas (Gandía et al., 2021). The effects of mono-cropping can be extremely detrimental to the environment as it is associated with the intensive use of agricultural inputs.

The AgrEcoMed project will look into the impact of continuous wheat mono-cropping on yield, yield components, and grain quality in durum wheat. In the experimental fields, a wheat mono-cropping system (Figure 6) was designed. On 22 December 2022, durum wheat (cv. Tirex) was seeded with a conventional seeder at a seeding rate of 250 kg/ha. Tirex is an early variety cultivar of Italian origin that is well-known for its high yield and resistance to cold and disease. Crop leaf chlorophyll content, leaf area index (LAI), weed, and pathogen load, gas exchange, and soil organic matter will be determined at different growth stages and quantitative aspects of yield will be measured at the end of the cycle. The leaf chlorophyll content is one of the most important factors for the growth of winter wheat. It helps to understand the nutritional status of the plant, and scientifically guide fertilization management to ensure good crop quality and yield. The objective of pathogen load will be to explore strategies to control the potential hazardous pathogens in wheat grain and wheat flour. Leaf area index (LAI), as an essential parameter of wheat growth, can provide dynamic information during wheat growth.

2.2.2 Legumes demonstration fields

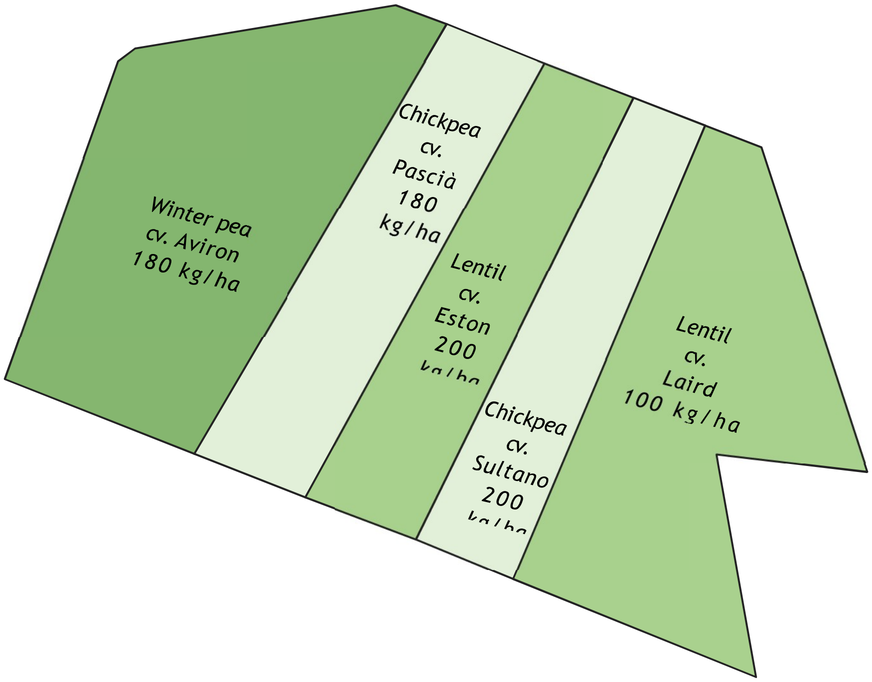


Figure 7. The layout of legume demostration fields.

Loss of biodiversity in the Mediterranean Region is one of the main reasons for the negative effect on the environment and crop yields, soil degradation, and water over-exploitation, particularly in the rain-fed cropping systems of Mediterranean areas. The rotation of crops is one of the most important agronomic practices that may have a significant effect on crop quality and quantity. Crop rotation has been suggested as a general strategy to sustain yields and reduce the risk of yield losses (Marini et al., 2020). It is used to overcome soil sickness, improvement of soil physical structure and aggregation, the increasing diversity of soil microbiota and associated beneficial microbes, and control soil-borne, as well as airborne, pathogens by breaking their natural life cycle (Woo et al., 2022). It could also mitigate the effects of climate change and market variability (Selim, 2019).

Grain legumes grown in rotation with annual cereal crops contribute to the total pool of nitrogen in the soil and improve the yields of cereals (Danga et al., 2009). However, the anticipated N benefits of the legume may be positive or negative depending on the legume species and its interaction with the environment. Dry peas, lentils, and chickpeas are the most common pulses produced in the world and are typically grown in rotation (i.e., alternating years) with cereal grains. Consumer demand for pulses has increased due to the demand for plant-based protein (Thavarajah et al., 2022). The Chickpea (Cicer arietinum L.) is the third most important grain legume in the world, after the bean and the pea. It is an important cool-season food legume crop that is mainly cultivated as a rain-fed crop.

The cultivated area in the world is about 11 million hectares. India is the largest chickpea producer in the world producing more than 60 % of the world's chickpeas[1]. Chickpea is native to the Mediterranean region and the Middle East. The seeds are high in fiber and protein and are a good source of iron, phosphorus, and folic acid (Sellami et al., 2021). Lentil (Lens culinaris Medikus) is a protein-rich cool-season food legume with an excellent source of protein, prebiotic carbohydrates, minerals, and vitamins (Choukri et

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[1] https://www.atlasbig.com/en-us/countries-chickpea-production

al., 2020). Lentils contain a high level of protein (20-30%) and have been reported as tolerant to high temperatures and drought. Worldwide more than 6.3 million tons of lentils are produced per year with Canada, India, and Turkey as the biggest world producers[2]. Dry pea or field pea (Pisum sativum L.) is one of the most important and highly productive cool season pulse crops grown worldwide. Yellow peas and green peas are the two most commonly available varieties of dry peas. Nutritionally, dry pea (*Pisum sativum* L.) is a rich source of low-digestible carbohydrates, protein, and micronutrients (Thavarajah et al., 2022). The top producer of green peas – by far – is China, followed by India, USA, France, and Egypt.

An objective of AgrEcoMed is to identify wider crop rotations (Figure 7) introducing legumes, forage crops, and alternative crops like medicinal species that contribute to improved land management practices on the production system and enhancement of agroecosystem sustainability. AgrEcoMed project's three-year rotation includes grain legumes (specifically, chickpeas, lentils, and peas) field with wheat and medicinal plants. The legume plots include Sicilian organic chickpeas (cv. Pascià) with a seeding rate of 230 kg/ha, chickpeas (cv. Sultano) with 200 kg/ha, Canadian lentil cultivars “Eston” and “Laird” with 200 and 100 kg/ha, and winter pea (cv. Aviron) with 180 kg/ha. The long-term effect of crop rotations (functionally diverse rotations vs. mono-cropping), the occurrence of plant disease, physical (e.g., bulk density), chemical (e.g., soil organic carbon, total nitrogen, cation exchange capacity, pH, etc.,) and biological (e.g., microbial biomass carbon and nitrogen) soil properties, nitrogen fertilizer (with vs. without nitrogen), nitrogen management (high vs. VRT) and crop yield will be evaluated for understanding the synergistic effects of crop rotations.

2.2.3 Medicinal plants demonstration fields

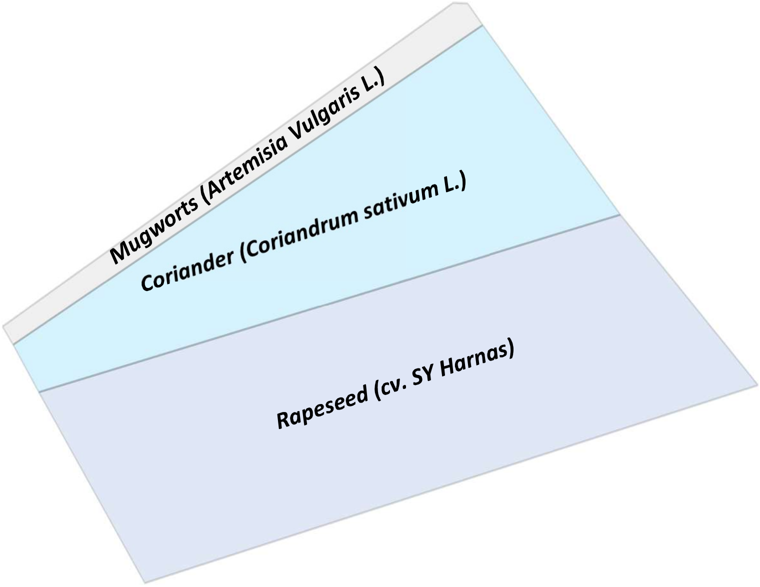

Figure 8. The layout of medicinal demonstration fields.

In agriculture farming systems, the valorization of biodiversity is strictly related to the planning of wide and rational crop rotations also with alternative species as medicinal plants, and to the valorization of local genotypes and restoration of Mediterranean biodiversity. Brassica napus L. (B. napus L) commonly known as rapeseed (or canola), is one of the cultivated medicinal food plants in Middle Asia, North Africa, and West Europe (Soodabeh Saeidnia, 2012).

Rapeseed oil is used for industrial and culinary purposes. Rapeseed

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[2] https://www.atlasbig.com/en-ca/countries-by-lentil-production

is reported to have three to four times higher proteins than rice and wheat (Raboanatahiry et al., 2021). Rapeseed crop in rotation with wheat generally increases wheat yields (Mazzilli and Ernst, 2019) and could supplement nutrients in the soil (Raboanatahiry et al., 2021). Coriander (Coriandrum sativum L.) is one of the most important essential oil crops on a global scale (Harizanova et al., 2022). It is one of the most useful essential oil-bearing spices as well as medicinal plants, belonging to the family Umbelliferae/Apiaceae. The leaves and seeds of the plant are widely used in folk medicine in addition to their use as a seasoning in food preparation (Mandal and Mandal, 2015).

On the same rotating plots cultivated in the AgrEcoMed demonstration farm, part of the surface will be used to test and grow medicinal plants (Figure 8) such as Coriandrum sativum L. (C. sativum) with 20 kg/ha, Rapeseed (cv. SY Harnas) with 3.5 kg/ha, and Mugworts (cv. Artemisia). The AgrEcoMed will study the feasibility of medicinal crops in rotation with wheat and grain legumes and evaluate their potential to improve yields, economic profitability, and the sustainable protection of field crops. Nitrogen fertilizer (with vs. without nitrogen), nitrogen management (high vs. VRT), and crop yield will be evaluated for understanding the synergistic effects of medicinal plants.

2.2.4 Intercropping demonstration fields

Nitrogen management adapted to crop and field conditions ensures higher yield and protein content However, several abiotic and biotic factors (e.g. water deficit and weed competition, respectively) may limit the profitability of spring nitrogen fertilization, and the high cost of off-farm organic fertilizers may be prohibitive (Vrignon-Brenas et al., 2016). If forage legumes are associated with wheat, simultaneously or successively, they can help to reduce the impact of limiting factors through the ecological services they provide. Intercropping is defined as the agronomic practice of growing two or more crops on the same field at the same time. The major benefits of intercropping are (1) increasing the rate of crop production, with the advantage of simultaneously decreasing the risk of total crop reduction, and (2) controlling weeds. Intercropping is considered by its advocates to be a sustainable, environmentally sound, and economically advantageous cropping system (Khanal et al., 2021). Intercropping legumes with cereals for forage production is a sustainable technique showing

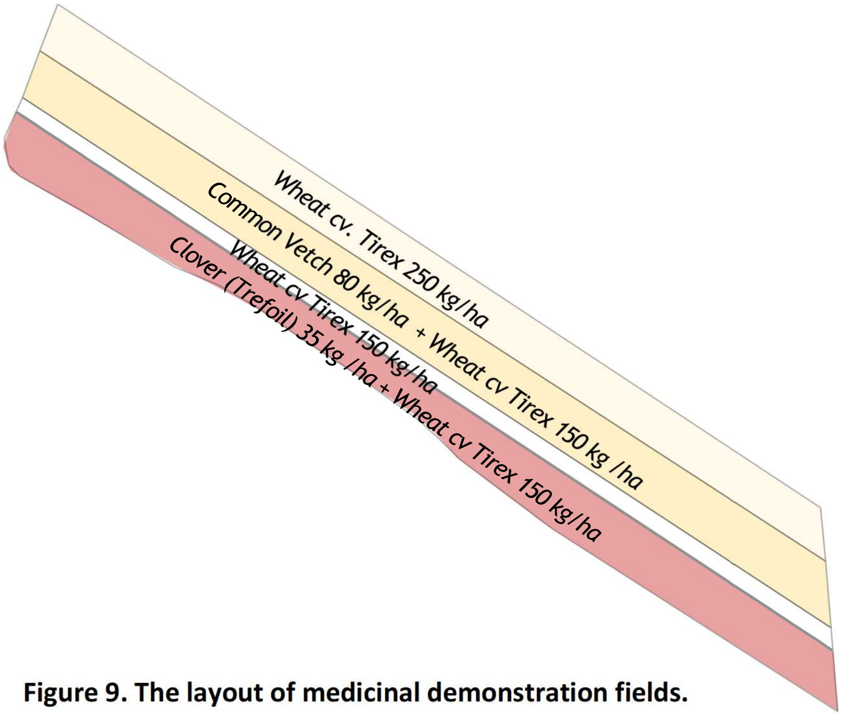

Figure 9. The layout of medicinal demonstration fields.

several environmental benefits (Lithourgidis et al., 2007). Intercropping has shown significant potential to increase resource efficiency and resilience against biotic and abiotic stresses, thereby allowing to deliver yield gains without increased inputs or stabilizing yields with decreased inputs[3]. Most research findings showed that the yield of intercropping is often higher than sole cropping (Bitew et al., 2021). Intercropping also enhances the competitive ability of crops for nutrients and water related to monoculture systems. It provides year-round ground cover, or at least for a longer period than monocultures, to protect the soil from desiccation and erosion. It improves soil health and delivers multiple ecosystem services. by increased yield, better soil quality, and soil C sequestration (Cong et al., 2015) through decreasing tillage frequency and soil disturbance, and increasing soil organic matter and carbon storage. Economic analyses (Arsyad et al., 2020; Huang et al., 2015) of the different intercropping systems have indicated that farm incomes were increased from intercropping as it is leading to on-farm cost savings and reduced reliance on external inputs.

In the Mediterranean countries, one of the legumes extensively used in intercropping with cereals is common vetch, an annual legume with a climbing growth habit and high levels of protein. Common vetch (Vicia sativa L.) can be an alternative grain legume to fava beans, peas, lupins, and soybeans due to its high grain protein content. Vetch may grow in marginal cropping zones and is drought-tolerant and resilient to changeable annual weather patterns (Nguyen et al., 2020). Intercropping of white clover and cereals has been promoted for low-input farming systems because it offers several benefits for sustainability (Thorsted et al., 2006). Clover is a forage legume cultivated in the temperate world, noted for its high-protein feed. The benefits include atmospheric nitrogen fixation, soil conservation, structural soil improvements, and a suite of agroecosystem services including increased soil microbial activity, the phytoremediation of polluted soils, and the provision of food for pollinators (McKenna et al., 2018).

Another objective of the AgrEcoMed project will be also to compare the effects in terms of yields, quality, growth rate, seed rate (high vs. low), nitrogen management (high vs. VRT), and ecological services (mainly N provisioning and weed control) of simultaneous intercropping strategies (Figure 9) of clover (Trifolium repens L. cv. Kardinal) with durum wheat (Trefoil 35 kg /ha + Wheat cv Tirex 150 kg/ha) and common vetch (Vicia sativa L. cv. Ereica) with durum wheat (Vetch 80 kg /ha + Wheat cv Tirex 150 kg/ha). Two stand-alone wheat cropping strategies with seed rates of 150 kg/ha and 250 kg/ha with be used as control strategies.

2.2.5 Cereals demonstration fields

Wheat represents a target crop for Mediterranean agriculture. Wheat provides 20 % of calories to the world population, highlighting the relevance of this crop for current and future strategic cultivation. In this context, we have to intensify efforts toward crop improvement and yield stability under conditions of sustainable agricultural production (Royo et al., 2017). To achieve this goal it is crucial to use crop varieties that are either best adapted to the specific environments or have the potential and flexibility of becoming adapted to a more dynamic environment. This requires the growth of plants that show greater resistance to abiotic and biotic stresses and can maintain yields under adverse or low-input conditions. The use of

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[3] https://cordis.europa.eu/programme/id/HORIZON_HORIZON-CL6-2022-BIODIV-01-05

improved cultivars and the adoption of appropriate crop management practices have significantly increased yields. It is known that a well-planned crop rotation (with the adoption of legume and/or cruciferous crops within the cereal rotation scheme) can increase the sustainability of the system in dry regions of the Mediterranean basin (Ryan et al., 2008).

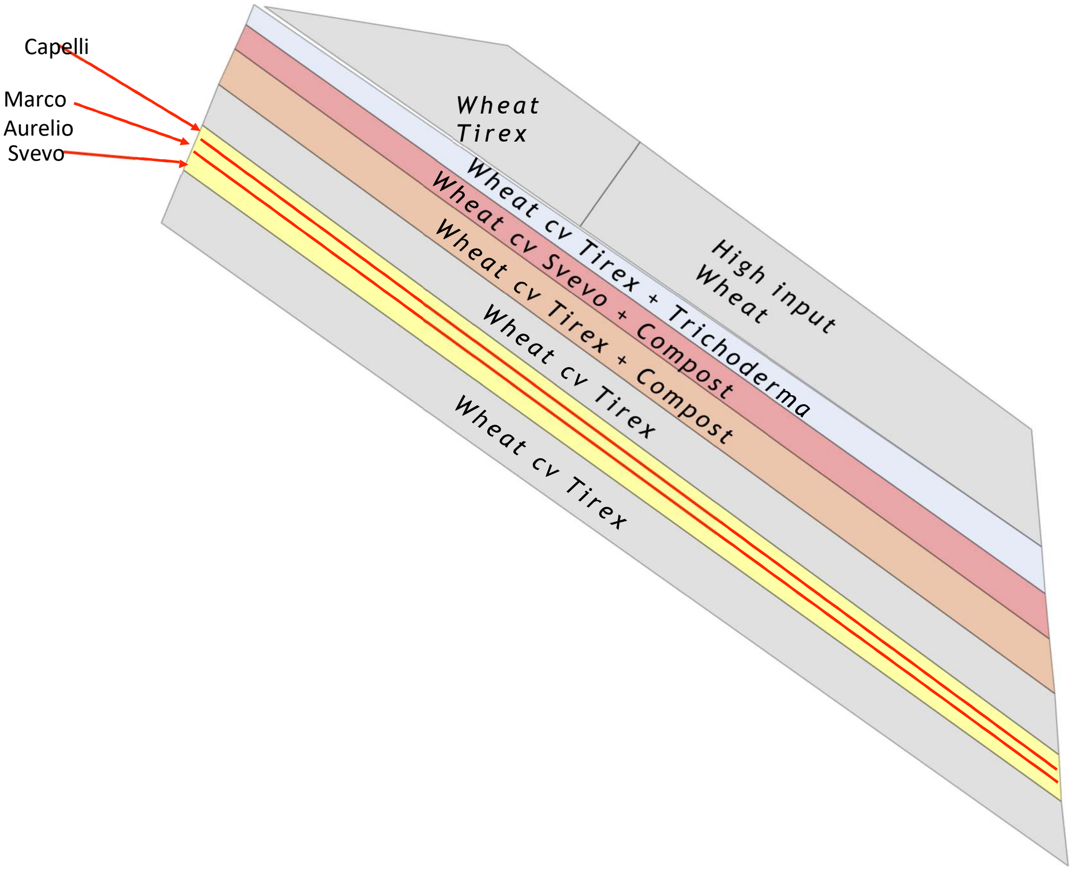

Figure 10. The layout of cereal demonstration fields.

In the AgrEcoMed project, wheat and legumes will follow the same rotation scheme already in place on the farm, but the wheat growth dynamics and productivity of modern varieties (cv. Marco Aurelio, Tirex, Svevo) grown on the farm will be compared with durum modern with ancient varieties (i.e cv. Senatore Capelli). The fertilization plan will be customized and used for the variable rate distribution of fertilizers through the "precision farming" technique.

Fertilizers and herbicides are major input costs in many cropping systems worldwide. Manipulation of crop fertilization is a promising agronomic practice in reducing weed interference in crops. Many weeds are high N consumers, thus limiting N for crop growth. Research has shown that crop–weed competitive interactions can be altered by N dose, source, application timing, and application method. At present, composts are mostly used within agriculture as a source of organic matter. Soil organic matter concentrations are declining in intensive arable rotations and the loss of organic matter from the soil is associated with increased soil erosion, particularly from fields of winter-sown cereals. At present, composts are mostly used within agriculture as a source of organic matter. Compost is the product of artificially controlled bio-oxidation and humification of a mix of organic materials such as solid organic waste from green and woody biodegradable plant residues such as pruning waste, manure, and sewage waste. When compost is added to soil, it has multiple positive effects on its physical, chemical, and biological properties, which result in improvements in the productivity and quality of crops (Ho et al., 2022). Using agricultural by-products, predominantly manure, as compost may also be an effective way to sequester carbon. A trial ran for 19 years (Tautges et al., 2019) showed that the use of compost and cover crops boosted soil carbon content by 12.6%. The use of bio-waste compost on land can have beneficial effects on the plant-soil system. Nine environmental benefits were identified in an extensive literature review: nutrient supply, carbon sequestration, weed pest, and disease suppression, increase in crop yield, decreased soil erosion, retention of soil moisture (blue water is saved), increased soil workability, enhanced soil biological properties and biodiversity, and gain in crop nutritional quality (Martínez-Blanco et al., 2013). Compost is not just beneficial to farming: because it is produced from waste, it also helps the circular economy process and leads to more sustainable production methods. It improves contaminated, compacted, and marginal soils through better soil water-holding capacity, nutrient retention, and soil structure. It provides cost savings over conventional soil, water, and air pollution remediation technologies.

Particular attention in the AgrEcoMed project will be paid to assess the effects of the by-products and wastes, used for their use as compost for soil fertility, defense of crops, and weed control. The field experiment plots (Tirex- Compost and Svevo-compost) are designed to determine the growth dynamics of winter wheat to synthetic fertilizer level (high and low), nitrogen management (high vs. VRT), and fertilization management (conventional vs. a new concept of organic micro granular fertilizers with biostimulant action).

Fusarium head blight (FHB) is the principal disease affecting wheat worldwide, decreasing grain quality, and production. This disease is mainly caused by members of the *Fusarium graminearum* species complex (FGSC), which can produce mycotoxins in the contaminated grains. The pathogen overwinters on crop residues (wheat straw). Trichoderma spp. is the most popular research tool as a microbial inoculant which has been largely used against several plant pathogenic fungi causing soil-borne, airborne, and post-harvest diseases of the plant through their high antagonistic and mycoparasitic potential.

Another objective of the agrEcoMed project is to evaluate the growth-promoting ability of wheat crops treated with bioformulation Trichoderma harzianum (Th3).

2.3 Data collection

During the field traits, all the data for monitoring cropping system behavior (crop growth analysis, yield quantitative and qualitative response, soil organic matter and nutrient balance, etc.) and the input of cultivation (seeds, fertilizers, energy for machinery, etc.) will be collected for the computation of energy balance and efficiency. Some of the core data to be collected include:

i. Soil map and soil analysis and statistics;
ii. Electric resistivity of soil;
iii. Spatial analysis of soil physical-chemical characteristics;
iv. Climate indexes (Average annual precipitation, Number of wet days per year, Mean elevation);

v. Crop chlorophyll content and leaf area index (LAI);
vi. Timing of soil cultivation, sowing, and harvesting;
vii. The seed rate and number of seedlings used for cultivation;
viii. Type and quantity of N-P-K fertilizers and agro-chemicals for plant protection;
ix. Fertilization maps;
x. Soil amendment quantities;
xi. Fuel and machinery expenditures for farming activities;
xii. Human labor working hours;
xiii. Type and quantity of soil conditioners and compost;
xiv. The yield of main products and yield by-products;

A customizable, generic life cycle inventory template for data collection was designed to facilitate the data collection. The field activities planned for WP1 will provide data, information, and materials for the activities of WP2, tasks 1,2,3,4, P UNIBAS, UNIBA, CREA-PB, CBS, and ENAM. WP3, task 1,2,3,4, P UNIBAS, UNIBA, UCO, UPV. WP4, task 1,2,3 P UNIBA, UCO, WP5, and WP6. The environmental impacts and damage generated by the cultivation of the products grown in the experimental tests will be carried out using Life Cycle Assessment (LCA), by following ISO 14040-44 standards. Additionally, the economic sustainability and potential economic benefits for farmers in given contexts will be explored.

2.4 Delays and difficulties

The most difficult factors to control in field trials are the environmental conditions (weather, pests and diseases, soil conditions). High variations of environmental factors reduce the consistency of results. It is like field experiments in that not all factors are controlled; therefore the level of variation is taken into account by using multiple replicates for the same experiment and the trials are repeated for at least three years.

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