Escola Superior
Agrária
Politécnico de Coimbra

ESCOLA SUPERIOR AGRÁRIA
INSTITUTO POLITÉCNICO DE COIMBRA

MESTRADO EM AGRICULTURA BIOLÓGICA

Ricardo João Cerdeira Veiga Leitão

Os Sistemas Agroflorestais de Sucessão em Portugal

Qual o seu contributo no futuro da Agricultura Biológica?

Orientador: Pedro Mendes-Moreira

Coimbra, 2022

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Relatório de Estágio apresentado à Escola Superior Agrária de Coimbra para cumprimento dos requisitos necessários à obtenção do grau de mestre em AGRICULTURA BIOLÓGICA

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“**Escolhe um trabalho de que gostes,**

e não terás que trabalhar nem um dia na tua vida..”

PROVÉRBIO ANTIGO CHINES (ANÓNIMO)

RESUMO

Os Sistemas Agroflorestais de Sucessão (SAFS) são modelos agroflorestais com uma recente implementação em território europeu e como tal com limitada investigação científica em climas temperados e de influência Mediterrânica. A Escola Superior Agrária do Instituto Politécnico de Coimbra, pelas mãos do professor Pedro Mendes Moreira, da doutora Rosa Guilherme e do mestre Walter Sandes, é, à data da realização da presente dissertação, a única instituição superior que se tem dedicado ao estudo destes sistemas em Portugal. Tendo como base o trabalho desenvolvido até então e partindo da hipótese de que os SAFS poderão contribuir para o aumento da sustentabilidade e resiliência às alterações climáticas de modelos agrícolas da agricultura biológica moderna, foi realizado um levantamento e caracterização das principais iniciativas de SAFS em Portugal continental. Utilizando uma abordagem participativa, com visitas às explorações e levantamento de dados de campo e aplicação de questionários em entrevistas semiabertas, foi recolhida e processada informação detalhada com vista ao conhecimento do ponto de situação dos SAFS portugueses. Foram selecionadas 9 explorações num total de 22 campos de SAFS. Apesar da elevada heterogeneidade registada foi constante um desenho de arvores em linha (baseado no modelo de agrofloresta *alley-cropping*), uma estrutura base assente em pomares de fruta e uma elevada biodiversidade de espécies vegetais arbóreas, arbustivas e herbáceas. Foi registada uma grande afinidade com a agricultura biológica tendo os SAFS sido identificados como uma potencial fonte de transferência de conhecimento sob a forma de soluções de base ecológica. Foram também identificadas necessidades de validação de resultados, quer ao nível dos benefícios ambientais como da produtividade e rentabilidade destes sistemas. Como potenciais vantagens dos SAFS encontraram-se uma menor necessidade de rega, uma diminuição na fertilização e uma baixa incidência de pragas e doenças por comparação com modelos agrícolas equivalentes. Foram também identificadas estratégias de conversão de modelos de uso de terra agrícola em agroflorestal para além da confirmação do potencial em restauro já validado em climas tropicais. Os resultados e conclusões preliminares foram posteriormente apresentadas à comunidade científica sob a forma de comunicação em congressos internacionais de especialidade onde se submeteram à avaliação entre pares. Foi ainda promovida a divulgação da informação gerada para outros públicos com a sua publicação numa revista técnico-científica nacional bem como a organização de um

evento de caracter técnico-científico onde foi possível promover o debate e a criação de conhecimento nesta área.

ABSTRACT

Succession Agroforestry Systems (SAFS) are agroforestry models that are new in Europe and, as a result, have limited scientific research in temperate regions with a Mediterranean influence. The Coimbra Agriculture School - Polytechnic of Coimbra (ESAC-IPC), by the hands of Professor Pedro Mendes Moreira, Doctor Rosa Guilherme, and Master Walter Sandes, is, by the time of this thesis, the only Portuguese Academic institution dedicated to the study of these systems. Starting from the hypothesis that SAFS can contribute to increasing sustainability and climate change resilience in modern organic farming systems, a survey was conducted to characterize the principal SAFS initiatives in mainland Portugal. Based on the work developed so far by the ESAC team and using a participatory approach, a series of visits to farms were taken to collect field data. Questionnaires were also applied to farmers in semi-open interviews. Nine farms were selected with a total of 22 SAFS fields and detailed information was collected and processed with the purpose of characterizing Portuguese SAFS. Although high heterogeneity between fields was recorded, there was a regular design of trees in rows (based on the alley-cropping agroforestry model), a basic structure made of fruit orchards, and high biodiversity of trees, shrubs, and herbaceous plant species. A close affinity to organic farming was noted, with SAFS being identified as a potential source of knowledge to be transferred under the form of nature-based solutions. Considering environmental benefits and the productivity and profitability of these systems, the need for results validation was also identified. Compared to equivalent agricultural systems, potential advantages of SAFS include lower irrigation needs, less fertilization, and lower incidence of pests and diseases. Strategies for the conversion of agricultural land-use systems into agroforestry were also identified and confirmed the potential for restoration, already validated in tropical climates. The preliminary results and conclusions were presented to the scientific community at international scientific conferences, where they were submitted for peer review. The data generated was also disseminated to other audiences by publishing two articles in a Portuguese journal with a technical-scientific line. The final step in the journey was the organization of a technical-scientific event for promoting discussion and the creation of knowledge in this specific area.

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SIGLAS

<u>Português</u>:

Agricultura Biológica (AB)

Direção Regional de Agricultura e Pescas do Centro (DRAPC)

Escola Superior Agrária do Instituto Politécnico de Coimbra (ESAC-IPC)

Gabinete de Planeamento, Políticas e Administração Geral (GPP)

Sistemas Agroflorestais de Sucessão (SAFS)

<u>Inglês (Capítulo 1)</u>:

Common Agriculture Policy (CAP)

European Agroforestry Federation (EURAF)

Organic farming (OF)

Successional Agroforestry Systems (SAFS)

CAPÍTULO 1: INTRODUÇÃO

1) Estado da Arte

A agrofloresta é um tipo de uso de terra com larga tradição nos países mediterrânicos (Rigueiro-Rodríguez et al., 2009a) e em particular em Portugal onde o Montado ocupa cerca de 1 milhão de hectares (den Herder et al., 2017), num total de superfície agrícola utilizada (SAU) de 3,9 milhões de hectares (43% da superfície territorial) (Instituto Nacional de Estatística, 2019). A definição de agrofloresta varia conforme a fonte, por exemplo para o Estado Português, e de acordo com o Gabinete de Planeamento, Políticas e Administração Geral (GPP), um organismo oficial do ministério da Agricultura: "Considera-se sistema agroflorestal, para efeitos de benefício de apoio à instalação e prémio de manutenção, as superfícies que combinam gestão do território com espécies florestais arbóreas ou arbustivas na mesma área e cuja densidade do povoamento não ultrapasse 250 árvores ou 500 arbustos por hectare, nem seja inferior a 80 no caso das folhosas e do pinheiro manso e 150 espécimes por hectare, no caso das restantes espécies." (GPP, 2021). Numa versão mais alargada a Federação Europeia de Agrofloresta (EURAF) define agrofloresta como: "As práticas agroflorestais incluem todas as formas de associação de árvores e culturas (sistemas silvoaráveis) e/ou animais (sistemas silvopastorais), numa parcela de terra agrícola, seja no interior da parcela seja nas suas margens" (European Agroforestry Federation, 2020). Duma perspetiva mais agroecológica a agrofloresta pode ser encarada como uma prática de base agrícola que assenta na diversificação dos componentes de produção do sistema (culturas perenes, culturas anuais e/ou pecuária) e na intensificação das relações agroecológicas entre esses diferentes componentes (Rosati et al., 2021).

A Agricultura Biológica (AB) é um modo de produção regulamentado por legislação da União Europeia (EU) (Parlamento Europeu e Conselho Europeu, 2018) e como tal com características únicas de entre os vários modos de produção agrícolas. De acordo com o regulamento (UE) 2018/848 do Parlamento Europeu e do Conselho Europeu em vigor desde Janeiro de 2022: "A produção biológica é um sistema global de gestão das explorações agrícolas e de produção de géneros alimentícios que combina as melhores práticas em matéria ambiental e climática, um elevado nível de biodiversidade, a preservação dos recursos naturais e a aplicação de normas exigentes em matéria de bem-estar dos animais e de normas exigentes em matéria de produção em sintonia com a procura, por parte de um número crescente de consumidores de produtos produzido através da utilização de substâncias e processos naturais." Adicionalmente, e pese embora a grande diversidade e nuances dos sistemas em AB, esta caracteriza-se por aplicar diversas práticas de gestão que contribuem para a mitigação das alterações climáticas, pelo grande potencial no sequestro de carbono (Gattinger et al., 2012), com benefícios adicionais para o ambiente e para a biodiversidade (Tully & McAskill, 2020). Estas características únicas de regulamentação e impacto ambiental positivo colocam a AB num lugar de destaque nas recentes estratégias europeias (Comissão Europeia, 2020a, 2020b, 2021b). A certificação permite ultrapassar os constrangimentos relacionados com as garantias de cumprimento dos requisitos para ser considerado um modo de produção distinto pois ao contrário de outros modelos, tal como a agricultura de conservação, esse trabalho é realizado pelas certificadoras. É assim de esperar que a UE aposte na AB como estratégia de futuro, com objetivos concretos de cobrir uma superfície agrícola da UE de 25% até 2030 (Comissão Europeia, 2020a) e com vontade expressa de promoção da agricultura biológica e na sua contribuição para a sustentabilidade (Comissão Europeia, 2021a). O recente plano de ação para o desenvolvimento da Produção Biológica da Comissão Europeia (Comissão Europeia, 2021a) define várias linhas de desenvolvimento futuras para a AB na EU a salientar:

- Encorajar a conversão, o investimento e o intercâmbio de melhores práticas (EIXO 2)
- Contribuição para os objetivos específicos da Política Agrícola Comum (PAC) na perspetiva dos agricultores, em especial no que diz respeito a "assegurar um rendimento justo aos agricultores" e "(reequilibrar) os poderes dos agricultores na cadeia de valor" (EIXO 2)
- Contribuição para os objetivos específicos da Política Agrícola Comum (PAC) na ótica ambiental "(garantir) o desenvolvimento sustentável e uma gestão eficiente de recursos naturais", a "(proteger) os serviços ligados aos ecossistemas (da biodiversidade), os habitats e as paisagens" (EIXO 2)
- Adaptação da AB às alterações climáticas da temperatura global e ao aumento das condições meteorológicas imprevisíveis e intensificação do papel que a AB desempenha na sua mitigação (EIXO 3).

2) Questões de investigação

Apesar de muito recentes em território Europeu os Sistemas Agroflorestais de Sucessão (SAFS), vulgarmente conhecidos por “Agricultura Sintrópica”, constituem desde 2019 uma linha de investigação na Escola Superior Agrária do Instituto Politécnico de Coimbra (ESAC-IPC) quer pela implementação de uma área piloto nos campos da Escola destinados à produção em AB quer pela dissertação final de mestrado do antigo aluno do Mestrado em Agricultura Biológica (MAB) Walter Sandes (2019). Este trabalho pioneiro na ESAC-IPC, sob a coordenação do Professor Pedro Mendes-Moreira, teve na sua origem uma aproximação identificada entre a AB e os SAFS. De facto, a agrofloresta e a AB já têm sido objeto de estudo, em particular por Rosati et al (2021) que partindo do problema já identificado da “convencionalização” da AB (Darnhofer et al., 2010) e da insustentabilidade dos sistemas agrícolas convencionais e intensivos (Charles et al., 2010) defende que a adoção de práticas agroflorestais pode contribuir para a sustentabilidade da AB. A intrínseca relação entre Agrofloresta e AB, as aparentes potencialidades que os SAFS revelavam e o trabalho iniciado por Walter Sandes (2019) onde foi realizada uma primeira identificação das principais iniciativas englobando SAFS em Portugal Continental serviram de mote para o trabalho desenvolvido na presente Dissertação Final de Mestrado. Assim pretendeu-se contribuir para dar resposta às seguintes questões de investigação:

- Que dificuldades estão a ter os agricultores dos SAFS em Portugal continental na implementação dos seus sistemas agroflorestais?
- Que estratégias e adaptações estão a seguir para se adequar às suas realidades edafoclimáticas e socioeconómicas?
- Quais as grandes diferenças entre os modelos de SAFS implementados em Portugal continental quando comparados com os modelos tropicais originais?
- Quais as potencialidades dos SAFS na ótica da promoção dos serviços de ecossistema e na adaptação às alterações climáticas?
- Qual o contributo prático que os SAFS podem trazer para aumentar a sustentabilidade da AB na Europa e em Portugal em particular?
- Que técnicas e modalidades de gestão podem ser transferidas para AB não agroflorestal?
- Podem os SAFS contribuir para promover a conversão de modos de produção agrícolas convencionais para AB?

3) Objectivos

Usando uma abordagem participativa a presente dissertação teve como grande objetivo conhecer a distribuição e caracterizar os atuais campos de SAFS implementados em território de Portugal continental. Partindo de uma prévia seleção das explorações a incluir esta consistiu em visitas aos locais de estudo com registo detalhado de informação de campo e com a aplicação de questionários semiabertos aos agricultores e responsáveis pelos SAFS. Procurou-se desde o início a difusão do conhecimento gerado, quer entre pares quer numa lógica de comunicação em ciência dirigida ao público mais específico constituído por agricultores e técnicos e que culminou na realização do I Encontro dos Sistema Agroflorestais de Sucessão.

O objetivo principal procurou ser alcançado pelos seguintes objetivos secundários:

1) Conhecer as principais motivações dos agricultores portugueses na adoção da prática de SAFS

2) Identificar as principais dificuldades encontradas pelos agricultores na implementação e manutenção dos SAFS

3) Caracterizar os SAFS portugueses na componente de fertilização, controlo de infestantes, combate a pragas e doenças, rega e principais operações culturais

4) Descrever os campos de SAFS portugueses no seu desenho concecional e composição cultural

5) Avaliar a adaptação dos SAFS portugueses à certificação em Modo de Produção Biológico

6) Promover a divulgação científica e disseminação de resultados para estimular novas linhas de investigação em AB

4) Cronologia

A presente dissertação teve como base de trabalho um conjunto de visitas realizadas a explorações de Portugal continental com SAFS implementadas. As visitas duraram desde algumas horas a 2 dias seguidos e em alguns casos foram realizadas mais que uma visita em diferentes períodos (Tabela 1). Durante cada visita procurou-se sempre que possível participar nas atividades diárias de cada exploração no sentido de gerar um clima de confiança entre investigador-agricultor que permitisse uma partilha de informação mais eficaz. Procurou-se ainda com este procedimento minimizar a perturbação na rotina diária da exploração pela presença de um elemento estranho (o investigador).

A divulgação científica resultante do presente trabalho foi diversificada e destinada a diferentes públicos. No total foram realizadas 9 atividades no âmbito da divulgação científica encontrando-se a sua descrição mais detalhada na tabela 2.

Tabela 1. Datas das visitas realizadas no âmbito do trabalho realizado para a presente de dissertação. *As quintas assinadas com x não foram integradas no presente estudo.

Exploração	Nº	Localidade	Visita 1	Visita 2	Visita 3	Visita 4
Quinta da Manguela	1	Santo Tirso, Porto	20-08-2020	17-09-2020	25-09-2020	06-07-2021
Quinta do Monte	2	Penedono, Viseu	11-10-2020			
Lugar da Terra	3	Praia de Santa Cruz, Leiria	02-12-2020			
PlantaFloresta	4	Venda do Pinheiro, Lisboa	05-01-2021			
Quinta do Alecrim	5	Torres Novas, Santarém	08-10-2021	07-01-2021		
Mendes Gonçalves S.A.	6	Golegã, Santarém	08-10-2020	17-06-2021		
Quinta da Abelhas	7	Montemor-o-Novo, Évora	23-10-2020	20-05-2021	28-07-2021	23-11-2021
Quinta da Malhadinha	8	Mértola, Beja	19-11-2020	02-04-2021	22-04-2021	
Quinta Vale da Lama	9	Lagos, Faro	16-12-2020			
Freixo do Meio	x*	Montemor-o-Novo, Évora	17-10-2020			
Quinta da Machamba	x*	Cruz da Régua, Leiria	28-09-2020			
Pinus Sintropico	x*	Guimarães, Braga	08-11-2021			

Tabela 2. Principais atividades de divulgação científica resultantes da presente tese de dissertação ordenadas por data de realização

Data	Atividade	Capítulo/Anexo
10 de Março, 2021	Comunicação oral intitulada "Successional Agroforestry Systems for Europe: the Portuguese example" na Conferência Internacional "Breeding and Seed Sector Innovations for Organic Food Systems" pela European Association for Research on Plant Breeding (EUCARPIA), Março 8-10, 2021, em Cēsis, Letónia (evento on-line)	Anexo 1
1 de Abril, 2021	Participação na tertúlia on-line "O Impacto das Práticas Agrícolas Sustentáveis na Biodiversidade, Solos e Ciclos da Água", a primeira de 3 tertúlias organizadas no |âmbito do evento "Encontros por uma Primavera Agroecológica - PrimaverAE2021 - As Dimensões da Agroecologia."	Anexo 2
2 de Abril, 2021	Organizador e formador do workshop "Biologia e Fertilidade dos Solos" no âmbito do projeto "Bolsa de Terras" promovido pela Associação Terra Sintrópica	Anexo 2
17 de Maio, 2021	Apresentação de um Poster intitulado "Successional Agroforestry Systems for the Mediterranean-Temperate transition: the Portuguese case" na 5a Conferência Europeia de Agrofloresta "Agroforestry for the transition towards sustainability and bioeconomy" pela Federação Europeia de Agrofloresta (EURAF), Maio-17-19, 2021, em Nuoro, Sardinia, Itália (evento on-line)	Anexo 3
6 de Dezembro, 2021	Publicação do artigo intitulado "Sistemas Agroflorestais de Sucessão em Portugal" na Revista Técnico-Científica Agrícola AGROTEC nº 41, edição de Dezembro de 2021	Capítulo 3
15 de Dezembro, 2021	Membro da Comissão Coordenadora do I Encontro de Sistemas Agroflorestais de Sucessão "Contributo dos Sistemas Agroflorestais de Sucessão para o Futuro da Agricultura Biológica", realizado pela ESAC-IPC e pela Direção Regional de Agricultura e Pescas do Centro (DRAPC) (evento on-line)	Capítulo 3
15 de Dezembro, 2021	Comunicação oral intitulada "Contributo dos Sistemas Agroflorestais de Sucessão para o Futuro da Agricultura Biológica: o caso Português" I Encontro de Sistemas Agroflorestais de Sucessão, pela ESAC-IPC e DRAPC, em Coimbra, Portugal (evento on-line)	Capítulo 3
15 de Dezembro, 2021	Moderador de "Mesa Redonda com agricultores e *stakeholders* pioneiros nos SAFS portugueses" no I Encontro de Sistemas Agroflorestais de Sucessão, pela ESAC-IPC e DRAPC, em Coimbra, Portugal (evento on-line)	Capítulo 3
10 de Março, 2022	Publicação do artigo intitulado "I Encontro de Sistemas Agroflorestais de Sucessão: Resumo e Conclusões" na Revista Técnico-Científica Agrícola AGROTEC nº 42, edição de Março de 2022 (artigo submetido e aceite para publicação)	Capítulo 3

5) Organização

A presente dissertação encontra-se dividida em: Introdução (Capítulo 1), dois capítulos distintos que retratam as diversas atividades de divulgação científica desenvolvida e Conclusão. O Capítulo 2 é um artigo científico que está em fase de submissão para publicação numa revista científica internacional da especialidades e revista por pares. A formatação seguida, bem como a língua inglesa em que se encontra escrito, estão já de acordo com esse objetivo. O Capítulo 2 faz um resumo de todo o trabalho de investigação realizado e apresenta os principais resultados e conclusões. O Capítulo 3 apresenta o percurso que conduziu à organização, participação e promoção do I Encontro de Sistemas Agroflorestais de Sucessão. A Conclusão faz um balanço de todo o trabalho feito e lança desafios para investigação futura nesta área.

CAPÍTULO 2: SUCCESSIONAL AGROFORESTRY IN THE EUROPEAN ATLANTIC-MEDITERRANEAN TRANSITION CLIMATE: A CONTRIBUTION TO ORGANIC FARMING SUSTAINABILITY?

O presente capítulo pretende fazer um resumo de todo o trabalho de recolha de informação desenvolvido pelo autor da dissertação e foi redigido num formato preparado para ser submetido a uma revista científica da especialidade o que justifica a língua inglesa, a estrutura em forma de artigo, a formatação das tabelas e imagens bem com da bibliografia.

Article title: Successional Agroforestry in the European Atlantic-Mediterranean Transition Climate: a Contribution to Organic Farming Sustainability?

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Abstract

The Successional Agroforestry Systems (SAFS) have been promoted and upgraded by Swiss farmer Ernst Götsch in Brazil over the last 30 years but only recently have been implemented in Europe. The presence of trees in arable systems is associated with the provision of a significant number of ecosystem services and has multiple benefits for climate change resilience and adaptation. Although based on ecological values, organic production has recently been accused of "conventionalization" and lacking sustainability. To unveil the potential benefits of successional agroforestry to improve climate change resilience and circularity in organic farming, nine Portuguese farms with SAFS implemented were studied in detail in 2020/2021. Fields design and species composition were recorded, and semi-structured questionnaires were applied to farmers using a participatory approach. Great field size and composition heterogeneity were found, but high planned biodiversity and tree densities were standard features. A close affinity with organic production certification was also confirmed. Multifunction trees and shrubs between fruit trees were a nature-based solution present in all study systems, following the stratification and ecological succession described for SAFS. Besides reinforcing the restoration potential, the combination of bio-intensive vegetable production in the alleys was a popular strategy. SAFS could be used as guidance and source of knowledge transfer in the conversion of organic vegetable production and organic fruit orchards agriculture systems to agroforestry systems with benefits in farm sustainability, namely relation to water use and fertilization. *Carbon farming* and the new Common Agricultural Policy's

Eco-schemes could provide additional funding. More research is needed to confirm environmental benefits, assess farms' productivity and profitability, and promote the inclusion of nature-based solutions with new technologies and digitalization in agriculture.

List of keywords: Agroecology, Climate Change, Ecological Restoration, Ecosystem Services, Ecological Succession, Soil Degradation

1. Introduction

The landscapes of the Mediterranean basin have coevolved with their environments and societies, resulting in an extreme diversity of agroecosystems with high historical and ecological value (Blondel, 2006). This area is also characterized as a "climate change hotspot", a region expected to suffer the effect of Climate Change (CC) with higher intensity (Michaelides et al., 2018). Indeed, during this century, precipitation is expected to decrease to around − 20 mm/K, and temperature will warm by 20% compared to the global average, putting this region at extreme drought risk (Lionello & Scarascia, 2018). Besides CC, many Mediterranean basin areas suffer from biodiversity loss (associated with traditional landscape mosaics) and severe soil degradation (Lagacherie et al., 2018). Rural abandonment, a major socio-environmental problem, is a direct consequence and aggravates the vulnerability to CC through the increase in fire risk {Aguilera:2020et}. These effects will be particularly severe for agriculture, which intrinsically depends on climatic conditions, forcing the need for new approaches that can promote higher climate-resilient food production systems and reverse soil degradation.

Organic farming (OF) is an agricultural method that aims for food production using natural substances and processes (European Parliament and European Council, 2018) and is also regarded as one option to increase the sustainability of modern agriculture and reduce its environmental impact (Bedoussac et al., 2015). Moreover, under severe drought conditions, farms with organic management can compensate yields gap compared to conventional farms and can even be more productive in some situations (Reganold & Wachter, 2016). In the last 20 years, the natural evolution of OF generated a debate around its conventionalization in Europe and worldwide (Darnhofer et al., 2010). Apart from all the controversy around OF, farmers are practicing OF that ranges from more linear standard systems, strictly following organic certification regulations, to systems that go beyond the regulations by limiting external inputs as much as possible and using ecologically and technological-based resources. This opens the door for many possibilities and innovations. Although OF has an unquestionable role in developing sustainable farming systems to keep up with the world food requirements, no single farming system or practice works best everywhere, and research for organic and other innovative farming systems is needed (Reganold & Wachter, 2016).

Europe, particularly the Mediterranean basin, has a historical and tight bond between society and agriculture, resulting in valuable traditional ecological and agricultural knowledge. These rich agricultural traditions have evolved due to historical and geographical characteristics, such as adverse climatic conditions, which lead to the development of a synergistic interaction between human land uses and nature conservation (Migliorini et al., 2018). In these socio-cultural and biophysical conditions, agroecology could represent a valuable transition to sustainable farming systems that are more environmentally friendly. It designs, develops, and promotes the transition toward farming and food systems based on diversity, external input substitution by ecosystem services, and a social approach. It includes the economic perspective while providing multiple benefits (Wezel et al., 2018). By combining knowledge from traditional, indigenous, practical, and local producers, with global scientific knowledge (Food and Agriculture Organization of the United Nations, 2018) agroecology can be an effective tool to find local solutions to global problems. The term "agroecology" can be described by three main definitions: a scientific discipline, a movement, and a practice (Wezel et al., 2009). In Portugal, like in France, agroecology is currently considered a group of practices. It is increasing in area and getting more attention, particularly on the social media and more recently in research and education institutions, such as the Caravana Agroecologica national project (Pereira et al., 2020). Agroecological practices have been proposed as promising tools for CC adaptation (Altieri et al., 2015). These practices, based on sustainable use of local renewable resources, combine farmers' practical knowledge with the latest scientific research (Catalogna et al., 2018) and include: cover crops, green manure, intercropping, biological control, resource and biodiversity conservation practices, livestock integration, and agroforestry with timber, fruit or nut trees (Wezel et al., 2014).

Agroforestry is considered a sustainable land use option and an example of enhancing diversity in farm structure and management (Wezel et al., 2020). These systems have been recorded from about 4,500 years ago in the southwest of the Iberian Peninsula (Pinhasi et al., 2005). There is a long tradition of different agroforestry systems all over Europe, such as silvoarable agroforestry, forest farming, riparian buffer strips, improved fallow, and multipurpose trees. *Dehesas* (in Spain) or *Montados* (in Portugal) are the most relevant broad-leaved agroforestry systems in Europe, with around 1 million ha in Portugal (den Herder et al., 2017).

Besides the *Montado*, there are several traditional agroforestry systems in Portugal that, although much less representative, are good examples of sustainable adaptation to local conditions. The most common agroforestry systems in Portugal's northern and central regions are the *Lameiros*, *Soutos* and *Castinçais,* the *Bocage,* and the *Touças. Lameiros* agroforestry systems are natural pastures where trees are included either randomly or in hedges, borders and/or in riparian forest lines. Traditionally built for field demarcation, these trees are important for local firewood consumption, animal fodder, soil protection from water or wind erosion, and pasture improvement. Deep and fertile soils typically characterize these areas (Paulo et al., 2014). *Soutos* and *Castinçais* agroforestry systems include low tree density stands of *Castanea sativ*a species, managed for chestnut (*Souto*) or high-quality wood production (*Castinçal*) in association with permanent pastures (natural or improved) for animal consumption. These areas are also frequently characterized by mixed stands with *Quercus pyrenaica* trees(Paulo et al., 2014). In *Bocage* agroforestry systems (also known as *Boscagem*, in the center of Portugal), hedgerows are planted on field boundaries, which are often organized into a spatial network at the landscape scale. High- and medium-stemmed trees with a herbaceous stratum on the ground are among them. Their purpose is to define property lines, provide shelter for cattle and crops (windbreaks), and generate enough firewood and timber to meet demand(Aviron et al., 2016; Paulo et al., 2014). *Touças* is a pyrenean oak coppice agroforestry system characterized by the presence of a tree layer, planted at densities between 400 and 1,100 stems. The understory is dominated by oak regeneration and, to a lesser extent, by shrubs such as *Cytisus* spp., *Erica* spp., and *Genista* spp. The herbaceous layer is scarce due to leaf fall and tree shading. The wood obtained during the felling operation is sold as firewood, the primary commercial use, and the woodlands were not generally managed conventionally. These agroforestry systems provide forage and enhanced welfare to small ruminants since trees have a direct value as a fodder crop, providing acorns in autumn and leaves mainly in summer (Rigueiro-Rodríguez et al., 2009b). Olive (*Olea europeaea* L.) orchards with other annual crops cultivated between the trees and animal (mainly sheep) production form a continuous landscape in many parts of Portugal inland. In these diverse agroforestry systems, where animals are a component of crop production, pruning provides a valuable additional foodstuff, thereby reducing the cost of animal feeds (Rigueiro-Rodríguez et al., 2009b). *Alfarrobais* is a rare agroforestry system in the south region that includes *Ceratonia siliqua* tress with cattle.

The presence of trees in arable systems provides many ecosystem services and has multiple benefits for adapting to CC (Brown et al., 2018; Jose, 2009; Torralba et al., 2016). Moreover, agroforestry has real potential to reduce fire risk and protect ecosystems (Damianidis et al., 2021). These benefits to the agroecosystem functioning can positively impact overall yields (Lehmann et al., 2020; Temani et al., 2021). On the other hand, agroforestry systems usually require higher management needs and demand more labor while the trees' component occupies land available for the arable cash crop (Wezel et al., 2014). Silvoarable agroforestry is characterized by widely spaced trees intercropped with annual or perennial crops. It comprises alley-cropping, scattered trees, and line belts (Mosquera-Losada et al., 2012). Alley-cropping systems are expanding in Europe, in particular in France and Germany, offering an up-and-coming land-use option for the temperate zone (Quinkenstein et al., 2009; Wolz & DeLucia, 2018). Evidence from the ecosystem services enhanced by this type of agroforestry and conservation potential is emerging (Boinot et al., 2019; Cardinael et al., 2015; Cary & Frey, 2020). As reflected in the Green Deal and respective Farm to Fork Strategy and Biodiversity Strategy for 2030, the European Commission promotes agroforestry as one sustainable practice and includes it as a potential "eco-scheme" for the following 2023-2027 Common Agriculture Policy reform (CAP) (European Commission, 2021a).

The “forest transition”, also known as the forest-area transition, refers to the shift from shrinking to expanding forest areas that have occurred in many developed countries (Mather, 1992). According to Rudel et al. (2005), there are two types of arguments about forest recovery after agricultural development: the “economic development path” and the “forest scarcity path”. In the particular case of Portugal, during the 1970s and 1980s, farm laborers left the land for better-paying non-farm occupations. This loss of labor booted the wages of existing employees and led to more agricultural businesses being unprofitable. Under these circumstances, farmers forsook their more remote and less productive farms and pastures, after which these lands were reverted to forest. This social transformation, called the “economic development path”, opened the door to the expansion of forest areas (Rudel et al., 2005). Although most European traditional agroforestry systems were implemented a long time ago, the “forest transition” is currently an opportunity to promote new agroforestry areas (and models) as a specific kind of Reforestation. It’s the example of smallholders developing agroforestry systems associated with secondary successions on former pastures or fallows that can be enriched with valuable species (Meyfroidt & Lambin, 2011). According to these authors, these forested landscape mosaics are most common at forest edges, in regions where smallholders rather than large-scale operators operate. They can help maintain or improve the health of natural forest ecosystems by providing continuity between planted and natural forests.

Successional Agroforestry Systems (SAFS) are an ancient type of agroforestry, original from indigenous people that smallholder farmers have practiced throughout the centuries all over the tropics (Bertsch, 2017). Indonesia (*Rattan agroforests*), Myanmar (*Taungya system*), India (*Jhum*), Mexico (*Milpa*) are good examples of worldwide indigenous SAFS. These agroforestry systems often originate within shifting agriculture and the slash-and-burn agriculture systems (this last one is still common throughout the tropics today) and form some of the oldest agricultural practices known. Many indigenous SAF systems are still practiced today, adapting to a shifting economy. They maintain their traditional characteristics, such as the diverse cropping assemblages, long fallows, and selective planting to foster the regeneration of the forests where they are included. The silvicultural approaches, based on farmers' consistent recognition and awareness of tropical forest ecology and "natural" ecological succession, constitute a valuable form of knowledge. The array of indigenous successional agroforestry systems directly inspired the modern approach to SAFS (.Bertsch, 2017; J. Schulz, 2011; Young, 2017), particularly the Swiss farmer Ernst Götsch who promoted and improved SAFS in Brazil over the last 30 years. Ernst Götsch created the concept "Syntropic Agriculture" (D. Andrade et al., 2020), and SAFS are the agroforestry design that supports it. The modern approaches to SAFS combine indigenous knowledge with a more functional approach to improve productivity and sustainability in degraded agricultural landscapes while regenerating the soils (B. Schulz et al., 1994; Young, 2017). This particular type of agroforestry differs from other agroforestry systems for having ecological succession and stratification as the two main processes in its foundation (J. Schulz, 2011) (Figure 1). In the particular case of Ernst Götsch, he was influenced by the beginning of the organic agriculture movement in Europe. Still, he diverged from it by refusing any kind of "unnatural" interventions in the systems (e.g., the use of active compounds for plant protection) and by chasing a zero-input objective. From a theoretical point of view, there is a contrast between Ernst Götsch´s explanation of the ecologic succession processes and the current ideas in Ecology. By defending the theory of the earth as a unique organism (Andrade, 2019; Pasini, 2017) Ernst Götsch is, in some sense, more closely related to Frederic Edward Clements (1874 –1945), an American plant ecologist and pioneer in the study of plant ecology and vegetation succession and responsible for coining same of the ecological terms still in usage. According to Clements, succession was primarily driven by interactions between species that assisted succession and the species composition of the climax community was largely predicted given a set of environmental conditions. Clements compared ecological succession to the development of an organism and the climax community to some superorganism. In addition, he proposed that the climax community was supported by interactions in essential species (Molles & Sher, 2019). Today's theories and weight of evidence on ecological succession and communities incorporate Clements's thoughts with the ideas of Henry Allan Gleason (1882–1975) (Egerton, 2015). Gleason was an American ecologist, botanist, and taxonomist. He was known for his endorsement of the individualistic or open community concept of ecological succession and his opposition to Frederic Clements's concept of the climax state of an ecosystem. Gleason proposed that ecological communities, including the climax community, were the consequence of a coincidence of independent species distributions along environmental gradients rather than predictable groupings of highly interdependent species(Molles & Sher, 2019).

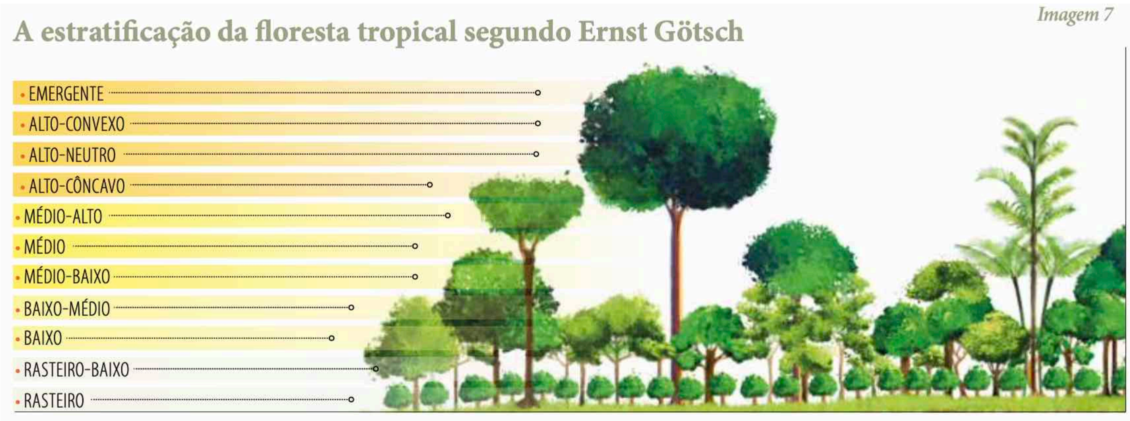

Figure 1. Tropical forest stratification according to Ernst Götsch and “Syntropic Agriculture” principles. From Rebello & Sakamoto, 2021

Ernst Götsch believes that current agriculture practices, conventional or organic, interfere with ecological succession and therefore promote ecosystem degradation (Pasini, 2017). Although this view is in line with current perspectives of scientific research (Crews et al., 2016; Smith, 2015), the assumption of *syntropy* as the core mechanism for managing life on this planet (Andrade et al., 2020) places the Syntropic Agriculture as more than an agriculture system, making it closer to a philosophical and ethic current of though. The study of Syntropic Agriculture and its principles is out of the scope of the current project, where a simplistic agronomic approach to the baseline SAFs designs and a standard set of practices was favored. It is also relevant to compare Ernst Götsch's perspective with the work of Josias Braun-Blanquet (1884 –1980). Braun-Blanquet established the modern way of classifying vegetation according to floristic composition, making him one of the most influential botanists until today (Westhoff & van der Maarel, 1978). He contributed to developing a modern approach to Phytosociology, also known as phytocoenology or plant sociology, which is the study of groups of plant species that are usually found together. Phytosociology aims to describe a given territory's vegetative environment empirically and, as a consequence, its place as a discipline of Ecology is not consensual (Egerton, 2015). According to the work of Braun-Blanquet (Westhoff & van der Maarel, 1978), a specific community of plants is considered a social unit, the product of definite conditions, present and past, and can exist only when such conditions are met. This assumption of the community, and not the individual, as the unit of the ecosystem and the relevance given to the "social" relations between plants in the community is somewhat in line with Ernst Götsch's field designs and plant neighboring.

Recent estimates refer that a few thousand family farms have adopted modern SAFS not only in Brazil in other countries in Latin America, the Caribbean, Europe, Africa, and Oceania (D. Andrade et al., 2020). Yet, the scientific literature is scarce and focused on South America, particularly Brazil and Bolivia (e.g. (Araújo et al., 2020; Armengot et al., 2016; Froufe et al., 2020), with no published papers on European systems that we have known. The first designs of SAFS had a typical nest design (B. Schulz et al., 1994; J. Schulz, 2011), but recently have evolved into multispecies tree rows densely planted a few meters apart from each other. The soil between the tree rows can have different utilities from biomass production to intense horticulture with a commercial purpose. It is possible to find design similarities between alley-cropping agroforestry (Wolz et al., 2017) and current SAFS, although the latter usually have higher tree biodiversity and density. In this sense, SAFS can be included in the alley-cropping category (European Agroforestry Federation, 2020). One of the most successful uses of SAFS in tropical climates is in restoration projects and soil regeneration, promoting forest restoration efforts while incorporating small farmers' business models (Vieira et al., 2009).

One problem with the agroecological transition of agriculture is that scientific knowledge lacks the practical side to achieve sustainability. One solution can be to include the researcher’s intentions in farmers’ projects (Hazard et al., 2018). This study aimed to characterize the current state of SAFS in the “Atlantic-Temperate transition climate”, using Portugal as a case study. It included the assessment of field areas, systems designs, species composition, and also farmers’ opinions and perceptions. We hypothesized that (i) in Portuguese SAFS species choice and management technics still have a "tropical climate" influence leaving room for optimization, particular field design and fertilization, (ii) there are local adaptations and solutions developed by SAFS farmers that can be valuable for adapting to climate change and reversing soil degradation, and (iii) there is a great potential for knowledge transfer from SAFS to "conventional" OF systems.

“Atlantic-Temperate transition climate” is not in accordance with the Köppen-Geiger climate classification (Beck et al., 2018, 2020), currently one of the most used classifications. According to the Institute of Meteorology of Portugal (2011), Portugal has mainly a *temperate climate* (type C) with a particularly dry period in summer (sub-type Cs). The Csa climate (*temperate with dry or hot summer*) covers the majority of the southern central plateau region of the Iberian Peninsula and the Mediterranean coastal region. The Csb climate (*temperate with dry or temperate summer*) covers almost all of mainland Portugal’s west coast (Figure 2). In Portugal, only in a small region of Baixo Alentejo, in the district of Beja, the climate is considered *dry climate* (type B) and *hot steppe* (sub-type BSh).

The “Atlantic-Temperate transition climate” is a bioclimatic classification (Rivas-Martínez et al., 2011) that was chosen because, in our opinion, it better reflects Portugal’s climate specificity. Also, it considers the relationship between the climate (temperature and precipitation) and the areas occupied by plant communities, in accordance with this project subject (Figure 3).

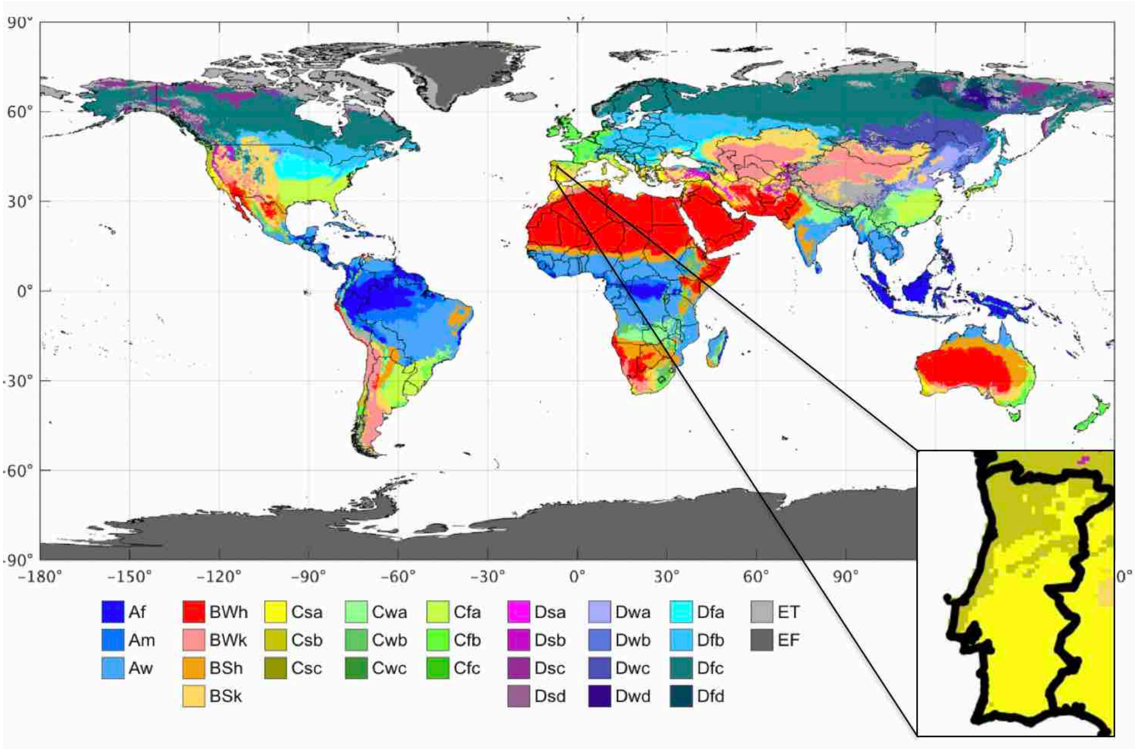

Figure 2. The present-day world map (1980–2016) of Köppen-Geiger climate classifications at 1-km resolution with Portugal highlighted (adapted from Beck et al., 2018, 2020)

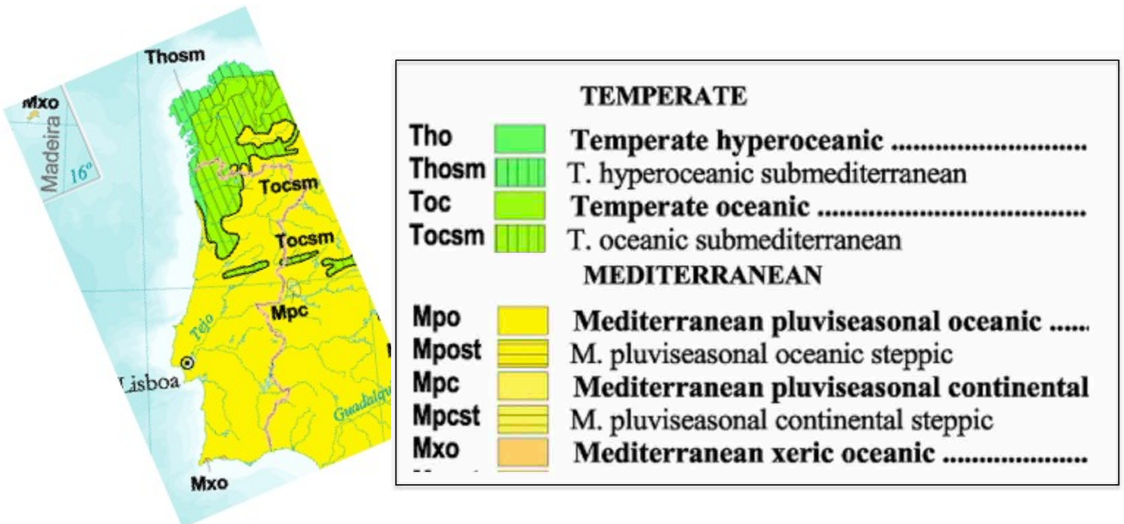

Figure 3. Bioclimatic classification of Portugal's mainland according to (Rivas-Martínez et al., 2011) (adapted from https://webs.ucm.es/info/cif/form/bi_med.htm)

2. Materials and methods

We analyzed nine case studies on the implementation of SAFS on Portugal's mainland. They differed in the locations, type of farm, fields' sizes and design, and farmer's and stakeholders' profiles. This allowed us to analyze how SAFS are being implemented in a temperate climate and compare between different farms. The study took place over a twelve-month period in 2020-2021. During that period, we collected information on SAFS's fields, and farmers' and stakeholders' perspectives to conduct a reflexive analysis of the potential contribution of SAFs to the sustainability of Organic Farming.

2.1. Literature search for SAFS

There is very little information on SAFS implemented in Europe. In order to assess the scientific literature published on this particular type of agroforestry system, a literature search on the topic of SAFs was conducted. A systematic review aims to find, evaluate, and systematically synthesize research findings. According to Grant & Booth (2009), it is defined as a "means of identifying, evaluating and interpreting all the available research, a particular research question, topic area, or phenomenon of interest".

Although the literature search we did could not be considered a formal systematic review, since it was more straightforward and less laborious, it could be regarded as more closely related to a scoping review (Peterson et al., 2017). According to Peterson et al., (2017), a scoping review might be conducted as the first step in a larger project, such as a systematic review. In this particular situation, . In this particular situation, it was aimed at unveiling the state of the art for the SAFS and finding the most adequate designation for this specific type of agroforestry.

A first scoping was performed to find the most useful keywords and get a first overview of the availability of SAFS studies. After the scoping, the keywords selected were: "successional" AND "agroforestry", "multistrata" AND "agroforestry", "complex" AND "agroforestry", "diverse" AND "agroforestry", "integrated" AND "agroforestry", "dynamic" AND "agroforestry", "forest gardens", "multistoried" AND "agroforestry", "successional ecosystems", and "homegardens". We searched the following databases for relevant journal articles: Scopus, Science Direct, and Web of Science. All papers published until December 2020 were elected for selection. Additionally, to locate grey literature, we also considered the first ten pdf and word documents provided by the

Google Scholar engine. Our review considered studies in English and Portuguese languages.

2.2. Search methodology and Inclusion criteria

The search for farms to be included in the study was based on the previous work of Sandes (2019), in which a first survey of the Syntropic Agriculture initiatives on Portugal's mainland was performed. A total of twenty-two farms were identified (Figure 4). SAFs are the baseline design used in the more recent fields of Syntropic Agriculture. However, some of the farms included in the survey performed by Sandes (2019) were mixed models and small areas used for hobbies or solely for home food production and didn't gather the necessary condition to be included in this study or had already been deactivated.

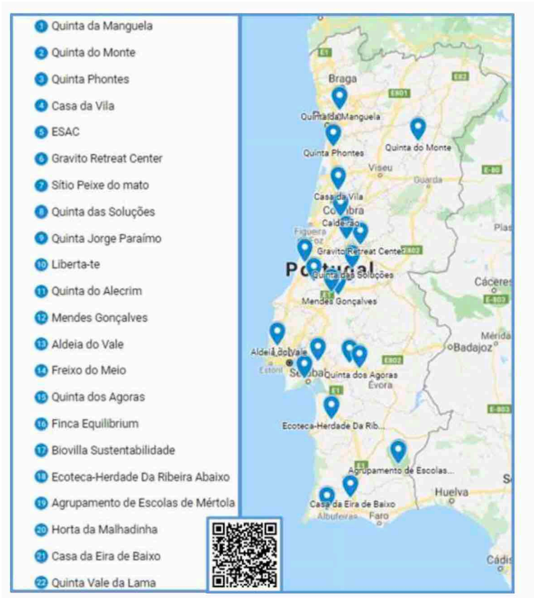

Figure 4. Location of the Syntropic Agriculture initiatives visited by Sandes (2019), and which consisted the baseline for the present study.

In addition to the data provided by the author, Sandes (2019) also actively contributed to reviewing the data analysis performed by him to more accurately select the farms to be visited for the present study. Internet and social media were also used to find other potential farms to be included in the study. Additionally, information on other Portuguese farms with SAFs was collected during the first visits. See Figure 5 for the framework followed.

The selections' criteria to select farms to be visited were: having an alley-cropping design (trees in rows widely spaced); having SAFS as the unique agronomic system or at least the dominant system; having a commercial (product selling) activity and/or consultant activity of the farmer/stakeholder.

After the selection, farms were sent an email explaining the study's context and goals and a request to schedule a visit. Of the eleven farms visited, one didn´t accept to participate in the study, and the other didn´t meet the criteria. The other nine farms were included in the study. Some farms required an additional visit to finish the data collection. Posterior visits and contacts were taken to clarify recorded information and inform farmers of the study developments.

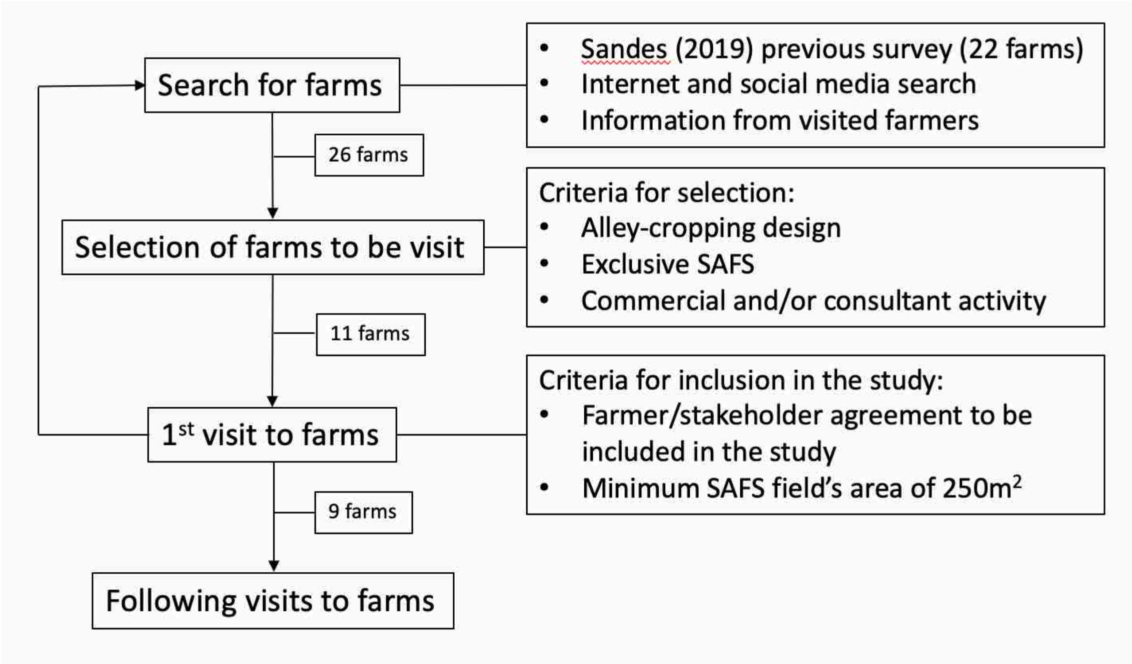

Figure 5. The framework used for farm selection.

2.3. Information collection

The visits to the farms started in August 2020, and the last visit took place in July 2021. The first contact was made by email and/or phone, and the visit date was arranged for every visit. Visits lasted from a minimum of half-day to two full days according to farms availability. In each visit, one semi-structured questionnaire (which took on average 30 to 60 minutes to answer) was applied to each farmer or person responsible (see Anexo 1), and field data was collected.

Questionnaires were inspired by the models used in previews published studies in agroecology (Morel & Léger, 2016; Rois-Díaz et al., 2018; Sagastuy & Krause, 2019), and were adapted to accommodate study objectives. The questionnaire had 78 questions and included five major topics: Workload, Irrigation, Weeds, Fertilization, and Pests and Diseases. For each of these topics, two specific questions (Figure 6) tried to better systematize farmers' empiric information to evaluate SAFS's potential for climate change adaptation and resilience, and for limited dependence on external inputs. Every plant species planted was identified and recorded for each farm visited, either visually (most of the time) or using farmers' information. We considered the previous and current seasons for annual plants (Autumn-Winter and Spring-Summer) at the time of the visit to include the whole year planting plan. The spacing of trees and shrubs in the tree rows was also recorded (and in the alleys whenever possible). To promote farmers' engagement with the study and researcher involvement in SAFS's daily dynamics, the researcher offered an assistance of any kind to farmers in compensation for the time given by the farmer. Consequently, during the visits, the researcher regularly helped some of the farmers in several farms' daily operations. This type of participatory approach allowed to create an empathic relationship with the farmers and the stakeholders. This contributed to complementing the information collected with valuable data from the composition of the SAFS fields and, more relevant, from farmers' own ideas and perceptions of SAFS experience.

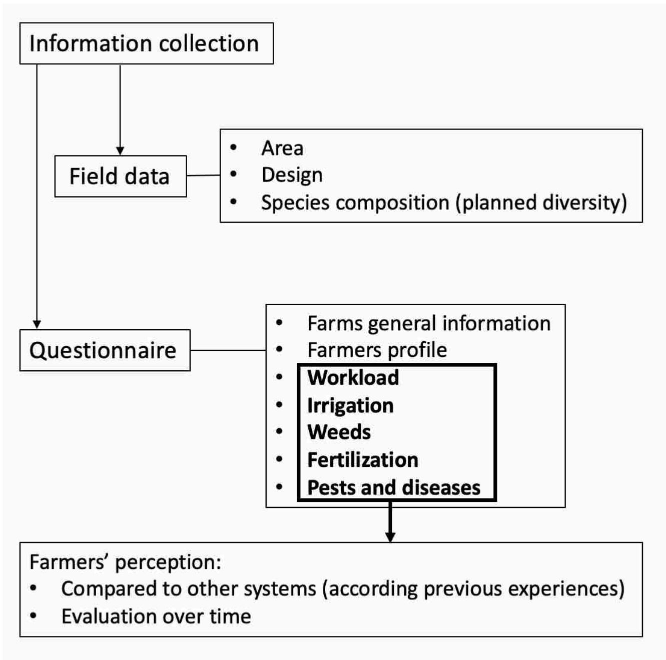

Figure 6. The framework for information collection in each visited farm.

3. Results and discussion

3.1. Literature review

A total of 27 journal papers and book chapters were selected to be included in the literature review (Table 1). None of the selected works was developed in Europe, with the great majority being done on Tropical South American SAFS. From Europe, we only found two abstracts:

- Jennifer J. Schulz and Philipp Weckenbrock (2016). Complex agroforestry systems for Europe: inspiration from successional agroforestry. Poster presented at the 3rd Conference of the European Federation of Agroforestry (EURAF)
- Cathy Bouffartigue and Philippe Weckenbrock (2016). Poster presented at the 3rd Conference of the European Federation of Agroforestry (EURAF)

Adapting successional agroforestry to a European context with collaborative methods. We decided to adopt the name "Successional Agroforestry" throughout the present study since it is the most consensual for these systems. However, and considering the difficulty in establishing boundaries between different "types of Agroforestry", it is relevant at this point to stand out the similarity in design between the SAFS and Current alley-cropping systems. Based on Wolz et al. (2017), the first author considers that it would not be incorrect to classify SAFS as successional alley-cropping systems.

Table 1: Literature review resume with information on Author, Year of publication, Journal or Book title, Title, DOI (or ISBN or site if not available) and definition used to describe SAFS

Author	Year	Type of publication	Journal/Book	Title	DOI/ISBN/site	Definitions
Andrade et al	2020	Journal	Current Opinion in Environmental Sustainability	Syntropy and innovation in agriculture	https://doi.org/10.1016/j.cosust.2020.08.003	succession-based agroforestry designs
Armengot et al	2020	Journal	Crop protection	Cacao agroforestry systems do not increase pest and disease incidence compared with monocultures under good cultural management practices	https://doi.org/10.1016/j.cropro.2019.105047	successional agroforestry system
Araújo et al	2020	Journal	Agroforestry Systems	Use of the activity-based costing methodology (ABC) in the cost analysis of successional agroforestry systems	https://doi.org/10.1007/s10457-019-00368-6	successional agroforestry systems
Froufe et al	2020	Journal	Agroforestry Systems	Nutrient cycling from leaf litter in multistrata successional agroforestry systems and natural regeneration at Brazilian Atlantic Rainforest Biome	https://doi.org/10.1007/s10457-019-00377-5	multistrata successional agroforestry systems
Marconi and Armengot	2020	Journal	Agriculture, Ecosystems and Environment	Complex agroforestry systems against biotic homogenization: The case of plants in the herbaceous stratum of cocoa production systems	https://doi.org/10.1016/j.agee.2019.106664	complex agroforestry systems
Schneidewind	2019	Journal	Experimental Agriculture	Carbon Stocks, Litterfall and Pruning Residues In Monoculture And Agroforestry Cacao Production Systems	doi:10.1017/S001447971800011X	complex agroforestry systems
Santos et al	2019	Journal	New Forests	Modeling the height–diameter relationship and volume of young African mahoganies established in successional agroforestry systems in northeastern Brazil	https://doi.org/10.1007/s11056-018-9665-1	successional agroforestry systems
Niether et al	2019	Journal	Science of the Total Environment	Below- and aboveground production in cocoa monocultures and agroforestry systems	https://doi.org/10.1016/j.scitotenv.2018.12.050	successional agroforestry system
Young	2018	Journal	Tropical Resources	Floristics of cacao agroforestry in the Mata Atlântica of southern Bahia, Brazil.	https://tri.yale.edu/tropical-resources/tropical-resources-vol-37/floristics-cacao-agroforestry-mata-atlantica-southern	agroforestry systems
Niether et al	2018	Journal	Annals of Forest Science	Shade trees and tree pruning alter throughfall and microclimate in cocoa (Theobroma cacao L.) production systems	https://doi.org/10.1007/s13595-018-0723-9	successional agroforestry
Schneidewind	2017	Journal	Experimental Agriculture	Cocoa And Total System Yields Of Organic And Conventional Agroforestry Vs. Monoculture Systems In A Long-Term Field Trial In Bolivia	doi:10.1017/S0014479716000417	highly diverse agroforests
Young	2017	Book chapter	Integrating Landscapes: Agroforestry for Biodiversity Conservation and Food Sovereignty, Advances in Agroforestry 12	Mimicking Nature: A Review of Successional Agroforestry Systems as an Analogue to Natural Regeneration of Secondary Forest Stands	ISBN: 978-3-319-69371-2	successional Agroforestry Systems
Armengot et al	2016	Journal	Agronomy for Sustainable Development	Cacao agroforestry systems have higher return on labor compared to full-sun monocultures	DOI 10.1007/s13593-016-0406-6	agroforestry systems
Andres et al	2016	Book chapter	Sustainable Agriculture Reviews	Cocoa in Monoculture and Dynamic Agroforestry	ISBN: 978-3-319-26777-7	dynamic Agroforestry
Cezar et al	2015	Journal	Agroforestry Systems	Soil biological properties in multistrata successional agroforestry systems and in natural regeneration	DOI 10.1007/s10457-015-9833-7	multistrata successional agroforestry systems
Alfaro-Flores et al	2015	Journal	Agroforestry Systems	Microbial biomass and cellulase activity in soils under five different cocoa production systems in Alto Beni, Bolivia	DOI 10.1007/s10457-015-9812-z	successional agroforestry
Jacobi et al	2015	Journal	Renewable Agriculture and Food Systems	Agroecosystem resilience and farmers' perceptions of climate change impacts on cocoa farms in Alto Beni, Bolivia	doi:10.1017/S174217051300029X	successional agroforestry
Jacobi et al	2014	Journal	Agroforestry Systems	Carbon stocks, tree diversity, and the role of organic certification in different cocoa production systems in Alto Beni, Bolivia	DOI 10.1007/s10457-013-9643-8	successional agroforestry

Celentano1 et al	2014	Journal	Journal of Ethnobiology and Ethnomedicine	Perceptions of environmental change and use of traditional knowledge to plan riparian forest restoration with relocated communities in Alcântara, Eastern Amazon	doi:10.1186/1746-4269-10-11	successional agroforestry
Schulz	2011	Book chapter	Agroforestry as a tool for landscape restoration	Imitating natural ecosystems through successional agroforestry for the regeneration of degraded lands - a case study of smallholder agriculture in northeastern Brazil	ISBN: 978-1-61728-940-8	successional agroforestry
Vieira et al	2009	Journal	Restoration Ecology	Agro-Successional Restoration as a Strategy to Facilitate Tropical Forest Recovery	doi: 10.1111/j.1526-100X.2009.00570.x	successional agroforestry
Wiersum	2004	Journal	Agroforestry Systems	Forest gardens as an 'intermediate' land-use system in the nature–culture continuum: Characteristics and future potential	https://doi.org/10.1023/B:AGFO.0000028994.54710.44	forest gardens
Ewel	1999	Journal	Agroforestry Systems	Natural systems as models for the design of sustainable systems of land use	https://doi.org/10.1023/A:1006219721151	successional ecosystems
Schulz et al	1994	Journal	Agroforestry Systems	Indigenous knowledge in a 'modern' sustainable agroforestry system -- a case study from eastern Brazil	doi:10.1007/BF00705706	integrated' agroforestry system
Ewel	1986	Journal	Annual Review of Ecology and Systematics	Designing agricultural ecosystems for the humid tropics	http://www.jstor.org/stable/2096996.	successional ecosystems
Blanton and Ewel	1985	Journal	Ecology	Leaf-Cutting Ant Herbivory in Successional and Agricultural Tropical Ecosystems	https://doi.org/10.2307/1940548	successional ecosystems
Fernandes et al	1984	Journal	Agroforestry Systems	The Chagga homegardens: a multistoried agroforestry cropping system on Mt. Kilimanjaro (Northern Tanzania)	https://doi.org/10.1007/BF00131267	homegardens

3.2. Physical description of study farms and SAFS fields

3.2.1. Farms description

The study included nine farms that the authors considered covering most of the ongoing SAFS initiatives on Portugal's mainland. Although it is a limited number of farms, most farmers involved in this study were also involved in consulting activities. Combined with the subject's popularity in social media and grey literature, the number of SAFS implemented in Portugal is expected to expand in the following years.

Farm 1: This farm was located further north of Portugal, in a region with an average of 1,144.0 mm of precipitation and air temperature of 14.8 ºC over the last thirty years, according to data from the *Statistics About Portugal and Europe* (https://www.pordata.pt/ - PORDATA – Meteorological Station of Porto). It was a farm with 7 ha, focused on vegetable and fruit production, and with two farmers responsible for the operations. It used to have an organic aromatic production, but its fields were gradually converted to SAFS and organic certification was not mantained. The remaining area was left in a semi-natural condition. One of the farmers lived with the family in a house inside the farm's area.

Farm 2: This farm was located in the interior north of Portugal. The climate has less Atlantic influence, with an average of 773.1 mm of precipitation and air temperature of 12.9 ºC (PORDATA – Meteorological Station of Bragança). It was a 9.5 ha farm, with most of the area devoted to organic cereal and legume production. It used to be an organic pig production, but it did not have any animal production at the time of our visit. SAFS represented only a small fraction of the farm, with the reminiscent of the area being a native forest of oaks and chestnuts. It was a familiar farm run by a female farmer living in a house inside the fam area.

Farm 3: This was the smallest farm in the study, with 5.000 m^2 of the total area, including the house where the two farmers (couple) live. It is located just 5 km from the sea, in a region with an average of 779.4 mm of precipitation and air temperature of 17.6 ºC (PORDATA – Meteorological Station of Lisbon). Most of the area was devoted to high-intensity vegetable production, both with and without SAFS. It was located in a peri-urban area and around 90 km from the city of Lisbon, where the farmers delivered their boxes of vegetables.

Farm 4: This was a 1 ha farm that worked mainly as a testing ground for the farmer's consulting activity. It was located on Lisbon's metropolitan perimeter, with similar climatic conditions as farm 3, and used to be an old Eucalyptus production forest. Although there was vegetable production in the SAFS fields and some selling to local restaurants, the farmer mentioned that he was more committed to restoring the soil from the impact of the previous *Eucalyptus* plantation.

Farm 5: This 3 ha farm was located in the center of Portugal, and although the nearest Meteorological Station was Lisbon, it was located in a region with a more challenging climate than the previous farms, with higher temperatures amplitudes and less precipitation. This farm used to be a conventional vineyard that the farmer converted to organic vegetable production. Later, the farmer gradually transited their vegetable fields into SAFS but maintained the direct selling of vegetable boxes as his main activity. This farm was run by a farmer that lived with his family in a house inside the farm.

Farm 6: This farm was located 20 km from farm 5 and belonged to a renowned food Portuguese company whose main products are vinegar and sauces. The agricultural fields adjacent to the main factory, with a total area of 22 ha, had implemented the largest SAFs fields identified in the study. The area used to be dedicated to conventional maize production and currently was divided into SAFs and other systems (grasslands, olive groves, etc.). It was run by two farmers hired by the company and had a team of employers to deal with daily farm operations. All SAFS fields were organic certified, and peppers and fruit products were the main products destined to be transformed in the factory.

Farm 7: This farm was located in the Alentejo region with an average of 517.2 mm of precipitation and air temperature of 17.1 ºC (PORDATA – Meteorological Station of Beja). This Portuguese region is known for its high summer temperatures and low precipitation rates. This farm was located inside a 600 ha *Montado* area. The farmer explained that he was testing a new design of fruit trees as the understory of the *Montado* system. He referred that he was still in the experimentation stage, gradually converting the *Montado* area to SAFS fields. In our last visited he already had around 20 % of his

5 ha occupied with SAFS. Of note, this farmer was one direct student of Ernst Götsch and received regular visits from him to help to design and manage his fields.

Farm 8: This farm is located in the region of Portugal at a higher risk of desertification (see section 3.10.). It has climatic conditions similar to farm 7 but even lower precipitation rates. This farm had 3.5 ha and used to be an organic aromatic production that was converted to organic vegetable production exclusively with SAFS fields. The farm also worked as an agroecological educational center and had a plant nursery inside the farm's area. The place was run by a farmer and several volunteers.

Farm 9: This 43 ha farm was located in the south region of Portugal. Although it was located in a region with an average of 413.0 mm of precipitation and an average air temperature of 18,2 ºC (PORDATA – Meteorological Station of Faro), it had access to large quantities of water all year round because of a local dam. It had the oldest SAFS field corresponding to only a small fraction (2.500 m^2) of the farm's area. One part of the farm was destined for rural tourism, and the other for animal production (mainly sheep).

3.2.1.1. Spatial distribution

The study farms were evenly distributed throughout the Portuguese territory, with higher concentration in areas with stronger Mediterranean influence (Figure 7). This might be a consequence of the benefits that agroforestry can bring to hot and dry climates reflected in the prominent number of extant agroforestry systems in the Mediterranean biogeographic region (den Herder et al., 2017; Mosquera-Losada et al., 2012).

Figure 7. Study farms distribution across Portugal's mainland. Each blue triangle represents one farm. A total of 9 farms were included in the study

3.2.1.2. Farm dimensions

Farms' sizes varied from 5000 m^2 in farm 3 to 43 ha in farm 9. Except for farm 6 (Figure 8) all fields implemented with SAFS had less than 1 ha (Table 2). The difficulty in mechanizing several farm operations, already described for these systems (D. Andrade et al., 2020), can justify the limited areas. Also, the fact that SAFS farmers are pioneers in these systems in Europe, with distinctive edaphic-climatic and social-economic realities from tropical countries, can play a significant role. Farm 6 SAFS fields ranged between 1 and 2 ha providing a good ground for future research. These differences in size are probably related to the farm´s industrial profile. In this particular case, it is expected that the company can support the lack of financial return that mixed fruit tree and vegetable farms have during the first years after implementation (Paut et al., 2021).

Figure 8. Large-sized SAFS field (1 ha) from the centre of Portugal (farm 6, field 1) with several tree rows and with two years when photography was taken (Winter 2020). Implementation date January 2018. Focus on mixed fruit production (Avocados, Citrus, Figs, and Pomegranates) in the rows and cover crops for biomass production in the alleys. (Photography by Ana Domingues)

3.2.1.3. SAFS age

Except for farm 9, implemented in 2011, all SAFS included in the study were implemented from 2017 onwards (Table 2). From an agroforestry perspective this limits the influence of the trees in the system. In farms 1 (Figure 9) and 5, with the first SAFS implemented in 2017, multifunction trees had already reached a considerable development (more than 5 m in poplar and eucalyptus trees). Also, some fruit trees had already started to produce what could be considered a step further in ecological succession.

Figure 9. Medium-sized SAFS field (1350 m^2) from north of Portugal (farm 1, field 2) with five tree rows and with two and half years when photography was taken (Spring 2020). Implementation date January 2018. Focus on lemon production. The main multifunction trees, poplar, are easily visible in rows 1, 3, and 5 (Photography by Ricardo Meireles)

3.2.1.4. Farm type

Most of the study farms were familiar, except for farms 6 and 8 (Figure 10). Farm 6 belonged to a corporate group, was included in the industrial complex area, and all yields were destined to be transformed into its factory. Farm 8 belonged to an association for local development focused on promoting agroecology as a solution for food sovereignty in low-density territories facing soil desertification processes (see section 3.9 - Case study: Mértola, a Lab for the Future). The goals of each farm can change, same farms were more commercial-oriented while others were more focused on consulting. Two farms had education activities. All fields with SAFS had fruit trees (fruit, nuts, and/or olive), and almost all referred to vegetable production as one primary objective (Table 2). Indeed, when confronted with the question: "What is the main production expected from your SAFS fields" a standard answer was that it changed with time, usually starting with vegetable production and some with aromatic, medicinal and condimental plants, followed over time by small fruits from commercial shrubs and then with fruit production (Table 2).

Figure 10. Small-medium sized SAFS field (900 m^2) from south of Portugal (farm 8, field 2) with five tree rows and with one year when photography was taken (Winter 2020). Implementation date November 2019. Focus on mixed fruit production (Apple, Fig, Grape, Loquat, Oriental persimmon, and Plum) in the rows and biointensive vegetable production in the alleys. (Photography by Pedro Nogueira)

Table 2. Resume of questionnaire answers of study farmers/farm responsible considering farm general characteristics, agronomic management options and personal thoughts. (n – no, y – yes, n.a. – not applicable)

Farm	1	2	3	4	5	6	7	8	9
Main purpose	Vegetable, aromatics, fruit, and wood production; Afforestation	Organic cereal and legume production	Vegetable, berries and fruits production; Afforestation	Vegetable, berries and fruits production; Soil restoration	Vegetable production; Education; Consulting	Pepper (*Capsicum annuum*) and fruit production; Soil regeneration	Aromatics, fruits and acorn production; Consulting	Vegetable, berries and fruits production	Vegetable production; Education; Tourism
Main crops of the SAFS - short term	Vegetables, aromatics	Vegetables, aromatics	Vegetables	Vegetables, aromatics	Vegetables	Vegetables	Vegetables, aromatics	Vegetables	Fruits
Main crops of the SAFS - long term	Fruits, wood	Fruits	Berries, fruit	Berries, fruits	Vegetables, fruits	Fruits	Berries, fruit, acorn, cork	Fruits	Fruits
Other systems (other than SAFS)	y	y	y	n	n	y	n	y	y
Farm area (ha)	7	9.5	0.5	1	3	22	5	3.5	43
SAFS total area (m^2)	3830	324	504	1500	14800	59750	9500	1575	2500
Number of SAFS fields	3	1	1	2	4	4	3	3	1
Implementation date (1st SAFS)	July 2017	May 2019	September 2020	November 2018	March 2017	February 2019	January 2020	May 2019	September 2011
Adjacent areas of SAFS fields	Conventional Agriculture; Forest	Forest (mainly chestnuts)	Conventional agriculture; Urban	Abandoned eucalyptus field, Urban	Conventional agriculture	Conventional agriculture; Urban/Industrial areas	Montado, Organic agriculture	Mediterranean Forest	Organic Agriculture
Organic certification	n	y	n	n	y	y	n	y	3rd year of conversion period
Animal production in the farm	n	n	n	n	n	y (chickens)	n	n	y (sheep)

Farm	1	2	3	4	5	6	7	8	9
Animal production in SAFS fields	n	n	n	n	n	n	n	n	n
Irrigation	Drip irrigation	Drip irrigation	Drip irrigation	Drip irrigation	Drip irrigation + Sprinkler Irrigation	Drip irrigation	Drip irrigation (field 2 without irrigation)	Drip irrigation + Sprinkler Irrigation	Flooding
Mineral fertilization	Dolomitic limestone at implementation and after one year	n	Rock dust at implementation	Rock dust and agricultural plaster at implementation	n	n	n	n	Rock dust after eight years
Organic fertilization	Compost at implementation and regularly	Compost at implementation and regularly	Horse manure and Biochar at implementation; compost and bird manure regularly	Compost at implementation	Compost at implementation; compost and bird manure regularly	Horse manure at implementation; drip organic fertilization and compost regularly	Horse manure at implementation; horse and bird manure annually	Horse manure and compost at implementation; compost, horse bird manure regularly	Compost at implementation; compost and sulphur sparsely
Compost origin (farm)	External	External	External and Internal	External	External	External and Internal	n.a.	External	External and Internal
Biofertilizers	n	n	Mycorrhizal fungi at implementation	n	Compost tee, Nettle and Horsetail extracts regularly	Mycorrhizal fungi at implementation	n	Home-made biofertilizers for regular foliar application	Home-made biofertilizers for regular foliar application
Green manure	y (in most alleys during winter)	n	n	n	y (in same alleys during winter included in the rotation)	y (in some alleys during winter)	n	n	n

Farm	1	2	3	4	5	6	7	8	9
Cultures exclusively for biomass production	n	n	n	n	n	y (in other fields of the farm)	y (in other fields of the farm)	n	y (in other fields of the farm)
Main species used for green manure/Biomass production	Fava bean, oat	n.a.	n.a.	Ryegrass, fava bean	Alfalfa, melilot, oat, sudan grass, vetch and grassland mixture	Alfalfa and grassland mixture	Ryegrass, fava bean, yellow lupin	Fava bean, oat, sudan grass, vetch	n.a.
Weeds control	Manual, mechanical, mulching	Manual, mechanical, mulching	Manual	Manual, mechanical, mulching	Manual, cover crops, rotations, timing of cultivation	Manual, mechanical, mulching, plastic cover	Manual, mulching	Manual, mulching	Manual, mechanical, mulching
Mulching material	Straw, wood chips	Straw	n.a.	Wood chips	n.a.	Straw, wood chips, paper card	Straw, wood chips	Wood chips	Straw, wood chips
Disease/pest more common	Slugs and snails, beetroot fungal, rot tomatos	Aphids (fruit trees)	Slugs and snails, caterpillars (vegetables)	Caterpillar (Brassica)	Alticini (Brassica)	*Phytophthora capsicid* (peppers)	No diseases/pests to report so far	Slugs and snails, caterpillars (vegetables)	Mediterranean fruit fly, caterpillars (fruit trees)
Methodologies for disease/pest control	No intervention required so far	No intervention required so far	No intervention required so far	No intervention required so far	Biofertilizaers, rotation, cover crops, timing of cultivation	Foliar micronutrient fertilization	No intervention required so far	Foliar application of homemade biofertilizers	Mass capture traps, *Casuarina equestifolia* extract for foliar application
Auxiliary ecological structures in SAFS fields	n	n	n	n	Ecological corridor (natural)	n	n	n	n
Ponds in SAFS field	n	n	n	n	n	n	y (natural)	n	n
Business type	Familiar	Familiar	Familiar	Familiar	Familiar	Corporate	Familiar	Associative	Familiar

Farm	1	2	3	4	5	6	7	8	9
Time allocated	Part-time	Part-time	Full-time	Part-time	Full-time	Full-time	Full-time	Part-time	Full-time
Nº workers	2	1	2	1	3	4 + external	1	3	3
Nº working days of the week	3	1 to 2	1	5	6	6	6 to 7	6	2
Nº working hours of the day	8	8	8	4	5	8	12	8	4
Nº hours/worker/week	24	12	4	20	30	48	78	16	2,7
Nº hours/week	48	12	8	20	90	288	78	48	8
Nº workers/ha	2,6	15,4	39,7	3,3	2	1	1,1	9,5	6
Nº hours/week/ha	125,3	370,4	158,7	133,3	60,8	48,2	82,1	304,8	32
Regular use of tractor	y	n	n	n	y	y	Only during fields implementation	Only during fields implementation	n
Regular use of rototiller	n	y	y (electric)	y	n	y	n	y	n
Other machinery use	Wood chipper	Strimmer	Strimmer	Strimmer, wood chipper	Strimmer	Strimmer	n	Strimmer,	Strimmer
Sources of income*	Sales of production, workshops	Workshops	Sales of production, workshops, consultancy	Consultancy, workshops, sales of production	Sales of production, consultancy	(Factory self-supply)	Funding	Sales of production	Rural tourism
Selling strategy	Vegetable boxes	none	Vegetable boxes and to local restaurants	On farm sales and to local restaurants	Vegetable boxes	Industrial product processing	none	Vegetable boxes	Tourist consumption on farm
Furthest delivery point (km)	17	n.a.	90	2	30	n.a.	n.a.	19	n.a.
Farm profitability			n	n	y	n.a.	n	y	y

Farm	1	2	3	4	5	6	7	8	9
Farm profitability exclusively on SAFS production sales	n	n	n	n	n	n	n	n	n
SAFS expected profitability	Short term (1-2 years)	Short term (1-2 years)	Short term (1-2 years)	Medium term (5 years)	Medium term (5 years)	Medium term (5 years)	Medium term (5 years)	Short term (1-2 years)	Short term (1-2 years) but only combined
Nº of SAFS responsible/farmers	2	1	2	1	1	2	1	1	2
Age of SAFS responsible/farmers	45; 46	40	30; 39	30	46	41; 41	25	45	61; 40
Gender of SAFS responsible/farmers	Male; male	Female	Female; male	Male	Male	Female; male	Male	Male	Male; male
Previews experience with SAFS	n; y	n	y; y	n	n	n	y	y	n; n
Higher education	Agronomist (farmer 2)	Agronomist	Nutritionist (farmer 1)	Informatic engineer	Architect PhD	Biotechnological engineer (farmer 1)	Agronomist	n.a.	Biologist (farmer 2)
First contact with SAFS	Internet; professional context	Internet	Internet; internet	Internet	Internet	Internet; internet	University	Internet	Friend; professional context
Link to Ernst Götsch	Ernst Götsch´s workshop attendance	Not personally (indirectly through a consultant)	Ernst Götsch´s workshop attendance	Ernst Götsch´s workshop attendance	Ernst Götsch´s workshop attendance	Ernst Götsch´s consultancy	Ernst Götsch´s student	Ernst Götsch´s workshop attendance	Ernst Götsch´s workshop attendance
Satisfied with SAFS	y	y	y	y	y	y	y	y	y
Plans for new SAFS fields	y	y	y	y	y	y	y	y	n**

* All activities related to SAFS enrolled by farmers/farm responsible that are paid

** Farmers have plans for a new fruit orchard that could be considered an hybrid between SAFS and conventional with fruit tree rows filled with one or two additional strata, such as berries shrubs.

Some farmers also mentioned that timber was the last product they expected. This reflects the ecological succession path these systems try to mimic (Young, 2017). In most farms, SAFS represented the central focus of the activity and production. In farms 2 and 9 SAFS represented a small fraction of the farm's activity. Farm 2 mainly had organic cereal production while farm 9 was more tourism-oriented. All farms were located in rural areas with forestry and agricultural fields neighbouring. Farm 8 was situated in the Guadiana Valley Natural Park, a protected area included in EU Natura 2000 network and surrounded by natural habitats. Farms 2, 5, 6, and 8 had organic certification, and farm 9 was in the third year of conversion period at the time of our visit. The rest of the farms gathered the necessary conditions to be certified, but their owner/responsible chose not to be for different reasons. Livestock is residual and was never associated with SAFS fields.

3.2.1.5. Irrigation strategies

Except for field 2 on farm 7, all fields on all farms were irrigated. The great majority used drip irrigation, both in the tree rows and the vegetable beds when present. In farms 4 and 8, sprinkler irrigation was also used, and farm 9 used the flood irrigation method exclusively, which contributed to the field's heterogeneity and supported some riparian vegetation.

3.2.1.6. Fertilization options

There was a common pattern of intense organic fertilization at the implementation stage. According to farmers, these high amounts of organic fertilizers accounted for the soil´s low fertility and advanced degradation in most study farms. Horse manure and compost were the main fertilizers used. Apart from the initial fertilization stage, only the farms that relied on vegetable production as a commercial strategy (farms 1, 3, 5) applied regular quantities of compost and bird manure into the vegetable beds. In farm 6, drip organic fertilization was regularly used (replacing the bird manure) and compost (Table 2). On all farms, fertilization of trees and shrubs relied almost exclusively on vegetable biomass material that could have different sources: prune residues from the perennials of the same tree row; plant material from the cover crops planted located in the alley next to the tree row; crop residues from the vegetable beds next to the tree row; plant biomass external to the respective field, either from the same farm or from external origin. Mineral fertilization was not routinely used. Almost no farm had soil analysis, with farmers referring that the initial high amounts of organic matter were used to guarantee nutrient availability and a practical buffer effect in soil properties. Although some farms produced their compost, it was not enough to fill farms' needs, and external resources were always required. Some farmers used biofertilizers, specifically Mycorrhizal fungi, during implementation. Others applied homemade ones by foliar application but not with a significant extension (Table 2).

It may be stated that forestry and agricultural land in Europe were inextricably linked until the widespread use of synthetic fertilizers. The value of agricultural land in a developed area, as well as its fertility, was tied to the amount of forest it contains (with a temporal and spatial perspective) (Rigueiro-Rodríguez et al., 2009b). In the Mediterranean context, applying manure from goats or sheep grazed in an extensive regime, such as the traditional silvopastoral systems in the mountains, was a significant way of supplying nutrients to crops (in particular nitrogen, phosphorus, and potassium). Animal manure was continuously transferred from woods to cultivated land, which helped make these locations effective for agriculture in the past. Traditionally during the summer, flocks slept in the olive groves to help fertilize the trees, which was another significant aspect of their dual-use. Until the end of the 1960s, leguminous woody species were sown to be harvested for compost in stables as they were used as a bed for animals, fodder, and wood production (Rigueiro-Rodríguez et al., 2009b). Only with the invention of synthetic fertilizers in 1910 did cattle gradually lose this important function. Although animal production was not found in the study SAFS, it would be interesting for these systems to use this source of fertilizers to reduce the inputs of products incompatible with the regulation of organic farming. Also, the control of vegetable fuels and reducing the risk of fire, and adding an additional economic activity in the same area increases the overall productivity could be seen as other benefits of using the animal component.

Green manure is a widely used technic in organic systems and was also present in some study farms. According to farmers, it was used with the dual purpose of enriching the soil with nutrients and generating biomass used for mulching the tree rows. During the winter season, green manure was usually included in the rotations, particularly in the larger fields where available crop space was not a problem (farms 1, 5, 6, and 7). Fava bean was the most common species used, and mixtures of more than ten were frequently used. Other fields on the farm (not SAFS) were sometimes used for plant biomass production, usually with legume species in combination with a non-legume.

3.2.1.7. Weeds control

In most study farms, weed control was regularly done by hand or with a strimmer in a time-consuming process. However, weed control was seen by many of the farmers as effortless and pleasant. This was in accordance with the lack of repetitive operations and the continuous challenge of mental stimulus that SAFS's farmers pointed out as an advantage of these highly biodiverse systems. Mulching with organic materials was a common practice for all farms enrolled in the study. Besides weed control, it was used with the purpose of adding organic matter to the soil and maintaining soil moisture (both tree rows and alleys). Straw and woodchips were the most common organic materials used for mulching except for farms 3 and 5, in which only compost was applied to the soil. When questioned, the farmer from farm five 5 identified several reasons for not using mulching material. The lack of economic viability with the use of other materials for mulching was the major one, as he had to buy them from outside his farm. He also referred to the importance of allowing soil warming during winter days to promote the growth of vegetables. In his opinion, straw, and woodchips mulch delayed plant growth in the cold season. However, on farm 5 (Figure 11) high amounts of compost were regularly applied to vegetable beds in the alleys that can be considered mulch, in accordance with the recent bio-intensive vegetable production technics (Jeavons, 2001; Morel et al., 2017; Morel & Léger, 2016).

Figure 11. Small-medium sized SAFS field (3000 m^2) from center of Portugal (farm 5, field 3) with 1,5 years when photography was taken (Spring 2020). Implementation date January 2019. focused in organic biointensive vegetable production with 6 m alleys (3,75 cm vegetable beds) between tree rows with fig trees. (Photography by Denis Hickel)

On farm 5, cover crops, rotations, and cultivation timing were techniques used in combination to decrease weeds competition, apart from manual control. These are biodiversity-based solutions with proven benefits already described (Petit et al., 2011). The farmer also referred that whenever he "relaxed" in weed control they quickly become dominant in the system. Plastic mulch was regularly used for weed control only on farm 6. On farm 7, hay and straw were used for heavy mulching creating a barrier with a "nest" appearance along the tree rows (Figure 12), 30 to 40 cm high, what can also contribute to water retention and, in the long term, will increase organic matter content of the soil. This can be a limiting factor since it requires large quantities of organic material at an additional cost. This material is also used as a substitute for organic fertilization combined with the organic matter resulting from the plant cutting of the alleys. The majority of the farmers enrolled in this study expected that with the evolution of the system and the growth of multifunction trees and shrubs, most of the fertilization needed would be supplied by the system itself.

Figure 12. Medium-large sized SAFS field (4000 m^2) from south of Portugal (farm 8, field 3) recently implemented when photography was taken (Spring 2021). Implementation date January 2021. Focus on mixed fruit production (Citrus, Fig, Grape, Peach) under a Montado landscape. Heavy mulch is visible in tree rows. (Photography by Marc Leiber)

3.2.1.8. Disease and pest control

Slugs and snails were the most common pest reported (Table 2), particularly on the farms with intense vegetable production. Although this is a recurrent problem when perennial plants are present (Eggenschwiler et al., 2013; Griffiths et al., 1998; Staton et al., 2019), no control measures were taken specifically for this problem in any of the farms considered. No additional measures were taken to control other pests and diseases, except for the Mediterranean fruit fly in farm 9, the oldest system included and where fruit trees were already in full production. This could reveal a future problem in controlling fruit tree pests in SAFS, a problem already well described in organic orchards with high yield losses reported (Culliney, 2014; Shaw et al., 2021). In the mixed fruit tree-vegetable systems, a similar agroforestry type, and where vegetable production at the ground level is combined with tree fruit production, the impact of trees on pest abundance was not clear (Imbert et al., 2020). One reason pointed out by Imbert et al. (2020) was the influence of trees' presence on pest reproduction, survival, and dispersion. Although in high biodiverse agroecosystems, such as other agroforestry systems, biological control is usually enhanced (Brzozowski & Mazourek, 2018; Staton et al., 2019), in the case of the

SAFS and fruit trees, it is expected the need for the combination of different pest control technics, such as mass capture with traps (already in application in farm 9). Only on farm 5 several technics, such as the timing of cultivation and rotations, were used to prevent pests and diseases outbreaks. In farms where fruit trees were already starting to produce, there was a common opinion about the trees' positive development and health condition, which the farmers attributed to the holist effect of the SAFS.

3.2.1.9. Ecological structures

Despite the marked ecological logic behind the management of the SAFS very few farms presented ecological structures build specifically for increasing spontaneous fauna and flora biodiversity. There is a strong belief that this type of systems is enough to support all the needed biodiversity. This is a clear opportunity to further potentiate some of the ecosystem services, such as pollinators and bio-control. The introduction of native flowers strips or uncut spontaneous vegetation in marginal areas on even in some alleys, the inclusion of ponds or same artificial nests can be a valuable option promoting beneficial animals (arthropods, reptiles, birds and small mammals).

3.2.1.10. Labor requirements

Considering that most of the farms were familiar and some were only managed part-time, an estimate was made to account for the number of workers and the days and time spent working. In that sense the data presented here should be evaluated with caution. In general, the farms with a strong vegetable production component required more working hours per week (e.g., farms 3 and 8) (Table 2). Similar to organic production, this high manual volume of work can be considered a limitation for scaling up in European countries (Jansen, 2012). Social-economic conditions in Europe impose higher salaries and it is not easy to find agricultural workers, as opposed to South American countries such as Brazil and Bolivia where SAFs are highly implemented (Araújo et al., 2020; Armengot et al., 2016).

3.2.1.11. Machinery

Consistently with described for SAFS from tropical countries, the great majority of work was done by hand. The exception was at the field implementation, where tractors were used for the heavy work, mainly with conventional equipment (such as ripper, rotavator, and disk harrow) and some new prototypes. Only on farms 1, 5, and 6, the tractor was regularly used for vegetable bed preparation in the alleys. Rototiller was usually used in the smaller fields. Work was still done by hand for bed preparation to avoid soil compaction. All the planting, punning, and harvesting were also exclusively done by hand. Small machinery was used for weeding and cutting cover crops.

3.2.1.12. Economic strategy

Farms 1, 3, 5, and 8 had vegetable selling as their central focus. The other farms usually sold only a small portion of the yields, but their primary income was from consulting activities (Table 2). Demand for consulting for agroforestry and *Regenerate Farming* is increasing, and some of the farms, such as 4 and 7, were asserting their farms as testing grounds for their farmers. The goal was to try and develop new combinations and designs to gain experience in the Portuguese climate and establish their consulting activity. Farm 6 production was exclusively destined for transformation in the corporation's factory that owns it. SAFS field from farm 9 was used mainly for educational purposes, and some of the fruit produced was consumed in the rural tourism unit inside the farm area. None of the farmers engaged in selling their products exclusively from SAFS fields as the primary source of income at the time of the interview. When asked about the profitability of the farm, farmers identified two main reasons, the limited area implemented, and that fruit trees were not in full production. In particular, the farmer from farm 5 referred that he could produce enough vegetables to be profitable. Still, he was located in a low-density area which limited the number of consumers. All farms regularly sold their products through direct sales in an action ray from 1 to 90 km. The prices applied to the products followed current market values with farms 5 and 8 using their organic certification as a marketing strategy to obtain for a higher values. The absence of mediation with direct selling allowed for increasing profit margins and was identified by the farmers as the solution for bringing viability to their projects. All farmers, except farmers from farm 9, also believed that they would be profitable with SAFS production in the short to medium term. In the farmer's opinion from farm 9, only the combination of activities apart from selling could guarantee profitability.

3.2.1.13. Farmer´s characterization

The study farmers were predominantly male, with an average age of 40 and a higher education. An educational background in agronomy was only present in 3 farmers (Table 2). Previous experience with SAFS was rare, and all farms, except farm 2, have had contact with Ernst Götsch, either through the participation of workshops lectured by him or direct consulting. Almost all farmers were satisfied with the adoption of SAFS and had plans to install new SAFS fields. Farm 9, the exception, was planning to install a new orchard field in what could be considered a simplified SAFS. He explained that we would prefer to plant a conventional fruit orchard and add an extra 1 or 2 species to complete tree rows' vertical strata. This concept is further explained in section 3.7 (Future Solutions).

3.2.2. SAFS fields description

A total of twenty-two SAFS fields were included in the study, with an average area of 4300 m^2 and a median of 2500 m^2, ranging from a minimum of 324 m^2 in farm 2 to a maximum of 2 ha in farm 6. Except for farm 6, which belongs to a large food company, all other SAFS fields had less than a hectare (Table 3). This could reflect the familiar typology and the high demand for labor requirements, as previously described for these and other highly biodiverse and complex agroecological systems (D. Andrade et al., 2020; Dumont et al., 2021; Tittonell et al., 2020). Apart from farm 9, all SAFS fields had been implemented recently in time (2017 and onward), representing four years old to just a few months at the time of our visits. Therefore, they can be considered very young systems from the perspective of fruit trees production. Also, considering the life cycle expected for these particular systems, where commercial trees belonging to late stages of ecological succession are present, Portuguese SAFS could be regarded as very young.

A common feature of all SAFS included in the study is the presence of a fruit orchard mixed (tree crops) with forestry trees used for multipurpose functions (multifunction trees) (Table 3). Multifunction forestry trees included in the orchard systems are expected to present several beneficial functions, such as physical protection of tree crops and biomass production (through pruning). They also have the purpose of "filling the gaps" in the vertical strata and the successional stages, according to the farmers, but are not expected to deliver any selling food (or for own consumption) or goods of any kind. The fruit orchard and the multifunction trees compose the tree component of the agroforestry system and confer a distinctive design to SAFS, contrasting with other traditional and modern agroforestry systems present in Portugal. The "multifunction" feature of the forestry trees (and shrubs) will be deeply explained in the following sections.

Table 3. Dimensions and designs of SAFS fields included in the study

Farm	1			2	3	4		5				6				7			8			9
Field	1	2	3	1	1	1	2	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1
Previous field use	Organic aromatics production			Conventional fruit orchard	Fallow/ Abandoned	Eucalyptus grove	Fallow/ Abandoned	Organic vegetable production				Conventional maize production				Montado			Organic aromatics production			Conventional fruit orchard
Implementation date	jun/17	jan/18	jan/19	mai/19	set/20	nov/18	mar/20	mar/17	jan/18	jan/19	jan/20	fev/19	fev/20	fev/20	fev/20	jan/20	nov/20	jan/21	mai/19	nov/19	nov/20	set/11
Field length (m)	30	45	100	18	28	50	25	70	150	60	60	130	200	400	400	100	80	100	15	60	30	100
Field width (m)	16	30	20	18	18	20	20	40	40	50	50	75	50	50	50	25	40	40	15	15	15	25
Field area (m2)	480	1350	2000	324	504	1000	500	2800	6000	3000	3000	9750	10000	20000	20000	2500	3200	4000	225	900	450	2500
Field goals	Vegetable and fruit production	Vegetable and fruit production	Vegetable and fruit production	Vegetable and fruit production	Vegetable and fruit production	Fruits and nuts production, Restoration	Vegetable production. Restoration	Vegetable and fruit and nuts production	Fruits and nuts production	Vegetable and fruit production	Vegetable and nuts production	Fruit production	Fruit production	Pepper and fruit production	Pepper and fruit production	Fruits and nuts production	Fruits and olive production	Fruits and olive production	Vegetable and fruit production	Vegetable and fruit production	Vegetable and fruit production	Fruit production. Education
Nº tree rows	3	5	3	5	3	15	12	9	8	9	9	27	40	6	7	21	23	13	3	5	4	7
Tree beds witdh (cm)	100	80	80	100	75	60	120	75	75	75	75	80	80	80	80	80	100	100	80	80	80	100
Tree rows spacing (m)	4	4	2.5	3	6	3	1.6	5.5	7	4	4	4.5	4.5	6	6	2	2	3	4	4	4	4
Trees orientation in field	Length	Length	Length	Length	Length	Width	Width	Width	Width	Length	Length	Width	Width	Length	Length	Length	Length	Length	Length	Length	Length	Length
Total nº trees*	90	225	300	90	84	600	240	200	128	225	225	2025	2000	2400	2800	4200	4200	3250	45	300	120	350
Total nº trees/ha*	1875	1670	1500	2775	1670	6000	4800	680	215	750	750	2075	2000	1200	1200	16800	13125	8125	2000	3330	2670	1400
Total nº fruit trees*	30	17	85	30	28	250	n.a.	252	65	180	180	1170	3000	800	700	700	560	434	23	100	30	200
Total nº fruit trees/ha*	625	125	415	925	555	2500	n.a.	900	110	600	600	1200	2900	400	350	2800	1750	1085	1000	1115	670	800
Tree design	A-B-C	A-B-A-C-A	A-B-A	A-B-C-D-E	A-B-C	A-B-A-B-...	A-A-A-...	A-B-C-D-...	A-A-A-...	A-A-A	A-A-A	A-B-C-D-...	A-B-C-B-A	A-A-A-...	A-B-A-B-...	A-B-C-B-A-...	A-B-C-B-A-...	A-B-C-B-A-...	A-A-A	A-B-B-A-A	A-A-A	A-B-C-D-...
Tree crops Row A	Mixed fruit	Lemon, Stone pine	Citrus, Stone pine	Mixed fruit	(Multifunction trees only)	Mixed fruit	(Multifunction trees only)	Mixed fruit	Peach, Olive	Fig	Walnut	Mixed fruit	Apple, Grape, Pomegranate	Apple, Grape, Pomegranate	Apple, Pomegranate	Citrus, Grape + Fig	Olive	Olive	Apple, Fig, Loquat	Fig, Oriental persimmon, Plumb	Fig, Peach	Mixed fruit
Tree spacing** Row A (m)	3	8; 8	4; 4	3	n.a.	3	n.a.	2.5	10; 10	3	3	3	6; 6; 6	4; 4; 4	4; 4	8; 8	0.8	0,8	2; 2; 2	2; 4; 4	4; 4	3
Tree crops Row B	Blackthorn	(Multifunction trees only)	Apple	Mixed fruit	Fig, Quince	(Multifunction trees only)	n.a.	Mixed fruit	n.a.	n.a.	n.a.	n.a.	Plum	n.a.	Citrus, Grape	(Multifunction trees only)	(Multifunction trees only)	Citrus, Fig	n.a.	Apple, Grape, Loquat	n.a.	Mixed fruit
Tree spacing** Row B (m)	3	n.a.	3	3	3; 3	n.a.	n.a.	2.5	n.a.	n.a.	n.a.	n.a.	2	n.a.	4; 4	n.a.	n.a.	4.5	n.a.	9; 4,5; 9	n.a.	3
Tree crops Row C	Pear, Plumb	(Multifunction trees only)	n.a.	n.a	Apple	n.a.	n.a.	Mixed fruit	n.a.	n.a.	n.a.	n.a.	Lemon, Grape	n.a.	n.a.	Olive	Grape	Grape + Fig, Peach	n.a.	n.a	n.a.	Mixed fruit
Tree spacing** Row C (m)	3, 3	n.a.	n.a.	n.a	3	n.a.	n.a.	2.5	n.a.	n.a.	n.a.	n.a.	4; 4	n.a.	n.a.	2	6	6; 6	n.a.	n.a	n.a.	3

Main multifunction trees/shrubs	Mulberry	Fig tree, Poplar, Willow	Banana, Eucalyptus, Willow	Bay tree, Poplar, Willow	Mulberry, Poplar, Willow	Fig tree, Loquat tree, Poplar, Willow	Poplar, Willow	Bloom, Eucalyptus, Poplar	Eucalyptus	Alder, Eucalyptus, Mulberry	Alder, Eucalyptus, Mulberry	Eucalyptus, Mulberry, Poplar	Mulberry, Poplar	Birch, Eucalyptus, Poplar	Poplar, Willow	Poplar, Terebinth	Poplar, Terebinth	Poplar	Poplar, Tagasaste, Willow	Cypress, Eucalyptus, Tagasaste, Wild pistachio	Eucalyptus, Poplar, Tagasaste, Wild pistachio	Mulberry, Poplar
Nº vegetable beds between tree rows (alleys)	3	3	3	0	4	1	n.a.	3	0	3	3	0	0	4	4	0	0	0	2	2	2	0
Hedge row	y	y	n	n	n	n	n	n	n	n	n	y	y	n	y	n	n	y	y	y	y	y
Alleys productions	Winter - oat, Summer - vegetables	Winter - oat, Summer - vegetables	Vegetables	Winter - vegetables +wheat, Summer - maize + vegetables	Vegetables + Tunnel	Multifunction shrubs and herbaceous	n.a.	Winter - mixed green manure, Summer - vegetables	Grassland mixture	Vegetables	Vegetables	Grassland mixture	Grassland mixture	Winter - mixed green manure, Summer - pepper	Winter - mixed green manure, Summer - pepper	Grassland spontaneous and mixed green manure	Grassland spontaneous and mixed green manure	Grassland spontaneous and mixed green manure	Vegetables	Vegetables	Vegetables	Grassland spontaneous
Intercropping (vegetable beds)	y	y	y	y	y	n.a.	n.a.	n	n.a.	n	n	n.a.	n.a.	y	y	n.a.	n.a.	n.a.	y	y	y	n.a.
Nº vegetable species per bed in intercropping (average)	5	5	5	5	3	n.a.	n.a.	1	n.a.	1	1	n.a.	n.a.	1	1	n.a.	n.a.	n.a.	5	5	5	n.a.
Vegetable spacing* (vegetable beds)**	Conventional monoculture	Conventional monoculture	Conventional monoculture	Conventional monoculture	Bio-intensive	n.a.	n.a.	Bio-intensive	n.a.	Bio-intensive	Bio-intensive	n.a.	n.a.	Conventional monoculture	Conventional monoculture	n.a.	n.a.	n.a.	Bio-intensive	Bio-intensive	Bio-intensive	n.a.
Vegetable beds width (cm)	100	80	80	100	75	n.a.	n.a.	75	n.a.	75	75	n.a.	n.a.	80	80	n.a.	n.a.	n.a.	80	80	100	n.a.

* Total number of trees per field/per ha was estimated considering the nº of rows and the average spacing between neighbor trees in the rows (independently of being o the same of different species).

** Spacing between trees of the same species in the tree rows

3.2.2.1. Design of SAFS fields

From an agronomic perspective, all SAFS included in this study could be considered an orchard since fruit trees were the core of the designs. Also, spacing between fruit trees (both within the lines and between the rows) was in accordance with conventional organic fruit orchards. There was a standard design for all fields where trees and shrubs were arranged in rows a few meters apart, creating alleys free of perennials. This design is very similar to alley-cropping agroforestry typology, although the distance between the tree rows is much smaller in SAFS than in the current alley-cropping systems {MosqueraLosada:2012iza}. In the studied farms, distances ranged from 2 to 7 m and varied according to the purpose of the alleys and the farmer's strategy. According to the adopted model, alleys were organized in two or three vegetable beds, usually with 80 to 100 cm wide or left undivided. Some farmers used the alley's beds to produce vegetable crops with different technics and intercropping combinations, while others planted vegetables exclusively in the tree rows together with the perennial component.

In these cases, vegetables are used for filling the lower strata and the initial successional stages to simulate the ecological succession processes occurring in a forest and promote the survival and growth of the high-value trees (mainly fruit trees and *Quercus* spp). In most SAFS fields, the rows of trees and shrubs were also used as vegetable beds, ranging from 60 to 100 cm wide, with annuals planted between the woody elements. Alleys were usually larger (e.g., farms 3 and 5) in the fields of farms where vegetable production was the core of the business than those more focused on fruit production (e.g., farm 7). This type of linear design, based on the arrangement in rows, is of great convenience to include mechanization in the different cultural operations (Wolz et al., 2017) and provides an opportunity to scale up. Total tree density was high, even in the oldest SAFS, despite some trees from early successional stages having already been removed. SAFS fields included in the study had a mean of 3480 trees/ha (ranging from 215 on farm 5 to 16800 trees/ha on farm 7). This is a direct consequence of including multifunction trees (and shrubs) in the tree rows, filling the available space between the cash tree-crops, and the practice of planting a higher number of plants than needed (Table 3). Compared with conventional apple orchards (Simon et al., 2011), fruit tree densities could be considered moderate to high. SAFS fields included in the study had a mean of 1020 fruit trees/ha and (raging 110 to 2900 fruit trees/ha) with high heterogeneity between farms. The strategy of sowing, planting, and transplanting (e.g., from cuttings) trees in large numbers was used by the study farmers to try to select more locally adapted genotypes. Concomitantly farmers were purposely using living plants to increase soil cover. This justifies the lack of bare soil on most farms, particularly in the tree rows beds. In those beds, live plants and heavy organic mulch limit the soil's exposure to erosion agents, particularly during the first years before the fast-growing trees become dominant. Of note, only fruit trees and the main multifunction trees were included for accounting purposes, making the number of trees described in Table 3 lower than the present for most of the study fields. The numbers presented are also estimated by default since farmers did not follow strict designs in most cases. They experimented every year and tended to densify beyond initial plans, even for cash crops trees. This is a direct consequence of the pioneer character of these farmers and the lack of knowledge on SAFS in temperate climates. Only in farms 5 and 6 fruit trees, cultivar/rootstock combination was carefully selected to better adapt to the fields, and system characteristics and tree training and pest management were taken more seriously. This can be seen as an opportunity to optimize future implementations of SAFS by including and combining more agronomic and technical-economic knowledge in the framework of the decisions (Simon et al., 2017). Concerning the repetition of the fruit trees' composition in each tree row, field designs could be grouped into two main approaches, "AAA" and "not AAA" (including ABC, ABAB, etc.). In "AAA", all rows were equal, with each row comprising all strata levels and stages of ecological succession. In "not AAA", a sequence of rows could be identified in which strata and stages were distributed in two or three adjacent tree rows, regularly repeated throughout the field. Looking at the heterogeneity of fields' design, even in each farm, it is possible to conclude that Portuguese SAFS are still at an experimentation stage, moving towards adapting this type of agroforestry to European temperate climatic conditions and socio-economic reality.

3.2.2.2. Planned diversity

Almost all SAFS fields included in this study had a high diversity of planned plant species planted in high densities. For the diversity assumptions only plants actively seeded and transplanted (seedlings and cuttings) by the farmers were considered. For the trees and shrubs component, the highest number of species found was sixty on farm 4 (field 1), and the lowest was only three on farm 5 (field 2) (Table 4). Beside planned diversity, the regular use of autochthonous species (Table 5) and the expense of herbicides, SAFS are expected to include high weeds diversity, what could also give these systems a great potential for promoting refugees for natural biodiversity (Boinot et al., 2019).

In the SAFS, there is a search for photosynthesis maximization (D. Andrade et al., 2020; Rebello & Sakamoto, 2021). This is done by combining different tree plants (and shrubs and herbaceous plants) at short distances (sometimes only a few centimeters). These combinations are selected according to plants' expected height and the stage they occupy in ecological succession. The objective is to attempt to fill all vertical strata of all succession stages considered. By pursuing this "rule," farmers tried from the system's implementation to have at least one species from each category (vertical strata and succession stage) sown/planted in each field. This leads to a large number of combinations, although rarely is wholly fulfilled. The definition and number of vertical strata and succession stages varied slightly among farmers. The final result was a highly biodiverse and densified agroforestry compared to other agroforestry types (e.g., alley cropping agroforestry). Farmers usually attempt to include all these plants of different species in each tree row or distribute them throughout two or three neighboring tree rows. The pattern is then repeated throughout the rest of the field. Each tree row usually also follows a pattern of tree species with fruit and multifunction trees intercalated. Annuals and perennial herbaceous are required to fill the first stages of ecological succession, which can be commercial crops or multifunction plants. Considering the studied fields, a clear perspective of this complex organization can be obtained by considering a conventional fruit orchard base design with standard spacing between trees (e.g., 4 by 4 m). Then, the tree line is filled with one or two main multifunction tree species in each row, usually 1 to 2 m apart. After, the available space in each tree row is occupied with shrubs (cash crops and multifunction shrubs), maintaining a single line. Finally, annuals are planted in the tree rows beds (80 cm to 1 m), in the line, and in the rest of the bed´s area. To complete, alleys are then planted as explained in section 3.2.1.1 (Fields design). A common practice identified was the inclusion of additional plant species in each tree row, with no particular pattern or combination, to test their adaptability to local conditions and better understand their potential added value for the system. All system shrubs and trees are usually planted during the implementation, and only annuals (and perennials that didn´t survive) are replanted in the following years. Plants were either sown or planted as cuttings or seedlings, depending on the specie and the availability to the farmer.

The management of the high plant density is done mainly through pruning in a continuous and meticulous operation. Consequently, it requires a massive volume of highly specialized manual work. During the pruning activities, competition for light is minimized, and cash tree-crops and vegetable-crops are favored to the detriment of multifunction plants. This can be considered almost an art form since it demands great training and expertise. Opposing to high-value trees (and shrubs) that are carefully pruned, favoring their healthy growth and production, multifunction trees and shrubs are pruned heavily and with little concern for their health. Instead, they are managed in favor of cash crops and, in some sense, favor the whole agroecosystem in a complex holist approach. Similarly to pruning, thinning was reported by the farmers as another fundamental operation in SAFS to promote vertical stratification of all the different plant species that constitute the system (trees, shrubs, and herbaceous). According to farmers' opinion, this operation contributes to managing good sunlight exposition and reduces competition for cash crops to flourish. In the oldest system, the tree number was high, despite the regular thinning (41 species of trees and shrubs in farm 9, a field with nine years at the date of the survey) (Table 4). This is a consequence of the close distance between different species of trees, a unique characteristic of SAFS compared to other common European agroforestry systems. This proximity (sometimes of only a few centimetres) was found only between cash crop trees and other function trees. According to farmers' experience, this short spacing reinforces the health condition of their high-value trees and promotes high growth rates. In this sense, farmers manage biodiversity to create "ideal conditions" for the plant species selected for commercial purposes to thrive, simulating a forest ecosystem. The densities recorded for the multifunction trees and shrubs in some farms exceeded several plants per square meter during the first years (Table 3). With the aging of the system, trees are gradually thinned. Short distances (sometimes only 1 m) were maintained between different fruit tree species and between fruit trees and other high-value trees, as seen in the older systems included in the study. According to farmers' statements, based on their present and previous experiences, the "whole system" benefits from keeping such a short distance between different species. One possible explanation is that by combining different species, the natural (ecological) succession is manipulated by favoring the biotic interactions of inter-specific facilitation (Pretzsch et al., 2013) and minimizing the competition. Beyond these strategies of planning field designs based on vertical stratification and successional stages, beneficial plant combinations were also recorded in an attempt to register farmers' empirical knowledge and open the door for future research (Table 6).

Table 4. Planned plant diversity of study SAFS fields. Species identification and classification into different functional categories (aromatic/medicinal/condimental, berries, fruit, multifunction, vegetables) were made considering farmers opinions.

	Total	**Farm 1**			**Farm 2**	**Farm 3**	**Farm 4**		**Farm 5**				**Farm 6**				**Farm 7**			**Farm 8**			**Farm 9**
SAFS Field		**1**	**2**	**3**	**1**	**1**	**1**	**2**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**1**	**2**	**3**	**1**
Total plants species	**198**	17	33	37	52	49	78	13	42	15	33	35	15	17	23	46	62	28	41	16	26	17	67
Total trees species	**78**	6	12	10	17	25	44	4	11	3	8	8	13	8	11	19	26	9	19	8	11	6	33
Total fruit trees species	**38**	5	6	5	12	15	21	1	9	2	1	1	8	5	6	10	12	3	9	6	9	2	21
Total multifunction trees species	**35**	1	5	5	4	9	21	3	2	1	7	7	4	3	3	8	11	4	8	2	2	4	11
Total *Quercus* spp. Trees species	**5**	0	1	0	1	1	2	0	0	0	0	0	1	0	2	1	3	2	2	0	0	0	1
Total shrubs species	**36**	2	5	3	10	2	16	0	2	0	0	0	2	2	3	11	4	3	6	3	6	3	9
Total berries shrubs species	**12**	2	2	1	5	1	6	0	1	0	0	0	2	2	3	8	2	1	3	1	2	0	4
Total multifunction shrubs species	**14**	0	1	0	0	1	4	0	1	0	0	0	0	0	0	3	2	2	2	1	1	1	3
Total aromatic/ medicinal/ condimental shrubs species	**10**	0	2	2	5	0	6	0	0	0	0	0	0	0	0	0	0	0	1	1	3	2	2
Total herbaceous species	**84**	9	16	24	25	22	18	9	29	12	25	27	0	7	9	16	32	16	16	4	8	7	25
Total berries herbaceous species	**2**	0	0	1	1	0	2	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	1
Total multifunction herbaceous species	**29**	2	3	3	2	0	6	0	3	11	0	2	0	0	0	0	8	3	4	1	2	1	6
Total aromatic/ medicinal/ condimental herbaceous species	**18**	0	5	3	5	1	5	1	6	0	5	5	0	0	3	3	5	5	2	1	0	3	6
Total vegetables herbaceous species	**35**	7	8	17	17	21	5	8	20	1	20	20	0	6	5	12	19	8	10	2	6	3	12
Total fruit/berries plants species	**52**	7	8	7	18	16	29	1	10	2	1	1	10	6	10	19	14	4	12	7	11	2	26
Total aromatic/ medicinal/ condimental plants species	**28**	0	7	5	10	1	11	1	6	0	5	5	0	0	3	3	5	5	3	2	3	5	8
Total multifunction plants species	**78**	3	9	8	6	10	31	3	6	12	7	9	4	3	3	11	21	9	14	4	5	6	20

Table 5. Autochthonous trees and shrubs planted in the study SAFS tree and so as part of field's designs. Ordinated according to number of fields where were present. Farms Identification of plant species was made visually and with the contribution of information provided by farmers. (Function: A – acorn, A/M/S – aromatic/medicinal/condimental, Be – berries, C/A – cork/acorn, F – fruit, MF – multifunction, N – nut)

Autochthonous Species	**Function**	**Nº of fields present**	**Farms (identification)**
Trees			
Fraxinus angustifolia	MF	11	2,4,5,6,7,8 and 9
Salix alba	MF	8	1,3,4,5,6 and 7
Alnus glutinosa	MF	7	3,5,6,8 and 9
Castanea sativa	N	7	1,2,3,6 and 7
Olea europea	F	7	4,5,7 and 9
Quercus suber	C/A	7	3,4,6 and 7
Corylus avellana	N	6	2,3,4,5 and 6
Popolus alba	MF	5	3,4 and 7
Pyrus communis	F	5	1,2,3,4 and 5
Quercus roduntifolia	A	5	4,7 and 9
Salix atrocinerea	MF	5	2,4 and 8
Laurus nobilis	MF	4	1,2,4 and 7
Ceratonia siliqua	F	3	3,7 and 9
Pinus pinea	N	3	1
Prunus spinosa	F	3	1,2 and 9
Quercus robur	A	3	1 and 6
Betula celtiberica	MF	2	6
Celtis australis	MF	1	4
Quercus faginea	A	1	7
Quercus pyrenaica	A	1	2
Ulmus glabra	MF	1	6
Shrubs			
Arbutus unedo	Be	11	1,2,4,6,7,8 and 9
Sambucus nigra	Be	11	1,2,3,5,6,7 and 9
Rubus ulmifolius	Be	6	4,6,7 and 8
Pistacia lentiscus	MF	4	7 and 9
Pistacia terebinthus	MF	3	7 and 8
Rosmarinus officinalis	A/M/S	3	1,4 and 8
Myrtus communis	MF	2	4 and 6
Quercus coccifera	MF	2	4 and 7
Thymus vulgaris	A/M/S	2	2 and 4
Atriplex halimus	MF	1	9
Buxus sempervirens	MF	1	6
Crataegus monogyna	MF	1	9
Cytisus striatus	MF	1	5
Lavandula stoechas	A/M/S	1	8
Retama sphaerocarpa	MF	1	8
Thymus mastichina	A/M/S	1	1
Viburnum tinus	MF	1	4

Table 6. Favorable and unfavorable plant consociations reported by study farmers according to their perception on regular growth rates and plant health status.

Favourable plant consociation	Unfavourable plant consociation
Perennials	**Perennials**
Peach tree + Strawberry tree	Hazelnut + *Melaleuca* spp.
Apple tree + Chestnut tree + *Quercus* spp.	Boldo + Lavender
Avocado + Eucalyptus	**Annuals**
Casuarina spp. + Guava tree + Sequoia tree	Beans + Garlic/Onion
Eucalyptus + Fruit tree	Beans + Strawberry
Eucalyptus + *Quercus* spp.	Cabbages + Lettuce
Perennials and annuals	Courgette + Lettuce,
Apple tree + Cabbages	Courgette + Maize
Blackberry + Tomato	Cucumber + Tomato
Elderberry + Cabbages ("Galega" cultivar)	
Annuals	
Basil + Carrot + Tomato	
Beans + Pumpkin + Maize ("3 sisters")	
Cabbages ("Kale" cultivar) + Onion	
Cabbages + Lettuce	
Cabbages + *Salvia* spp.	
Carrot + Onion + Radish	
Chard + Eggplant	
Courgette + Lettuce	
Fennel + Spinach	
Garlic + Radish	
Garlic + Strawberry	
Lettuce + Radish + Spinach	

3.2.2.3. Ecological succession

One of the central processes of the SAFs is ecological succession (D. Andrade et al., 2020). In human-altered landscapes, non-assisted recovery to late-successional communities with a slow species turnover can take many decades (Molles & Sher, 2019). There is a close similarity between SAFS and Ecological Restoration (a subdiscipline of ecology driven primarily by the urgency to re-pair damaged landscape) in the sense that there is an effort to manipulate the succession to shorten the time needed to reach the late succession stages (Walker et al., 2007). In SAFS, as well as in Ecological Restoration, the manipulation of ecological succession aims to increase ecosystem productivity and services. By using tractors to plow and till the soil during SAFS implementation and by adding large quantities of organic matter, farmers change the site physio-chemical conditions and, by doing so, manipulate the succession in the SAFS. In addition, introducing desirable plant species, both autochthones and exotic, combined with the intensive pruning and thinning, forces the system to move forward in the temporal axis, shortening the sequential stages of the "natural" ecological succession. One example of the active manipulation done by farmers is the selective removal of plant species from the system once they consider that they no longer belong to the "current" successional stage (for example, the eucalyptus are supposed to be removed from the system in five to ten years after planting). For this strategy, farmers rely mostly on multifunction trees. Apart from this active management, there is still a role for colonizing spontaneous plants as long as they are framed in the system. If considered adequate, spontaneous plants will be treated like multifunction trees by the farmers and seen as beneficial. It should be noted that the climax stage considered by farmers is always a forest, which could not be in accordance with the natural ecosystem expected for that site and presents a difficulty in managing and product commercialization throughout the years. One strategy farmers tried to follow was to suspend the ecological succession to the detriment of their cash/tree crops. Considering the predicted time needed to reach late succession stages, even under system manipulation, there is still room for optimizing Portuguese SAFS to promote sustainable profitability and a balanced provision of ecosystem services.

During the study's interviews, it became clear that SAFS's farmers use a proper classification of the ecological successional stages like the vertical stratification classification. These ecological successional stages classification can differ from farmer to farmer and is not the one used in the science of Ecology (Chang & Turner, 2019). This classification was simplified and adapted to current agronomic terminology (Table 7) to help study these systems.

Table 7. Examples of the most common crops of different ecological succession stages recorded in SAFS fields of the study

Successional stages	Most common cash crops identified
I	Vegetables (lettuce, cabbage, tomato, etc)
II	Aromatic/medicinal/condimental plants (lavender, rosemary, mint, etc)
III	Berries (blueberry, blackberry, raspberry, etc)
IV	Fruit trees (apple, citrus, fig tree, grape, etc)
V	Nut trees (chestnut, walnut, etc)
VI	Olive tree/*Quercus* spp.

3.3. Agroecological practices

Considering the agroecological practices defined by Wezel et al. (2014), it was possible to identify many of those practices in the studied SAFS. In particular, “practices that require a profound change in the cropping systems”. Rotations, intercropping and mix-cropping, manual direct seeding into living cover crops or mulch, and reduced tillage were common to almost all study farms (Table 8). As well as drip irrigation and organic fertilization as “efficiency increase and substitution practices”. In this sense, and from an agroecological perspective, SAFS can be considered more than a simple agroforestry practice in what can be seen as a more holistic agricultural system. The successful experiences identified during this study concerning horticultural and orchard fruit production, combined with the agroecological practices, make SAFS valuable sources of knowledge. This knowledge could be transferred to other less complex cropping systems considered unsustainable. Small or more significant changes could be implemented in other farming systems depending on the farmer's interests and possibilities. This could be done at an equivalent scale or in larger fields to bring more resilience and help close the energy and nutrient cycle. The conversion of simple arable crops into alley-cropping systems described by Rosati et al. (2021) is a good example of how the introduction of trees can contribute to the fertilization of understory crops

Table 8. Agroecological practices present in the study farms. Classification according to Wezel et al. (2014) divided in: a) no farm redesign needed and b) redesign agroecological practices. White: not present in any farm; Light green: present in some farms, Dark green: present in all farms.

	Agroecological Practices	Farm								
a)	**Efficiency increases and substitution agroecological practices**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Crop choice									
2	Splitting fertilisation									
3	Biofertilisers	x		x		x	x		x	x
4	Organic fertilisation	x	x	x	x	x	x	x	x	x
5	Drip irrigation	x	x	x	x	x	x	x	x	
6	Biological pest control									
7	Natural pesticides									
b)	**Redesign agroecological practices**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	Crop choice and rotations	x	x	x	x	x	x		x	
2	Intercropping and relay intercropping	x	x	x	x	x	x	x	x	x
3	Agroforestry with timber, fruit, or nut trees	x	x	x	x	x	x	x	x	x
4	Allelopathic plants									
5	Direct seeding into living cover crops or mulch	x	x	x	x	x	x	x	x	x
6	reduced tillage	x	x	x	x	x	x	x	x	x
7	Integration of semi-natural landscape elements at field or farm scale					x		x	x	
8	Management of landscape elements at landscape scale.									

3.4. Questionnaire

The questionnaire applied to the farmers and stakeholders engaged in the present study attempted to collect the empirical knowledge that years of experience with SAFS provided. It was focused on labor requirements, irrigation needs, crop protection (e.g. weed control interventions, pest and diseases need for intervention) and fertilization requirements. We believe that by covering these four topics (and addressing the two specific questions on systems comparisons and the evolution with the years), the most significant agronomic challenges were covered (Figure 13). The objective was to make a preliminary evaluation of the potential SAFS' resilience to CC and the potential contribution to improving sustainability in organic (and conventional) non-SAFS farms. It also had the objective to contribute to guiding further research in these high biodiverse agroecosystems.

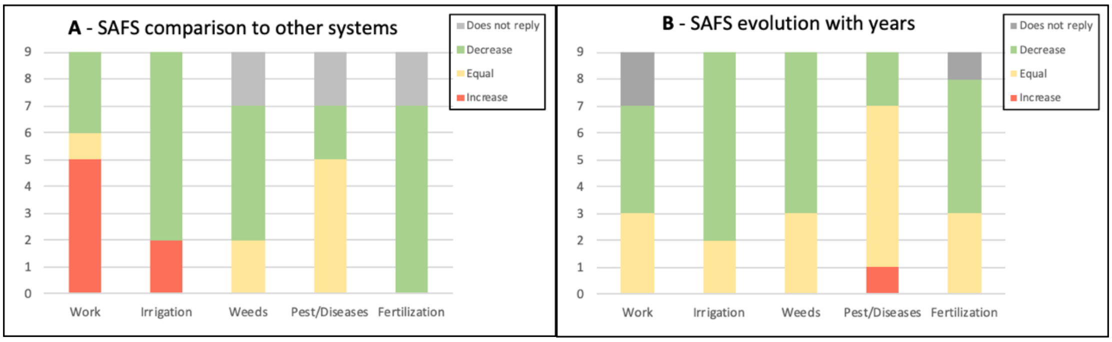

Figure 13. Farmers/farm responsible opinions on: workload (Work), irrigation needs (Irrigation), weed control interventions (Weeds), pest and diseases need for intervention (Pest/Diseases) and fertilization requirements. A – When compared with other farming systems that farmers had previous experience with. B – When compared with their SAFS evolution over the years.

3.4.1. Workload

Compared to other systems, the volume of work required to manage SAFS was, according to farmers, expectedly higher (Figure 13). This is probably a direct result of the lack of mechanization and the absence of the use of herbicides and chemical control for plant protection. Most farms' daily operations are done by hand or with simple tools, always relying upon a high workforce. In addition, the high cultural diversity, always planted with high proximity (often in the same spot exploring vertical space), makes daily operations more complex, such as harvesting or weeding. Although feasible in small areas, as found in most of the farms visited, this high workload poses an obstacle to scaling up or when dealing with a lack of available workforce. With the aging of the systems, the workload there tends to improve (Figure 13). A possible explanation is the diminishing of weeding due to the dominance of later successional stages.

3.4.2. Water

Considering farmers' opinions, the irrigation required for SAFS was usually less than for other agricultural systems. This information would be important to be confirmed by further research, particularly concerning future trends in Climate Change for the Mediterranean region (Lionello & Scarascia, 2018). Of note, when asked to compare the irrigation needs of their SAFS, only two farmers said that they require less water. One of the farmers (farm 1) was considering his previous experience with aromatic plant production, which typically has low water requirements, particularly the xerophytic

Mediterranean plants such as *Thymus* spp., *Lavandula* spp, and *Rosmarinus* spp., of which he was a producer. The other farmer (farm 7) considered the previous land use of his SAFS fields, which was the *Montado*, which required no irrigation. In farm 7, one of the fields (field 2) was an organic fruit orchard combined with a *Montado* system without any irrigation. That led to several design options that made it different from other SAFS, such as a closer distance between tree rows (2 m), high intense mulching with straw and hay, and a selection of plants favoring less water-demanding species. All the other farmers considered that SAFS required low water for irrigation. Moreover, farmers from farms 6 and 8, both in regions of Portugal with high summer temperatures and low precipitation, and both coming from organic vegetable production, openly affirmed that they decided to transit their original organic systems to SAFS to help mitigate the water scarcity they were facing. In their own words: "I felt the need to bring the tree element into the vegetable fields". It is expected that with the conversion into a SAFS system, water required for irrigation could be reduced when compared to equivalent monoculture or in other less complex systems, and it may be a consequence of several factors playing together. Alley-cropping systems design, with tree rows and arable crops in the alleys, provide wind shelter and sun protection, reduce water loss from soil evaporation, and promote soil moisture retention (Quinkenstein et al., 2009). It should be noted that, apart from the light modulation (Dufour et al., 2013) and temperature (Arenas-Corraliza et al., 2018) stabilization, tree-based intercropping systems are also known to reduce wind speed, reducing evaporative stress, which may have positive effects on water management (Jose et al., 2004). Although most of the SAFS included in the study were recent, all but two farmers considered that irrigation needs decreased with the aging of the systems (Figure 11).

3.4.3. Fertilization

One of the main goals of Ernst Götsch during his recent optimization was to make SAFS independent of external inputs, particularly fertilization (Rebello & Sakamoto, 2021). According to the study farmers, this was one of the main reasons for the inclusion of multifunction trees and shrubs, contributing to making this type of agroforestry unique. When asked to give their opinion on fertilization, only one farmer (farm 7) referred to an increase. All the other farmers (except farm 6) mentioned that fertilization needs were less than their past experiences with different agriculture systems. It must be considered that, as previously described, during SAFS implementation, large quantities of organic fertilizer are usually used. This guarantees that cultures have enough nutrients available during the first year. However, when asked about fertilization requirements when SAFS get older, three farmers referred that it remained constant. These farmers belonged to farms with intense vegetable production in the alleys and with high regular nutrient extraction. Five farmers referred to a decrease in their needs (Figure 11). In general, only the vegetable beds in the alleys received fertilization (mainly compost), with hardly any direct fertilization in the perennial tree rows. Agroforestry is characterized by a significant enhancement in soil fertility/nutrient cycling compared with conventional agriculture and forestry (Torralba et al., 2016). In SAFS, with the continuous input of organic matter resultant from the pruning and the regular mowing of multifunction herbaceous in the alleys (in some systems), it is expected to create a high flux of carbon and nutrients to the soil and back to plants in an almost close circle. In mixed cropping systems, the presence of trees and cover crops enhance the soil carbon content (Malézieux et al., 2009). Agroforestry systems usually have high soil invertebrate and microbial biodiversity (Udawatta et al., 2019) that, combined with the minimization of tillage verified in the study SAFS, create the conditions to improve the organic matter content in soils. This could contribute to increased water retention, substantiating the study farmers' reports of less irrigation required.

3.4.4. Weeds

Weeds are a major agronomic problem, either for annual or perennial crops. However, facing the direct question: "Are weeds a problem?" only farmers from farm 6 answered positively. This was probably a direct consequence of biodiversity's value, including non-planned biodiversity, to SAFS practitioners. Considering the number of workers/ha in the different farms, it is justifiable that farm 6 identified weeds as a significant problem since it is the farm with the largest implemented SAFS (approximately 6 ha total) of all farms included in the study. Although most of the farmers couldn't quantify the time, they spent controlling weeds, they referred that it was part of the daily operations on the fields, together with pruning and planting or sowing. Of note, it was not considered a control practice but instead an operation more associated with fertilization management. In a system where biodiversity and the presence of a high amount of vegetable biomass, live or dead, is seen as an advantage, it´s no surprise that weeds can be considered to have a positive impact by farmers. This can also be explained by the fact that we found a significant concern in keeping the plants of the system in a vegetative stage, particularly the non-crop species, among the study farmers. It was a general belief that some kind of "growth information" was transferred to the nearby plants, particularly the cash tree-crops and vegetable-crops, during the vegetative growth stimulated by pruning. In the SAFS, and according to the farmers, continuously pruning of trees and shrubs combined with cutting and chopping of annuals takes a central role in daily operations. It also requires specialized skills and experience. In this logic, weeds could be considered helpful by providing the necessary “growth information” that somehow compensates for the competition effect. Also, when cut and chopped, weeds contribute to biomass deposition and the mulching effect, particularly for the tree rows. In the daily operations, a significant amount of time is allocated to pruning and thinning, by hand or mechanically, which includes weeds and the plants planted and sowed in excess, that are then left in the alley beds or used as mulch for the tree rows. Planting and sowing in higher numbers than planned for later stages of the system is a technic used by these farmers to cover most the soil as quickly as possible. This applies both to herbaceous and woody plants. Considering farmers’ perception of the time allocated for weed control, five out of the nine farms mentioned that weed control was less than their previous experiences (Figure 11). Although this information is highly subjective and dependent on many factors, such as the number of workers/ha and the presence or absence of high vegetable production in the alleys, it is expected that in systems with higher plant biodiversity and densities, weeds are better controlled (Petit et al., 2011). Also, according to Pumariño et al. (2015), agroforestry can reduce weed management. In addition, when talking about the presence of weeds with the aging of their SAFS, six farmers mentioned that they perceived a reduction. This could be in part justified by an increasingly weed-suppressive soil. As the perennial plant roots invade the soil, ecological succession above ground is accelerated, reflected by a beneficial change in the soil microbiome (Battie-Laclau et al., 2020; Trognitz et al., 2016).

3.4.5. Pests and diseases

The great majority of farmers mentioned no differences in pests and disease management intensity compared to their previous experiences. The same was true for the aging of the system’s question (Figure 11). Agroforestry systems are commonly reported as beneficial in terms of pest and disease control, but data is limited, and more studies are needed, particularly in temperate zones (Pumariño et al., 2015; Sollen-Norrlin et al., 2020). Being an agroforestry system SAFS have the potential to increase soil microbial biomass and diversity (Araujo et al., 2012) and consequently increase the plant disease-suppressive capacity of the soil (Schlatter et al., 2017)**.** On the other hand, the high planned biodiversity and the presence of trees and shrubs will expectedly increase habitat availability, such as non-crop habitats, for pest natural predators and parasitoids, enhancing pest control service (Staton et al., 2019). Five farmers reported no need for interventions to control pests and diseases, and when intervention was needed, three of the farmers used biofertilizers, another agroecological practice. In farm 9, where the diverse fruit trees were already in full production, farmers reported incidence of the Mediterranean fly (*Ceratitis capitata*) and the need to resort to no-chemical control technics commonly used in an organic orchard, such as massive capture with traps. It is expectable that more farmers will have similar problems when their fruit trees start to produce because small areas of the SAFS plots don't guarantee the provision of ecosystem services more landscape scale-dependent (as opposed to farm-scale) (Wu, 2013), such as birds natural control, among others. Considering the most common problems reported, molluscan pests (snails and slugs) were mentioned by farms 1, 3, and 8 as recurrent (already described in section 3.1.1.8 Disease and pest control). These farms were characterized by intense horticultural production, similarly to published literature (Staton et al., 2019).

3.5. Limitations

Using science to help to identify barriers to adopting agricultural practices that respond to climate change and soil degradation is a demanding task. More than searching for global solutions, robust data is required to bring scientific evidence and understanding of the best farming systems and agroecological practices for each biophysical and socio-economic context (Lipper et al., 2014). Implementing scientific principles in Agroecology and, in particular, the creation of agricultural production based on biodiversity requires researchers to adjust their experiments to the farmer's needs. In contrast, farmers reflect the interaction with researchers in their goals and farm management (Hazard et al., 2018). Therefore, a solid and emphatic relation between the two parts is required and was at the core of the present study.

3.5.1. Difficulties identified

When farmers were asked to talk about the most significant difficulties they found with SAFS adoption, the most repeated were the gathering of the necessary plant material and the labor required for the implementation stage, and lack of knowledge for maintenance operations. (Table 9). SAFS fields are usually implemented during a short period, lasting from one to a few days according to the dimension and complexity of the field. It implies a great effort in plantation besides the usual work with soil preparation needed for a common agricultural field. It was a common practice for the farmer to gather many workers to complete the task, often volunteers or included in a workshop organized by him. As described by most farmers included in the study, by principle, almost all perennial plant species, plus annuals, for that season were sowed/planted during the implementation period. This operation requires a large number of plants. However, situations, such as in farm 5, field 1 was once an organic vegetable production agriculture field that gradually transited agroforestry (SAFS). This is a clear case of change in "land use". Contrary, all the other fields included in this study were implemented from the beginning as SAFS, independently of the use that land had previously. This approach of "gradually converting an agricultural field into agroforestry" can help promote a gradual adoption of more complex and diverse systems. It is less demanding and allows farmers to adapt to new conditions progressively, allowing the necessary time to develop skills for more holistic thinking. This increases the odds for long-term success {Wezel:2020ct}. For maintenance operations, labor requirements are also very high. They can be a decisive limiting factor in adopting these types of systems and for scaling to larger areas, as described in section 3.1.1.10 (Labor requirements). Farmers in this study also pointed out the lack of knowledge and expertise as significant problems, consistently with literature on SAFS and other equally complex systems (D. Andrade et al., 2020; Paut et al., 2021). In addition, the organic matter required for fertilization and mulching (particularly for implementation and maintenance operations), the lack of appropriate machinery, difficulties with planning and dealing with seasonal variation in labor, and water scarcity were also mentioned as problems (Table 9).

Table 9. Main difficulties reported by study farmers/farm responsible during SAFS fields implementation and maintenance.

		Farms								
Problems reported		1	2	3	4	5	6	7	8	9
Implementation	Gathering all necessary vegetable material (seeds, seedlings and cuttings) to			✓			✓	✓		✓
	Labor required	✓	✓		✓					
	Lack of knowledge		✓			✓				
	Getting all necessary organic matter (for fertilization and mulching purposes)			✓					✓	
	Planning	✓					✓			
	Adaptation of available machinery (too heavy causing soil compaction)								✓	
	Staff lack of training						✓			
	Communication between Ernst Götsch (teacher) and the students									✓
	Soil degradation levels				✓					
	EU regulation on invasive alien species					✓				
Maintenance	Labor required	✓	✓							✓
	Lack of knowledge		✓	✓				✓		
	Water scarcity					✓		✓		
	Getting all necessary organic matter (mulch and or compost)			✓					✓	
	Adjust labor cycles to a highly diverse farm, namely with the pruning seasons				✓	✓				
	Weeds						✓			
	Adaptation of available machinery (too heavy causing soil compaction)								✓	
	Available mulch with high C/N ratio						✓			

Most of the vegetable, fruit, and nut trees planted in the study farms were commercial varieties developed for conventional agriculture. This means that there is a clear opportunity for incorporating local varieties once these varieties usually are more adapted to local conditions and constraints. The pioneering stage of these systems, with farmers still enrolled in personal experimentation of different species combinations, and a certain alienation from the Academia is probably the reason behind this restriction. This could easily be surpassed by establishing scientific research protocols between Agriculture Schools, Universities, and farmers, like the already established with conventional farms.

3.5.2. Productivity

One of the characteristics identified in nature-like agroecosystems is the low yields compared to more conventional agriculture (Ewel, 1999). In the SAFS, similarly to alley-cropping systems (Dufour et al., 2013), there is a limitation created by the shade of trees with the maturation of the system. This results in a decrease in the area in the alleys available for vegetable production. However, it can be prolonged by favoring the choice of deciduous trees for the tree rows, using a wider distance between tree rows, selecting tree varieties with lower height, and managing trees' shape with pruning. Although not referred a problem by the study farmers, when converting less complex cropping systems into highly complex agroforestry systems, there is a justified concern that crop productivity will decrease and that profitability won't be attainable. Compared to monoculture systems, due to the higher number of crops involved, specific tools have been developed to assess productivity in intercropping systems, such as the Land Equivalent Ratio (LER) (Malézieux et al., 2009). Lehmann et al. (2020) reviewed the productivity of European agroforestry systems studies and found LER values higher than 1,00 for different agroforestry systems. Faced with water stress, agroforestry systems are expected to achieve better yields than monoculture systems (Temani et al., 2021). The stability of yields, a characteristic of intercropping systems highly valued in situations exposed to risk, can also be potentiated in multispecies systems such as complex agroforestry when the provision of a diversity of products can maintain a more stable income (Malézieux et al., 2009). Agriculture in Mediterranean countries depends heavily on fossil fuels, which generates a vulnerable situation for most farmers (Aguilera et al., 2020). With SAFS's less dependence on heavy machinery, there is an opportunity for reaching economic viability, providing that research activity continuous for these systems and adaptation is considered for different climatic and socio-economic contexts.

3.6. Current solutions

The combination of high-value fruit trees with vegetable production found in some of the study SAFS is in line with another particular type of agroforestry, the "Mixed Fruit Tree-Vegetable Systems (Paut et al., 2021). This agroforestry system shares the vertical stratification and high planned biodiversity but lacks both long-term temporal dynamics and the inclusion of functional trees of SAFS. SAFS farmers reported similar difficulties in managing the complexity of their systems. They were also faced with the need to choose between objectives and select trade-offs constraints, as described by Pault et al. (2021). We identified several strategies and practices that study farmers followed to promote higher yields. In the farms where vegetable production was prioritized and direct vegetable box selling was the key strategy of the farm (farms 1, 2, 3, 5, and 8), there seem to be two different approaches to SAFS: a wider distance between tree rows (e.g., farms 3 and 5) or less tree diversity (e.g., farms 5 and 8). The most promising strategy found was the combination of two innovative agriculture systems, SAFS, for tree rows, and an organic bio-intensive vegetable production system (Jeavons, n.d.; Morel et al., 2017; Morel & Léger, 2016) for the alleys.

Although studies assessing the profitability of agroforestry systems in temperate climates are scarce (Lehmann et al., 2020; Palma et al., 2007), biodiversity in agroecosystems is positively correlated with yields, nutrient retention, and system resilience to extreme events (Malézieux, 2012) what can be perceived as an advantage and a long-term risk reduction in SAFS. Despite the local solutions found by farmers, there is a risk of, in temperate climates, SAFS being only a productive system complementary to farmers' main activity. Farmers from the present study showed that it could be possible to make SAFS a profitable system small scale, family-run, and based on direct selling. In tropical climates, SAFS have a significant role in tropical forest restoration while simultaneously improving the social-economic conditions of smallholder farmers (J. Schulz, 2011). Looking from a future perspective, there is a clear need to find more effective strategies for scaling up and/or enhancing productivity and profitability in SAFS while at the same time maintaining climate change resilience and promoting soil degradation reversion. In our opinion, this should be seen as an opportunity for research in agroecology.

3.6.1. The *Market Garden* strategy

The combination of two complementary production systems in the same area, the SAFS and an organic bio-intensive vegetable production system, was the strategy followed by most farms that can be considered economically profitable or near profitable, namely farms 3, 5 and 8 (Table 2). The organic bio-intensive vegetable production system, popularly known as *Market Garden*, is a small-scale alternative farming system, typically located in urban and peri-urban areas that are gaining a growing interest and media coverage in some countries such as EUA, Canada, and France (Morel & Léger, 2016). Its original version does not include trees, is exclusively a vegetable production system, and is not considered agroforestry, although it is popularly called a form of "regenerative agriculture". Influenced by Coleman (1995) and Fortier (2014), it´s a farming system that focuses on high productivity per area through high cropping density, demanding culture and rotation planning and intensive crop successions (Morel et al., 2017). These systems lay in some common basic technics: focus on horticultural commodities; raised beds 75 cm wide; deep soil preparation with minimum stepping on the beds to minimize compaction; the exclusive use of organic fertilizers with heavy use of compost as the main fertilization input; close spacing between the plants in each bed; low or minimum intercropping (one, maximum two species per bed) and short selling circuits (Jeavons, 2001; Morel et al., 2017). Although the bio-intensive systems require a high volume of manual labor, labor efficiency is enhanced by using light mechanization such as tillers for superficial tillage and some new unconventional tools that reduce the weight of the farmer (Morel et al., 2017). In farms 3 and 5 the alleys were intentionally converted into short wide raised beds (Table 3) that were intensively cultivated with vegetables and received regular inputs of high quantities of compost. By mixing this organic bio-intensive vegetable production system between the perennial fruit tree rows of the SAFS, farmers saw an opportunity to reach economic viability in the first years after the system implementation. Although there are no available measurements of productivity and profitability in the study farms, it is expected to be similar to those described for the organic bio-intensive vegetable production systems (Morel et al., 2017). In these farms, a non-negligent part of the arable area is lost for the tree rows. Still, it can somehow be minimized by decreasing spacing between plants in the beds (a strategy of the *Market Garden* system as described above) or through vegetable production in the beds of the tree row during the first years, in consociation with the perennials plants. In addition, particularly in areas with high temperatures and lower precipitation (such as in farms 5, 6, and 7), the highly-dense tree rows are expected to create beneficial microclimate conditions during the hot springs and summer months for vegetables to grow.

Farms that also followed same form of organic bio-intensive vegetable production system strategy in the alleys but did not rely on heavy compost use (farms 1, 2, and 4) chose for intercropping with a high number of species/varieties of annual plants per bed. In these vegetable beds, annual plants were organized following a simple version of the vertical stratification and ecological succession used for trees and shrubs, maximizing the soil' area covered with different crops. Vegetables of different heights were combined, and harvesting was managed through the seasons (Spring/Summer and Autumn/Winter), with short-lived cultures harvested first and allowing for the long-lived ones to get to their full production. The soil vegetable beds were typically covered with straw and/or woodchips as mulch on these farms. Farm 7 can be considered a study case since it started as a classical organic bio-intensive vegetable production system (in the alleys) and gradually transited to more biodiverse intercropping, with less compost use and a high volume of woodchips as mulching. At the time of our visits, the farmer was testing the inclusion of a few perennials in the vegetable beds, mainly aromatic shrubs such as *Lavander* spp and

Rosmarinus officinallis, and the cereal *Sorghum bicolor*, in an attempt to reduce water use.

Another strategy followed by the great majority of the study SAFS was the use of a high volume of organic amends, both animal and/or green manure, at the time of implementation of each system (Table 2). Farmers expect to promote a boost in fertilization, promoting higher yields for annuals and perennials during the first years. Later in time, it would be expected that the system can be less dependent on external sources of fertilization, as explained above.

3.6.2. Restoration

There was a common belief among the study farmers that SAFS contributed to soil restoration. The great majority described that soil quality where SAFS fields were implemented was poor and that SAFS had the purpose of reversing soil degradation. Interestingly some farmers also referred that they usually choose what they considered the worst soils of their farm to implement new SAFS. Although scientific proof is needed for this assumption, SAFS are an identified restoration strategy in tropical contexts (Vieira et al., 2009). On the other hand, the use of the Natural (Ecological) Succession in restoration is generalized and widely used by its practitioners (Walker et al., 2007). It is expected that SAFS can become a successful means of restoration in temperate climates with the additional advantage of generating an income through food-producing in the process.

3.7. Knowledge transfer

Farmers from farms 5 and 8 had previous experience in organic vegetable production before turning their systems to Successional Agroforestry. Farmers from farm 1 had an organic aromatic production background. The introduction of a single species of trees in the cropland of a classical organic vegetable production farm is by itself capable of providing new ecosystem services (e.g., biological control, wind and sun protection) and enhancing existing services (nutrient cycling, carbon sequestration, and organic matter improvement) that can potentially contribute to increasing farms' sustainability and resilience (Beule et al., 2020). There is a trade-off between the number of tree species included in the system, the volume of work required for managing it, and the level of ecosystem services provided. Considering the high planned diversity observed in Portuguese SAFS and farmers' approach to converting an agriculture field into agroforestry could be regarded in particular situations, such as more arid climates and small-sized farms. For example, a solution for reducing workload could be condensing the successional stages and the vertical strata into fewer categories while following SAFS conceptual idea (B. Schulz et al., 1994), a strategy followed in farm 5. According to the ecological niche concept, the optimization of soil nutrient use is expected to be present in the SAFS and should have further research. In addition, ecological relations of facilitation promoted by the complex plant combinations of these systems should also be carefully evaluated to understand their potential role in productivity gains (Wolz et al., 2017). Scientific research is growing in alley-cropping agroforestry systems, and information could be used both ways to complement SAFS and improve new alley-cropping systems (Wolz & DeLucia, 2018).

3.7.1. Organic vegetable production

Taking a classical organic vegetable production farm the introduction a single species of trees in the cropland is by itself capable of providing new ecosystem services (e.g. biological control, wind and sun protection) and enhance existing services (nutrient cycling, carbon sequestration and organic matter improvement) that can potentially contribute to increase farms' sustainability and resilience (Beule et al., 2020). Farmers from farms 5 and 8 came from a previous classic organic vegetable production before turning their systems to Successional Agroforestry and farmers from farm 1 come from an organic aromatic production. Taking in consideration the high planned diversity observed in Portuguese SAFS this approach of converting an agriculture into an agroforestry field should be considered at least in some situations, such as arid climates and small sized farms. There should be given attention to the trade-off between the number of tree species included in the system, the volume of work required for managing it and the level of ecosystem services provided, for example by condensing the successional stages and the vertical strata in less categories while continue to follow SAFS conceptual idea (B. Schulz et al., 1994). It should be appointed that besides the obvious optimization of soil nutrients use according to the ecological niche concept (Malézieux, 2012; Malézieux et al., 2009) the facilitations relations promoted in these systems should be carefully evaluated in order to allow for productivity gains (Wolz et al., 2017). Scientific research is quickly evolving in alley-cropping agroforestry systems and a lot of information could be extrapolated from it (Wolz & DeLucia, 2018).

3.7.2. Organic fruit orchards

Conventional and non-organic low-input orchards usually have higher fruit yields when compared to organic (e.g., Simon et al., 2011) but have an increasing dependence on external inputs to the system, namely water for irrigation, fertilizers, and pesticides (Simon et al., 2017). The distinctive designs of SAFS, with several extra strata additional to a baseline fruit orchard, could bring new perspectives to monocropping orchards. In orchards composed of a unique fruit tree layer, only the herbaceous strata can be managed to provide additional ecosystem services inside the parcel. This raises the question of whether the current concept of the SAFS can be simplified while maintaining a sufficient provision of ecosystem services to compensate for a reduction in external inputs.

Farm 5 had the lowest level of complexity in species combinations and consequently the lowest number of vertical strata. On this farm, three workers are enough to manage up to one hectare of SAFS. According to the responsible farmer's reports, with a consolidated network of clients for a weekly vegetable boxes delivery system, he had enough production to become financially viable, even without full fruit production. In this way, it could be feasible for present and future implemented fruit orchards to explore and mimic SAFs strategies and include more vertical strata in the tree rows. This could bring more diversity into the agroecosystem in the form of perennial plants, and consequently increase the number and contribution of ecosystem services provided. In current organic orchards (and not only organic but also integrated pest management and/or conventional orchards), the addition of a limited number of perennial plants to the existing rows of fruit trees, instead of the large numbers found in most of the SAFS, could contain the additional labor requirements without compromising the farm’s profitability. Or even increase the economic return by including one or more cash crops in the new strata while keeping labor requirements accessible. This can be compared to what Lauri et al. (2019) described with the Apple-Based Agroforestry Systems in Europe. The recent economic interest in this particular type of agroforestry system results from the stability and security that producing mixed agricultural products and animals on the same plot can ensure throughout the years. Looking at the example of farms 1, 5, and 7, where farmers started their enterprises with classical organic farming before transitioning to SAFS, certified organic farms are in the first line to successfully accommodate innovation with SAFS. Organic farming shares many agroecological practices with SAFS, and organic farmers are used to manage more complex and ecological-based agroecosystems. Organic farming, in that sense, can be a good starting point for implementing new nature-based practices that can promote intensification in a more sustainable way (Darnhofer et al., 2010).

Certification systems already implemented, such as the "Regenerative Organic Certification (ROC)," can open the door to new categories, such as certification in agroforestry (Elevitch et al., 2018). Apart from the conventionalization and certification, climate change and soil degradation, particularly in the Mediterranean climate, will force farmers, stakeholders, and researchers to find new solutions, either in organic or conventional farming, so all possible solutions should be evaluated and considered.

3.8. Future solutions

3.8.1. Towards system simplification

System simplification (when referring to SAFS and the concept idea of a significant level of planned biodiversity) to increase the production by area that they can manage is a strategy already taken by some farmers in the present study. This approach can be more clearly identified in farm 5, with the lowest diversity of trees among all study farms (Table 4). In each SAFS field on this farm, fruit and multifunction trees and shrubs are reduced to a few species while maintaining intense vegetable production in the alleys. Although the SAFS concept includes high biodiversity of trees to mimic forest ecosystem dynamics, the possibility of reducing the number of perennial plant species to some extent should be better evaluated. By condensing into just a few categories the vertical strata and the succession stages, there is a theoretical possibility that a final number of species can guarantee the minimum functional biodiversity for the system to provide the same level of ecosystem services as a "conceptual full species" field design (Moonen & Bàrberi, 2008). Although there is no information on the "ideal" number of species, farms 4 and 8 with higher planned biodiversity can be considered close to SAFS conceptual design. This requires testing different species and designs to guarantee that the ecosystem services provided by the agroecosystem are enough to allow for external input reductions and, at the same time, ensure the system's resilience, particularly in water scarcity scenarios and other meteorological extreme events. This approach could reduce farmers' labor requirements and knowledge for dealing with high crop diversity and system complexity, allowing the system to reach economic sustainability. In this sense, SAFS simplification could also be seen as an intermediate step in the agroecological transition of now considered "conventionalized" organic systems (Darnhofer et al., 2010). In this path, some researchers in alley-cropping agroforestry, whose structural field design shares high similarities with SAFS, are promoting the complexity of the standard two species alley-cropping systems (one arable crop and one tree species) (Wolz et al., 2017; Wolz & DeLucia, 2018). This field of investigation could bring scientific evidence to SAFS to compensate for the current lack of studies in temperate climates and guide future developments. One of the main questions that system simplification raises is how far biodiversity can be diminished without compromising the system's resilience. To maintain the ecological functions of a particular ecosystem, several species are required to cope with interannual climatic variations (Isbell et al., 2011). More knowledge will be needed to define SAFS's role as a valuable cropping system in the sustainable food system transition.

3.8.2. Environmental conservation

Considering the trees and shrubs used for multifunctional purposes ("multifunction trees" and "multifunction shrubs"), we identified two different approaches used by the study farmers, sometimes in combination. On the one hand, some farmers preferred to use unfamiliar plant species, independently of their region of origin, to understand better their role in the system and potential interesting features, such as the tolerance to local edaphoclimatic conditions, growth rates, and intra-specific interaction outcomes. On the other hand, we found farmers highly motivated to use autochthones plants through local seeds and vegetable propagation material collected from the nearby natural and semi-natural ecosystems. By looking at the SAFS designs encountered during this study, it is reasonable to say that there is a margin to include plant species with a conservation purpose without creating any additional problems for farmers and even use it with benefits for the yields. There appears to exist remarkable plasticity in the field designs to include multifunction plants that can represent great value to local habitats, such as endangered plants or plants relevant for endangered animal species. It is also possible to intentionally include plants that can promote specific ecosystem services, such as pollinators or pest control insects, and even create ecological corridors increasing the connectivity between adjacent natural areas. Although scientific evidence is needed to confirm these hypotheses, there is a great potential to adapt and optimize SAFS to be a valuable solution for land sharing, as opposed to land sparing (Phalan et al., 2011). In general, in Europe, the agricultural area is in decline, contrary to what is happening in most tropical regions (Meyfroidt & Lambin, 2011). In Portugal, and according to the latest national survey (Instituto Nacional de Estatística, 2019), farms occupy an area of

5.1 million hectares, which corresponds to 55.5% of the national territory. The used agricultural surface represents 77.4% of the total surface of farms, followed by forest and bush areas without agricultural use (18.9%). This means that more than 35% of the territory is uncultivated, with forests occupying almost the same percentage. Moreover, with an expected increase in area affected by fires in the European Mediterranean region, from 40% to 100% for climate change scenarios ranging from 1,5 to 3 °C (Turco et al., 2018), converting less complex agriculture systems into innovative agroforestry systems is an option that can hypothetically reduce fires (Damianidis et al., 2021) while serving as protection for biodiversity (Griffith, 2000). Also, the suitability for ecosystem restoration characterizes this type of agroforestry (Miccolis et al., 2019), coupled with the high intrinsic biodiversity, makes SAFS of particular interest for food production in environmentally protected areas. Areas such as the European *Natura 2000* and other areas with natural or other specific constraints and high nature value farming areas.

To solve the problem of meeting rising food demand at the least cost to biodiversity, it is expected to ensure the provision of sufficiently high yields and multiple ecosystem services altogether. However, context and location-specific must be considered in selecting the best agriculture model because the large-scale increase in production does not necessarily imply that yields should rise in every cropland or at any externalities (Garnett et al., 2013).

3.8.3. Additional funding

The European Commission recently published a list of Eco-schemes, in the form of potential "Agricultural practices" (European Commission, 2021a), to be included in the future Common Agricultural Policy (CAP) for 2021-2027 to start to be implemented in 2023. Of the nine farms included in this study, four have organic certification, and one was in the third year of the conversion period. The rest of the farms had the necessary conditions and practices to require organic certification. For different reasons, these four farmers chose not to be organically certified. This compliance with organic certification is in accordance with the first category of "Practices established in EU policy instruments" of the new Eco-schemes list: *Organic farming practices.* Considering the second category (*Other practices*), SAFS can be considered to have a very good match with several practices such as "Mixed cropping", "Agroforestry", or " Appropriate management of residues". This extensive list of potential eco-schemes opens a possibility of direct funding to farms that implement fields with SAFS providing an extra income that can guarantee the financial viability during the first years after implementation when the perennial crops have not reached full production. But looking from a different angle, several current organic systems could be influenced by SAFS and partially adapt their designs and practices to come upon some of the Eco-schemes and receive extra funding from CAP pillar I.

The European Commission defines *Carbon Farming* as a "green business model that rewards land managers for taking up improved land management practices, resulting in the increase of carbon sequestration in living biomass, dead organic matter, and soils by enhancing carbon capture and reducing the release of carbon to the atmosphere, in respect of ecological principles favorable to biodiversity and the natural capital overall." (European Commission, 2021b). According to the European Commission, which has been influenced by the technical report "Setting up and implementing result-based carbon farming mechanisms in the EU" (COWI et al., 2021)**,** agroforestry is one of the practices recommended for carbon sequestration and, as such, is a valuable option for receiving carbon credits and respective payments. By converting agricultural land use into agroforestry, as exemplified above (section 3.6.2 *Organic fruit orchards*), farmers can get a chance of additional funding through the *Carbon Farming* model in strict accordance with the European Commission strategy "Farm to Fork" (European Commission, 2020) and the action plan "Sustainable Carbon Cycles" (European Commission, 2021b). However, caution should be considered when converting to agroforestry. The potential benefits and drawbacks of any decision that implies integrating trees in arable fields must be carefully assessed at each level (field, landscape level, and policy level). On the other hand, less intensive tillage, particularly zero tillage, can sequester more carbon due to less disruption of soil aggregate structure. Additionally, switching from annual to perennial crops improves below-ground carbon inputs (while reducing soil disturbance), resulting in increased carbon sequestration (Paustian et al., 2016).

3.9. Further research

Building scientific evidence, either in social and natural themes, to allow the development Building scientific evidence is a research priority in developing context-dependent strategies for sustainable intensification in agriculture (Garnett et al., 2013). Some combinations of fruit trees (and other high-value trees such as *Quercus* spp) and multifunction trees considered successful by the study farmers should be studied carefully. It could be of great interest to identify which ecological processes are favoured in each combination and unveil the functionality behind each relation, such as the contribution of microbiology or macrofauna and its reproducibility in different conditions. Studying SAFS could be of particular interest in improving young trees' survival after implementation and during the first years of life, considering farmers' reports on this subject. Also, the contributions these combinations can bring to the adaptation of current farming systems to future higher and longer heatwaves and water scarcity expected for the Mediterranean basin (Lionello & Scarascia, 2018) should not be minorized. The co-creation of knowledge, the agroecological principle that refers to knowledge sharing of local and scientific innovation (Wezel et al., 2020), can be applied to this approach. By working close to farmers, researchers can identify potential local solutions and validate them. This could promote sharing this information with other farms and with society. In the opposite direction, science could help improve those solutions. Looking from a different perspective, assisting the farmers in carrying out their experiments on farms is another goal of scientific research in agroecology (Catalogna et al., 2018). It could be easily applied in most of the farms in the study, taking advantage of the trusting relationship between researchers and farmers created through studies such as the present one.

Breeding research has been responsible for significant increases in yields in agricultural commodities, such as maize and soybeans. Breeding programs for annual cultures in complex agroforestry systems are thus urgent to help close the yield gap created by growing under shade. A lot could be learned from the work already done in temperate alley-cropping systems (Dupraz et al., 2018). Also for tree-crops, analogous investments in developing varieties with higher yield potential could result in system productivity improvements {Wolz:2017eq}. In this regard, attention should be focused on agroforestry for fruit trees in Europe and Mediterranean North Africa, particularly the multi-strata systems, where the endogenous ability of the fruit trees to grow under a shade has been explored for years (Lauri et al., 2019).

The study of SAFS' field designs and species selection are also good opportunities for improvement in other agroforestry systems. Mixed fruit tree-vegetable systems (agroforestry systems models that combine fruit trees and vegetable crops within a farming system) are getting attention in France and other parts of Europe (Paut et al., 2021). Similarly, the scope of temperate alley-cropping research and application is going toward diversification via woody polyculture (Wolz et al., 2017), which could be seen as a convergence to SAFS concerning field design and species composition. In this line of research, Wolz et al. (2018) strategically propose the inclusion of combinations of nut crops in agroforestry systems to contribute to caloric yields, which we found a parallel in some of the Portuguese SAFS of the present study, with *Castanea sativa*, *Corylus avellane,* and *Juglans regia* being the most common ones (Table 10).

Table 10. Five most common tree and shrub species in SAFS fields included in the study according to their function and successional stage.

Type	Top 5 species	Nº of fields present
Long lived trees	*Castanea sativa*	7
	Quercus suber	7
	Quercus roduntifolia	5
	Pinus pinea	3
	Quercus robur	3
Fruit trees	Fig tree	15
	Apple tree	13
	Grapevine	12
	Pomegranate tree	11
	Lemon tree	9
Multifunction trees	*Popolus nigra*	14
	Fraxinus angustifolia	11
	Eucalyptus globulus	10
	Morus nigra	9
	Salix alba	8
Fruit shrubs	Strawberry tree	11
	Elderberry	11
	Red currant	6
	Common hazel	6
	Blackberry	4

3.10. Case study: Mértola, a Lab for the Future (Farm 8)

According to Cortegano et al. (2021), "the project *Mértola, a Lab for the Future* is a project of agroecological transition, adaptation to climate change and desertification combat that places the local community leadership in the planning of a more sustainable and resilient future". This project is built by a wide and heterogeneous network of people, from innovation brokers, farmers, several local associations, and schools to local governments, both in private and public institutions. Mértola is a municipality located in Alentejo, in the south-east of Portugal, with a semi-arid climate, whose current climate scenarios predict a marked reduction in precipitation (to near 300 mm in the year 2100) and is amongst the regions in Europe most susceptible to desertification (Cortegano et al., 2021). As a direct result of the biophysical characteristics, but not exclusively, Mértola's socioeconomic indicators are, in general, very low. The Agroecological Centre (*Horta da Malhadinha)* (farm 8 of the present study) has three fields with SAFS (described in previous sections) that are used for demonstration, experimentation, and training purposes besides the production of vegetables and fruits that are commercialized by the

Local Food Network. This network was developed in the project *Mértola, a Lab for the Future,* and includes other farms, local associations of farmers, and different institutions, social and political, responsible for collective catering canteens and consumers in Mértola with the goal to generate most of the food supply for the municipality (Cortegano et al., 2021). Considering this context, since 2018, there has been an experience in transitioning the main organic production fields that supply the *Local Food Network* into agroforestry fields, starting with fields of the demonstrative centre (farm 8) as an example to others. This was a commitment to try to reduce water use and protect vegetables and fruit crops from excessively high temperatures and sunlight exposure during the summer peak. Successional agroforestry was the chosen type of agroforestry that was considered the best option, although never tested in the region. With the inclusion of trees in the arable fields and the reduction in requirements for external fertilization and other inputs, SAFS can, in theory, provide a profitable commercial organic horticultural production, particularly in a scenario where local organic farms were already supplying the *Local Food Network*. The great majority of Mértola's agricultural soils suffer from chronic loss of organic matter. This fact, combined with the circumstance of Mértola municipality being located inside the protected ecological area of Guadiana Valley Natural Park, contributed to the option for SAFS. These agroforestry systems have been successfully used for restoration in tropical areas (Miccolis et al., 2019; Vieira et al., 2009) and are now being tested in temperate areas. In the context of the agroecological transition promoted by the project *Mértola, a Lab for the Future* with the adoption of SAFS as an alternative to agricultural organic production and by adapting it to local conditions, there was a desire to contribute to the restoration and preservation of the local natural and semi-natural ecosystems. This strategy of combining food production with natural resources conservation can be more clearly noticeable by including regional autochthonous plants in the field's designs, such as *Rosmarinus officinalis, Pistacia terebinthus, Arbutus unedo,* or *Retama sphaerocarpa,* planted with locally collected seeds and cuttings (Table 5). By mimicking as much as possible the local ecosystems in the agricultural fields on the demonstration farm and without compromising the production, the project intended to take advantage of the natural resilience provided by the maintenance of major ecological functions of the ecosystem. Although still in an experimentation stage at the time of the present study, there was already a concern with the involvement of local traditional farmers in this project. Several discussion sessions were regularly promoted with local traditional farmers' participation where traditional local knowledge and SAFS results were combined in a peer learning process. Besides contributing to adapting local agriculture to climate changes and regional food security, SAFS also helped the settlement of young people in Mértola. This is a result of the new farmers included with the expansion of the *Local Food Network* or with volunteers and interns in the multiple agricultural programs promoted under the project "wings". Considering SAFS's role in this project and its contribution to the transition to more sustainable food systems, it is possible to identify several agroecological principles. In particular, input reduction, biodiversity, co-creation of knowledge, connectivity, and land and natural resource governance (Wezel et al., 2020). In the present scenario, it can be said that SAFS exceed the simple role of food production and ecosystem restoration to become a key element in the agroecological transition in a specific context of low-density rural territory suffering from depopulation and a dramatic climatic change.

4. Conclusion

Although scarce, the scientific information related to agroecology in Europe, particularly in the Mediterranean basin, is focused on the extreme diversity of agroecosystems with high ecological value and the associated traditional ecological knowledge of Mediterranean farmers (Aguilera et al., 2020; Migliorini et al., 2018). There is growing attention to agroforestry in Europe, both from the academic institutions and a pollical perspective (Mosquera-Losada et al., 2012; Santiago-Freijanes et al., 2018). Much of the research so far is being done in classifying, protecting and realizing the benefits and opportunities offered by the traditional agroforestry models, of which the European project AGFORWARD (2014-2017), funded by the European Union's Seventh Framework Programme for Research and Technological Development (FP7), was a perfect example. The traditional Portuguese agroforestry models have been implemented for centuries. They are well adapted to local conditions and promote a sustainable social, economic, and biodiversity balance that must be protected, particularly the less represented ones (e.g., the *Boscagem* system in the Baixo Vouga region, in the center of Portugal). Innovation in agroecology can be a solution to close the gap between traditional systems and the growing problems of climate change and soil degradation. In this sense, we believe that the knowledge generated by SAFS can be of great value. The site-specific characteristics identified in the study SAFS can be compared with the emphasis on the self-organization of a natural ecosystem (Malézieux, 2012). As a result of its intrinsic complexity and diversity, SAFS can thus provide valuable local solutions for restoration. Although agroforestry can be considered an agroecological practice and SAFS an agroforestry type, SAFS can also be regarded as a particular system. Taking this study as an example, Portuguese SAFS integrated several agroecological practices. Also, some SAFS were implemented in degraded areas with high climate change risk and potentially finding a way of being productive and sustainable. But beyond the restoration potential, SAFS could be a source of knowledge, in technics and designs, for other farming systems, preferably organic but also conventional. For example, in temperate climates under the Mediterranean influence, SAFS can be one valuable solution to equip small to medium size organic farming with nature-based solutions, such as stratification and the inclusion of multifunction trees and shrubs, that can reduce risks associated with extreme weather events and minimize (or even revert) soil degradation. This could be seen as a "conversion of an organic vegetable production or an organic fruit orchards system into an agroforestry system". This knowledge could also be translated as adapting components of the SAFS system (much like tools) to be incorporated into less complex systems. Extra benefits of this strategy are also expected to come from additional funding according to the new 2023-2027 CAP regulations and European Commission strategies. It is expected that taking SAFS's unique design and developing it through further research and field experimentation with a focus on water efficiency could, in some circumstances, reduce current water needs for vegetables and fruit production. Similarly, and although more research on species and combinations are required, fertilization needs in SAFS could potentially be reduced and the incidence of diseases and pests could also be favorably minimized. On the other hand, using innovation based on SAFS nature-based solutions and combining it with new technology and digitalization could contribute to optimizing other agronomic systems, better adapting them to their local conditions, and improving systems circularity, particularly in Mediterranean influence climate. Although scientific research is needed to validate both ecological benefits and climatic resilience but also economic viability, we firmly believe that SAFS can contribute to promoting organic agriculture sustainability, making it mainstream, and help to consolidate the consensus on organic agriculture systems as one valuable solution from the several solutions required to feed the world in a sustainable way.

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The authors would like to thank all farmers and farms responsible for their time and availability and for opening their farms to scientific research with full confidence in our work.

CAPÍTULO 3: I ENCONTRO DOS SISTEMAS AGROFLORESTAIS DE SUCESSÃO

Ao final de um conjunto de visitas às explorações no âmbito do trabalho realizado para a presente dissertação uma quantidade significativa de informação começou a ficar disponível, quer através do levantamento dos desenhos e composição dos campos de cultivo, quer através questionários aplicados (Anexo 4), mas também pelas inúmeras conversas mantidas com os agricultores. À medida que ia sendo processada esta informação foram consequentemente começando a ficar mais visíveis quais as reais potencialidades que os Sistemas Agroflorestais de Sucessão (SAFS) podem oferecer no âmbito da Agricultura Biológica (AB). Paralelamente as limitações e dificuldades na utilização sistemas foram-se igualmente revelando. De entre as limitações identificadas a falta de informação credível disponível sobre SAFS em climas temperados e a ausência atuais linhas investigação científica conhecidas são um entrave à progressão da inovação nesta área e surgiu a necessidade de encontrar soluções para tentar colmatar esta falha. Neste sentido surgiu a ideia de criar um evento à escala nacional onde fosse possível reunir pessoas cujo trabalho fosse conhecido, de alguma forma tivessem ligação aos SAFS ou existisse algum tipo de afinidade ou correspondência. Surgida a ideia o passo seguinte foi a criação de um grupo de trabalho com o propósito de avaliar a sua exequibilidade e definir os moldes da sua organização. Deste grupo de trabalho inicial fez parte o Professor Pedro Mendes-Moreira, a Professora Isabel Dinis, a Professora Daniela Santos, todos professores da Escola Superior Agrária do Instituto Politécnico de Coimbra (ESAC-IPC) e o aluno de mestrado Ricardo Leitão, autor da presente dissertação. Após a decisão de avançar com a organização do evento foi convidada a ingressar para o grupo de trabalho a Doutora Rosa Guilherme da Direção Regional de Agricultura e Pescas do Centro (DRAPC) que esteve diretamente envolvida com os primeiros trabalhos com SAFS na ESAC-IPC e que foi coorientadora da Dissertação de Mestrado do antigo aluno Walter Santes (já apresentado anteriormente no capítulo da Introdução). Ficou criada assim a Comissão de Coordenação daquele que viria a designar-se de "I Encontro de Sistemas Agroflorestais de Sucessão". Posteriormente foram convidados mais elementos da ESAC-IPC para a constituição da Comissão Organizadora. O objetivo principal do evento consistiu reunir durante um dia um conjunto de pessoas que pudessem contribuir para o tema e condições propícias à discussão de temas direta ou indiretamente relacionadas com os SAFS, tendo em vista dar-se início à criação de conhecimento científico, técnico e prático em SAFS em território português e da respetiva massa crítica necessária à sua validação. Optou-se por um modelo de evento do tipo simpósio, totalmente composto por oradores e moderadores convidados de diferentes áreas do conhecimento e profissionais, nomeadamente investigadores, professores do ensino superior, técnicos e agricultores de diferentes áreas (ver Anexo 5 para notas bibliográficas). O nome "Encontro" foi escolhido tendo em conta o objetivo de reunião e criação de um grupo de discussão que se perpetuasse no tempo. A tipologia inicial prevista foi mista, com a maioria dos oradores em presença física e alguns on-line e estava previsto decorrer num do auditórios da ESAC-IPC com uma limitação de lugares e com disponibilização de visualização on-line. Contudo a evolução desfavorável da pandemia por COVID levou a que se tomasse a decisão de converter o evento exclusivamente on-line mantendo-te a data original proposta de 15 de Dezembro de 2021 (Figura 1).

O evento foi dividido em: uma sessão de abertura, 4 sessões temáticas principais e uma sessão de encerramento com comentários finais (Figura 2). Procurou-se diversificar ao máximo possível os temas de modo a abranger os múltiplos aspetos que influenciam e condicionam não só a agricultura, mas todo o sistema alimentar. Os problemas que afetam a cadeia alimentar são complexos e multifatoriais e para se conseguirem encontrar soluções duradouras e minimamente consensuais é necessário o envolvimento quer da comunidade científica quer da sociedade. Neste contexto as sessões procuraram refletir essa diversidade desde a ciência e investigação, passando pela componente técnica, economia, sociedade, política até à prática, neste caso com a presença de vários agricultores e *stakeholders* que de alguma forma fossem pioneiros nos SAFS em Portugal e que tivessem participado nos trabalhos da presente dissertação.

Tendo em conta o âmbito do MAB, a proximidade dos SAFS com a AB e as potencialidades identificadas para este modo de produção com a utilização dos SAFS foi tomada a decisão de definir como sub-título do evento: "Contributos dos Sistemas Agroflorestais de Sucessão para o futuro das Agricultura Biológica". Deste modo pretendeu-se dar um enquadramento mais específico na abordagem aos SAFS, o que facilita a compreensão do seu potencial, e ao mesmo tempo identificar aqueles que provavelmente mais fácil rapidamente poderão beneficiar da incorporação do conhecimento gerado nestes sistemas ou em componentes dos mesmos, os agricultores de AB. Os agricultores AB são agricultores que já têm normalmente experiência com sistemas mais diversificados e têm sensibilidade acrescida para as potencialidades que os serviços de ecossistema podem oferecer na diminuição da necessidade ou mesmo em substituição dos fatores de produção. Serão por isso, em média, mais recetivos à adoção de inovação com novas soluções de base ecológica.

Figura 1. Poster do evento (versão final)

Escola Superior Agrária
Politécnico de Coimbra

DRAP Centro
DIREÇÃO REGIONAL DE AGRICULTURA E PESCAS DO CENTRO

1º ENCONTRO DE SISTEMAS AGROFLORESTAIS DE SUCESSÃO

Programa

15 de Dezembro 2021
9h00 (Lisboa), 6h00 (Brasília), 10h00 (Luanda), 11h00 (Maputo)
Formato exclusivamente online

Data limite inscrição: 13 de Dezembro

SESSÃO DE ABERTURA
9:00 - João Noronha (ESAC-IPC),
Fernando Martins (Diretor Regional DRAPC)

SESSÃO 1 – CIÊNCIA E INVESTIGAÇÃO
Moderação - Pedro Mendes Moreira (ESAC-IPC)
9:10 - SAFS, perspetivas e oportunidades - Pedro Mendes Moreira (ESAC-IPC)
9:25 - Agroforestry or Multi-Layer Agriculture? Inspirations from Europe and the Sahel – Ambrogio Costanzo (The Organic Research Centre, UK)
9:50 - SAFS: o caso português - Ricardo Leitão (ESAC-IPC/CFE-UC)
10:05 - Fronteiras na investigação em Ecologia - Luís Cunha (CFE-UC)
10:20 - Direitos do ambiente: qual a legitimidade política na remuneração dos Serviços de Ecossistema- Pedro Bingre do Amaral (ESAC-IPC)
10:35 – Coffee break

SESSÃO 2 – AGRONOMIA E FLORESTA
Moderação – Rosa Guilherme (DRAPC)
11:00 - Funcionalidade do Solo nos SAFS - Daniela Santos (ESAC-IPC)
11:15 - A importância dos SAFS no aumento da resiliência aos incêndios rurais- José Gaspar (ESAC-IPC)
11:30 - Desafios à viabilidade económica dos SAFS - Isabel Dinis (ESAC-IPC)
11:45 - Os SAFS e a Agricultura Biológica - Denis Hickel (Quinta da Rainha/Quinta do Alecrim)
12:00 - Sessão de perguntas
12:30 – Intervalo para almoço

SESSÃO 3 – ECONOMIA E SOCIEDADE
Moderação: Jorge Capitão (Consultor)
14:00 - Um retrato (impressionista) da agroecologia em Portugal - Sara Magalhães (cE3c-UL)
14:15 - Terra Sintrópica: a regeneração pelo uso - Pedro Nogueira (Associação Terra Sintrópica)
14:30 - A agroecologia e a transição alimentar: breve reflexão - Helena Freitas (CFE-UC)
14:45 - Contributos e desafios da Rede Rural Nacional para os SAFS - Mª Custódia Correia (Rede Rural Nacional)
15:00 - A arquitetura verde no Plano Estratégico da PAC - Eduardo Diniz (Gab. de Planeamento, Políticas e Administração Geral)
15:15 - Sessão de perguntas
15:45 - Coffee break

SESSÃO 4 - AGRICULTURA
Moderação: Ricardo Leitão (ESAC-IPC/CFE-UC)
16:00 - Mesa Redonda
António Coelho (Horta da Malhadinha)
João Ferreira (Mendes Gonçalves)
Marc Leiber (Quinta das Abelhas)
Ricardo Meireles (Quinta da Manguela)
Tânia Carvalho (Lugar da Terra)
Walter Sandes (Preguiça Activa)

SESSÃO DE ENCERRAMENTO
Moderação: Pedro Mendes Moreira (ESAC-IPC)
17:00 - Comentários finais:
Leonardo Collier (CoLAB Food4Sustainability/UFG-Brasil)
Joana Amaral Paulo (ISA/EURAF)
Jorge Cancela (Faculdade de Arquitetura-UL,/The Landscape Farm)

Apoio:
LIVESEED
Lebende Samen - Living Seeds e.V.

Figura 2. Programa do evento (versão final)

Como forma de promoção do I Encontro SAFS e ao mesmo tempo como divulgação dos SAFS e do trabalho feito até então na ESAC-IPC foi publicado um 1º artigo na revista AGROTEC nº 41, edição de Dezembro. A AGROTEC (http://www.agrotec.pt/) é uma revista Técnico-Científica Agrícola é uma publicação periódica, de caráter técnico-científico, especializada no setor agrícola pertencente ao Grupo Publindústria. É dotada de uma rede nacional e internacional de correspondentes, e conta também com a colaboração académica de vários investigadores e professores das mais prestigiadas universidades portuguesas que garantem a qualidade e o rigor científico necessários. A Revista AGROTEC chega a todo o território nacional, com uma tiragem média de 8 mil exemplares, tem uma periodicidade trimestral e procura transportar, consigo, assuntos de relevo para agricultores, empresários, técnicos e investigadores do setor agrícola. Está representada a nível internacional em vários pontos de venda, nomeadamente em Angola, Moçambique e Brasil. Deste modo pretendeu-se chegar a um público especializado e contribuir para divulgar os SAFS enquanto modelo agroflorestal inovador em climas temperados com potencialidade. Ficou também definido com a AGROTEC a publicação de um 2º artigo para permitir dar a conhecer o resumo e as principais conclusões que resultaram do I Encontro SAFS na edição nº 42 de Março de 2022, assim como agradecer a todos os palestrantes o seu importante contributo.

As inscrições para o I Encontro SAFS foram efetuadas pela plataforma informática *Google Forms* tendo atingido um valor de 326 inscrições. O evento decorreu na plataforma informática *Zoom* e pôde ser visualizado na plataforma informática *VideoCast*. Foi atingido um máximo de 161 visualizações em simultâneo durante a parte da tarde e uma média de 135 visualizações durante o dia. Os participantes tiveram a possibilidade de interagir com os palestrantes através da plataforma informática *slido* onde colocaram questões e deixaram algumas opiniões (Figuras 3 e 4). Durante o dia do evento uma pequena equipa da Comissão organizadora, constituída pelo Professor Pedro Mendes-Moreira e pelos alunos de MAB Ricardo João (autor da presente dissertação) e Marcus Medeiros, montou uma "base de operações" no anfiteatro da ESAC-IPC onde fez toda a gestão do evento (Figuras 5, 6 e 7).

As apresentações e discussões foram muito para além da especificidade dos SAFS e da AB, o que aliás seria de esperar pois muito dos intervenientes não tinham relação direta com os SAFS, o que em muito enriqueceu o evento e permitiu que cativasse a atenção de todos durante um dia completo de trabalhos. A opinião geral foi muito positiva tendo sido atingidos os objetivos a que nos propusemos. No final do evento ficou a vontade, quer da organização quer dos palestrantes e participantes, da organização de um 2º evento no próximo ano para dar continuidade à discussão iniciada.

Figura 3. Resumo da atividade da plataforma informática *slido* para interação com a assistência. Questões mais populares (à esquerda) e tópicos mais referidos nas questões colocadas (à direita)

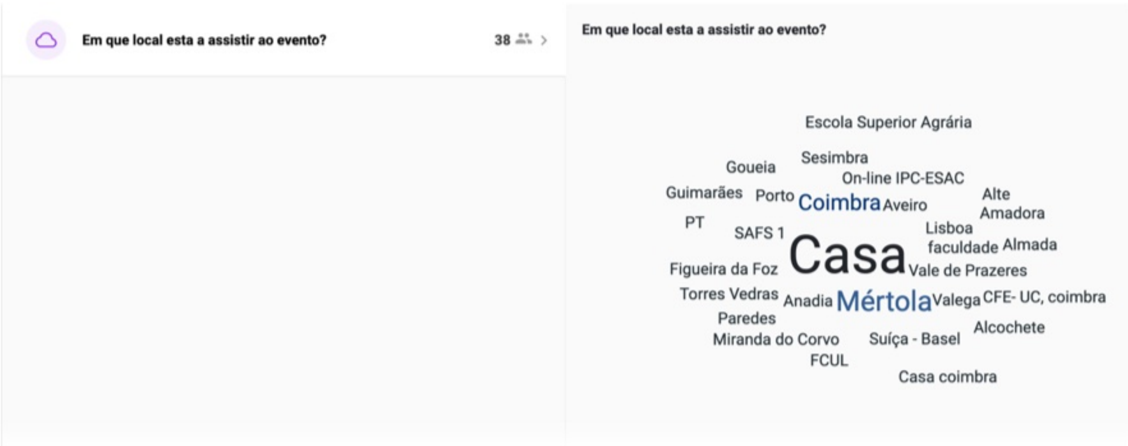

Figura 4. Resumo da atividade da plataforma informática *slido* para interação com a assistência. Localizações dos participantes (à direita)

Figura 5. Momentos da ação decorrida na plataforma informática *Zoom* durante o evento. Mesa-redonda com agricultores e *stakeholders* durante a sessão 4 (da parte da tarde)

Figura 6. Momentos da ação decorrida nos bastidores o evento. Mesa-redonda com agricultores e *stakeholders* durante a sessão 4 (da parte da tarde)

Figura 7. A equipa presente no dia do evento constituída pelos elementos da comissão de organizadora: Marcus Medeiros (à esquerda), Ricardo Leitão - autor da presente dissertação (ao centro) e o Professor Pedro Mendes-Moreira (à direita)

1) 1º artigo publicado na revista AGROTEC

SISTEMAS AGROFLORESTAIS DE SUCESSÃO EM PORTUGAL

FIGURA 1. Quinta das Abelhas, Foros de Vale Figueira, Maio de 2021. Campo experimental de SAFS com foco em produção de fruta integrado em área de Montado. Data de implementação, Janeiro de 2021. (Fotografia de Marc Leiber).

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RESUMO

Os Sistemas Agroflorestais de Sucessão são um modelo de agrofloresta típico de regiões tropicais e que tem vindo a ganhar notoriedade um pouco por todo o mundo. Apesar de muito recentes em Portugal, e na Europa em geral, estão em franco crescimento e a despertar a atenção da comunidade científica. Têm como pilares a estratificação vertical e a sucessão natural de espécies biodiversas, com dinâmicas ao nível do espaço e ao longo do tempo, e procuram criar sistemas de produção de alimentos com elevada biodiversidade inspirados em ecossistemas florestais. Dois levantamentos de sistemas já implementados realizados, em 2019 e 2020, respetivamente, procuraram caracterizar a realidade portuguesa e tentar compreender as potencialidades e limitações desta nova abordagem agrícola e agroflorestal. Em particular no que diz respeito ao Modo de Produção Biológico (MPB) estes sistemas podem vir a dar um contributo para o aumento de resiliência às alterações climáticas e para a sustentabilidade das explorações numa lógica de transferência de conhecimento. A elevada dependência de trabalho manual e de conhecimento muito específico para a correta gestão dos Sistemas Agroflorestais de Sucessão contribui para a sua dificuldade em ser aplicado em maior escala. A contínua procura por novas soluções, quer tecnológicas quer ao nível de desenhos mais simplificados, contribuirá para a sua aproximação a outros modelos agrícolas pelo que o estudo destes sistemas revela-se de grande importância para o futuro.

ABSTRACT

Succession Agroforestry Systems are an agroforestry model typical of tropical regions that has been gaining notoriety all over the world. Although very recent in Portugal, and in Europe in general, they are growing rapidly and capturing the attention of the scientific community. These systems have the vertical stratification and natural succession of species as their main pillars and seek to create high biodiverse food production systems inspired in forest ecosystems. Two recent surveys on systems already implemented, carried out in 2019 and 2020 respectively, aimed to characterize the Portuguese reality and unveil the potential and limitations of this new agricultural and agroforestry approach. In particular, regarding Organic Farming, these systems can have a contribution in increasing farms resilience to climate change and sustainability based on a knowledge transfer idea. The high dependence on manual work and very specific knowledge for the correct management of the Succession Agroforestry Systems contributes to their limitation in being applied at larger scales. The continuous search for new solutions, through new technologies and more simplified designs, will contribute to bring them closer to other agricultural models, therefore the study of these systems is of great importance for the future.

INTRODUÇÃO

No âmbito da realização do 1º Encontro Nacional de Sistemas Agroflorestais de Sucessão organizado pela Escola Superior Agrária de Coimbra (ESAC), e que decorrerá a dia 15 de dezembro, surgiu a oportunidade de desenvolver este artigo com o objectivo de dar a conhecer as principais características destes sistemas agroflorestais bem como partilhar a informação disponível sobre a realidade portuguesa.

«A elevada dependência de trabalho manual e de conhecimento muito específico para a correta gestão dos Sistemas Agroflorestais de Sucessão contribui para a sua dificuldade em ser aplicado em maior escala»

ORIGEM

Os Sistemas Agroflorestais de Sucessão (SAFS) têm a sua origem em povos indígenas, um pouco por todo o mundo, com especial relevo para os das zonas tropicais (Young, 2017). Desde os "jardins-floresta" dos povos da floresta amazónia (Schulz *et al.*, 1994), aos jardins tradicionais na ásia (Wiersum, 2004), muitos são os exemplos de modelos agroflorestais em que o ser humano procurou imitar a complexidade da floresta onde estavam integrados, nomeadamente, fenómenos da sucessão natural de espécies ao longo do tempo.

INFLUÊNCIA

Mais recentemente coube ao agricultor de nacionalidade suíça e radicado no Brasil, Ernst Götsch, a responsabilidade de conjugar este conhecimento antigo com uma visão moderna da agricultura. Numa tentativa de converter o conhecimento adquirido ao longo de anos de experiência e de experimentação num modelo moderno de SAFS desenvolvendo-se um conceito original a que atribuiu o nome de "Agricultura Sintrópica" (Rebello and Sakamoto, 2021). Apesar de um cunho muito pessoal é notório nos desenhos dos seus trabalhos mais recentes uma inspiração no tipo de agrofloresta em faixas "Alley cropping", com a organização dos elementos arbóreos em linhas e a possibilidade de cultivo da entrelinha, permitindo uma maior compatibilidade com a mecanização e, consequentemente, a aplicação em maior escala, o que tem contribuído para uma gradual aceitação pela comunidade agrícola internacional. De acordo com Young (2017) numa revisão bibliográfica recente, o conceito SAFS integra um conjunto constituído por conhecimento indígena, técnicas modernas agroflorestais e regeneração natural assistida promovendo a biodiversidade do sistema e o uso do fenómeno da sucessão ecológica tendo como objectivo o estabelecimento de um sistema florestal produtivo.

PRINCIPAIS CARACTERÍSTICAS

Os modelos de SAFS mais modernos e inspirados direta ou indiretamente no trabalho de Ernst Götsch caracterizam-se pela presença de um grande número de espécies anuais e perenes cuja seleção e distribuição no terreno segue uma lógica alicerçada em duas premissas: a sucessão natural e a estratificação vertical (Andrade *et al.*, 2020). Esta elevada biodiversidade planeada é uma característica diferenciadora e vai diminuindo ao longo do tempo à medida que os anos passam e algumas espécies de etapas sucessorais mais iniciais são removidas do sistema. Na prática, na implementação de um novo campo de SAFS verifica-se a plantação simultânea de um conjunto alargado de diferentes espécies numa tentativa de preencher o máximo número de estratos verticais de cada etapa sucessoral. A título de exemplo considerando cinco estratos verticais e quatro etapas sucessorais dará uma combinação mínima de 20 espécies vegetais, nomeadamente herbáceas, arbustivas e arbóreas, que serão instaladas em cada linha ou em linhas próximas num padrão de repetição. São escolhidas as culturas principais, geralmente árvores de fruto e/ou para produção de madeira, e cujo espaçamento entre a mesma espécie segue geralmente espaçamentos convencionais. São posteriormente selecionadas outras espécies arbóreas e arbustivas, produtivas ou multifuncionais, de modo a completar a biodiversidade planeada. Um aspeto muito interessante desta abordagem é a inclusão destas espécies multifuncionais cujo papel no campo vai desde a produção de biomassa vegetal para fertilização/cobertura de solo até à proteção física das espécies produtivas. Estas espécies sem valor comercial direto são utilizadas durante períodos de tempo mais curtos sendo alvo de intensas podas e retiradas do sistema assim que a sua função seja considerada como terminada. As entrelinhas podem ser utilizadas para a produção de hortícolas ou apenas para produção de biomassa vegetal para as linhas de árvores adjacentes. Como resultado final toda a área do campo agrícola (horizontal e vertical) está constantemente preenchida ao longo do tempo procurando maximizar o aproveitamento da luz solar.

PORTUGAL

Historicamente a Europa tem uma grande tradição no uso de modelos agroflorestais tendo a sua prevalência diminuído ao longo dos anos (Mosquera-Losada *et al.*, 2012). Atualmente a agrofloresta ocupa cerca de 3,3 milhões de hectares na Europa, principalmente em Espanha, Portugal e Itália com alguma áreas menores em França e Áustria (Herder *et al.*, 2017). Partindo da mais recente classificação de sistemas agroflorestais na Europa, desenvolvido pela Federação Europeia de Agroflorestas (EURAF, 2021), poderíamos classificar os SAFS como uma combinação de três tipos de sistemas: os Sistemas Agroflorestais em faixas (Alley cropping), Jardins de árvores multi-estrato (Multi-layer tree gardens) e os Pomares consociados (Orchard intercropping). No levantamento dos SAFS em Portugal efetuado em 2020 por Leitão et al (2021) o total da área

FIGURA 2. Quinta da Manguela, Santo Tirso, Junho de 2020. Campo de SAFS com foco na produção de limões. Data de implementação, Janeiro de 2018. (Fotografia de Ricardo Meireles).

FIGURA 3. Horta da Malhadinha, Mértola. Campo de SAFS com foco na produção de hortícolas. Data de implementação: Novembro de 2019. Fotografias tiradas do mesmo local: (A) Novembro 2020, produção de diversas variedades de couves; (B) Junho de 2021, produção de tomate. (Fotografia de Pedro Nogueira, Associação Terra Sintrópica).

implementada com SAFS não ultrapassava os 10 hectares e os sistemas caracterizavam-se por uma grande heterogeneidade entre si, ao nível do desenho dos campos, dimensões e espécies utilizadas. No entanto, e embora ainda sem grande expressão em Portugal, verifica-se um crescimento exponencial de iniciativas a que não é de estranhar o enquadramento histórico de Portugal no que diz respeito às agroflorestas. Com o montado como elemento dominante, Portugal é considerado um "cluster" europeu agroflorestal (Herder *et al.*, 2017), resultado da resiliência histórica das agroflorestas ao nosso clima de forte influência mediterrânica. A modificação do microclima que geralmente é promovido pela agrofloresta, com menor radiação solar, temperaturas mais amenas e maior humidade, garantiram a estes sistemas uma maior adequação ao sul da Europa (Mosquera-Losada *et al.* 2012). Apesar desta aparente complexidade de espécies, e olhando para a realidade portuguesa a partir dos trabalhos de levantamento destes sistemas já efetuados em 2019 e 2020 por Sandes (2019) e Leitão *et al.* (2021) respetivamente, pode concluir-se que há uma tendência pela simplificação e adaptação às realidades socioeconómicas locais. Embora com forte vocação "regenerativa" em climas tropicais (Vieira *et al.*, 2009) verificou-se que as explorações portuguesas, com SAFS implementados, desenvolvem uma atividade de carácter produtivo principalmente nas áreas da fruticultura e da horticultura (Figuras 1, 2 e 3). Podemos afirmar que coexistem dois subtipos principais de SAFS em Portugal, um com grande enfoque no cultivo de hortícolas, normalmente caracterizado por um maior espaçamento das linhas de árvores, variando entre os quatro e os sete metros, e um sub-tipo mais focado na produção de fruta e cujo espaçamento das linhas de árvores varia entre os dois e os quatro metros. Nas explorações mais focadas na produção de hortícolas o seu cultivo ocorre principalmente na entrelinha. De referir que, apesar das diferenças entre estes dois sub-tipos, o desenho base de cada campo é sempre um pomar, frequentemente biodiverso, cujos espaços livres nas linhas de árvores são depois preenchidos com outras culturas perenes e anuais e com espécies multifuncionais que, nas explorações estudadas, as mais usadas foram os choupos (*Populus* spp.), a amoreira (*Morus* spp.) e o eucalipto (*Eucalyptus* spp.). O regadio é transversal a todos os sistemas encontrados com predominância da rega gota-a-gota (Leitão *et al.*, 2021).

FIGURA 4. Escola Superior Agrária de Coimbra (IPC-ESAC), Agosto 2021. Campo de SAFS experimental implementado na ESAC (Sandes 2019). São visíveis os sacos de polinizações necessários nas experiências de co-melhoramento em milho. Data de implementação, Abril de 2019. (Fotografia de André Pereira).

«É frequente encontrar SAFS com certificação biológica o que revela a total adequação das práticas aos respetivos regulamentos europeus»

LIMITAÇÕES

A pequena dimensão da maioria dos campos SAFS implementados em Portugal, raramente ultrapassando os 3000 m² por campo, reflete de certo modo a sua grande necessidade de mão de obra, não só pela componente manual, mas também pelo conhecimento especializado necessário para as inúmeras operações e gestão dos sistemas. Essa é, porventura, a sua grande limitação atual já identificada noutras latitudes (Andrade *et al.* 2020) e que é partilhada pelos modelos agrícolas complexos (Paut *et al.*, 2021). A necessidade de tornar o sistema rapidamente produtivo, conduz à necessidade de elevadas quantidades de matéria orgânica que estes sistemas necessitam, principalmente durante os primeiros anos, não só sob a forma de fertilizantes/corretivos, mas também para cobertura do solo ou "mulching" (prática corrente nos SAFS). Um dos objectivos da incorporação de grandes densidades de espécies multifuncionais, principalmente árvores, é exatamente no sentido de diminuir a dependência de fertilização externa. Os sistemas agrícolas inspirados em modelos naturais, na qual o próprio MPB se pode incluir, são tradicionalmente associados a menores produtividades (Ewel, 1999; Reganold and Wachter, 2016). Contudo, os modelos agroflorestais podem apresentar produtividades superiores aos sistemas de monocultura quando vistos numa perspetiva global, em que a totalidade da produção das várias culturas produzidas numa área é frequentemente superior à produção de uma só cultura numa área equivalente (Lehmann *et al.*, 2020). É de salientar que a multiplicidade de produtos produzidos nos SAFS e, consequentemente, as pequenas quantidades obtidas por produto, possam ser encaradas como uma forte limitação à rentabilidade das explorações.

POTENCIALIDADES

É no campo das potencialidades que o estudo dos SAFS se torna mais relevante. A vasta publicação científica referente a benefícios agronómicos e ambientais com o uso dos diversos modelos agroflorestais, torna plausível esperar que a presença de linhas de árvores em grande densidade como ocorre nos SAFS também promova ganhos ao nível da gestão da água, do sequestro de carbono, da reciclagem de nutrientes, do controlo biológico natural de pragas e doenças e, também, na prevenção dos incêndios (Sollen-Norrlin *et al.* 2020). A resiliência que os SAFS aparentam apresentar perante o cenário de alterações climáticas para os próximos anos é de alguma forma traduzido pelo predomínio destes sistemas em explorações localizadas nas regiões do Ribatejo, Alentejo e Algarve. De referir que a multiplicidade de produtos gerados nos SAFS pode contribuir, ainda, para a resiliência económica da exploração, pois podemos ter condições climáticas favoráveis a uma ou várias espécies em detrimento de outras, situação variável ao longo dos anos, ganhando mais relevo no cenário atual de grande volatilidade de preços nos mercados. O modelo policultural pode ainda contribuir para a resiliência do sistema quando associado a circuitos curtos de comercialização e venda direta quer pelo lado da produção quer pelo rendimento gerado, em geral, mais distribuído no tempo de que são exemplos mais comuns, nos SAFS portugueses, a entrega de cabazes semanais.

A título de curiosidade é de referir o prazer que muitos agricultores referem nesta "nova" forma de fazer agricultura, em que o estímulo intelectual e criativo é constante e que pode contribuir para uma maior aproximação de mais pessoas, em particular jovens, da prática da agricultura e, de certo modo, também, para a valorização da atividade pela sociedade.

AGRICULTURA BIOLÓGICA

O contributo da agrofloresta para a agricultura biológica tem sido recentemente apontado como uma aposta de futuro (Rosati *et al.* 2020) e, na nossa opinião, os SAFS são modelos privilegiados para o desenvolvimento do MPB em Portugal. A procura pela simplificação e a combinação com novas tecnologias facilitará a incorporação de técnicas inspiradas nos SAFS em modelos de MPB no sentido de conseguir um melhor aproveitamento dos vários Serviços de Ecossistema para a produtividade e rentabilidade gerais. É frequente encontrar SAFS com certificação biológica o que revela a total adequação das práticas aos respetivos regulamentos europeus tais como a não utilização de produtos fitofarmacêuticos de síntese e a fertilização a ser predominantemente de proveniência orgânica, com o estrume e o composto como as principais opções dos agricultores portugueses. Deve ser referido, ainda, que os SAFS são estruturas por excelência favoráveis à criação de uma maior diversidade de diásporos (estruturas de disseminação, quer através de sementes quer de órgãos de propagação vegetativa) na medida em que são locais com aptidões para co-melhoramento (duas ou mais espécies são melhoradas em conjunto) e onde a diversidade é necessária dada a heterogeneidade dos SAFS pela exploração das plantas quer ao nível do espaço aéreo quer radicular (**Figura 4**). Esta necessidade é convergente com a meta a atingir, em 2036, na qual se pretende que os diásporos a utilizar em Agricultura Biológica provenham 100% da Agricultura Biológica.

FUTURO

Neste sentido, o estudo mais aprofundado dos SAFS torna-se necessário quer para confirmação das suas potencialidades quer para gerar conhecimento que possa ser transponível para outros sistemas, no sentido de contribuir para uma transição global para modelos agrícolas/agroflorestais mais resilientes e sustentáveis. Neste último ponto é de realçar a grande compatibilidade da maioria das práticas levadas a cabo nos SAFS com os "Regimes Ecológicos" (Eco-Schemes) propostos para serem incluídos no primeiro pilar da Política Agrícola Comum, na reestruturação em curso para 2023-2027. Desta forma, o estudo das várias práticas agrícolas presentes nas SAFS pode constituir uma ferramenta para a sua adoção por outros agricultores permitindo um rendimento extra e uma maior circularidade a que acresce, ainda, a crescente valorização das agroflorestas como prestadores de serviços remunerados no mercado do Carbono (Kay *et al.* 2019).

«O contributo da agrofloresta para a agricultura biológica tem sido recentemente apontado como uma aposta de futuro»

2) 2º artigo publicado na revista AGROTEC

I ENCONTRO DE SISTEMAS AGROFLORESTAIS DE SUCESSÃO

POTENCIAIS CONTRIBUTOS DOS SAFS PARA O FUTURO DA AGRICULTURA BIOLÓGICA EM PORTUGAL

SAFS do projeto "Vila Feliz Cidade" da Casa Mendes Gonçalves, Golegã, junho de 2021. Data de implementação, fevereiro de 2020 (Fotografia de Ana Domingues).

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RESUMO

Realizou-se a 15 de dezembro o I Encontro de Sistemas Agroflorestais de Sucessão (SAFS) sob a tutela da Escola Superior Agrária de Coimbra em colaboração com a Direção Regional de Agricultura e Pescas do Centro. O evento reuniu um conjunto de atores no campo da investigação científica, agronomia, florestas e agricultura e permitiu uma discussão alargada em torno do tema das agroflorestas e da sustentabilidade do sistema agroalimentar a partir da questão do potencial contributo dos SAFS para o futuro da Agricultura Biológica. Entre os principais pontos a salientar estão o impacto dos modelos agroflorestais no solo, o seu enquadramento político e acesso ao financiamento e o papel que a investigação científica e a inovação podem assumir como catalisadores na otimização de soluções de base ecológica e na sua validação. A necessidade de integração conjunta do conhecimento de diferentes áreas e do diálogo interpares reuniu o consenso geral.

Palavras-chave: Agricultura Biológica, Agroecologia, Serviços de Ecossistema, Solo.

INTRODUÇÃO

Decorreu no passado dia 15 de dezembro o I Encontro de Sistemas Agroflorestais de Sucessão. Tratou-se de um evento de caráter técnico-científico que teve como principal objetivo a discussão dos potenciais contributos de um modelo agroflorestal originário dos países tropicais, os Sistemas Agroflorestais de Sucessão (SAFS), para o futuro da Agricultura Biológica na Europa e em Portugal em particular. Os SAFS são muito recentes na Europa, o que contrasta com a longa história dos modelos agroflorestais tradicionais europeus, e como tal, ainda pouco representados, quer em área implementada, quer na literatura científica publicada para climas temperados. Desta forma, este evento pretendeu criar um espaço de discussão sobre o tema dos SAFS com a contribuição de investigadores e de técnicos que, não trabalhando diretamente com estes sistemas em particular, realizaram já trabalho e/ou investigação capaz de contribuir para a criação de conhecimento em torno dos SAFS. Foram ainda convidados sete agricultores portugueses com experiência em SAFS para partilhar as suas experiências. Deste conjunto de cerca de 25 oradores e moderadores convidados, ao longo de 18 intervenções, resultou um dia pleno de diferentes visões sobre agrofloresta e agroecologia. Foram, deste modo, lançadas as bases para futuros eventos sobre diversas temáticas habitualmente menos expostas à discussão crítica e cujas potencialidades para otimização dos sistemas de produção existentes e contributo para a resiliência e adaptação climática podem assim ser avaliadas. O evento foi organizado em quatro sessões principais: Ciência e Investigação, Agronomia e Floresta, Economia e Sociedade, e Agricultura na qual teve lugar a Mesa Redonda com agricultores e *stakeholders* (**Figura** 1) seguindo-se os comentários finais. A organização ficou a cargo de professores e alunos da Escola Superior Agrária do Politécnico de Coimbra (ESAC-IPC) em colaboração com a Direção Regional de Agricultura e Pescas do Centro (DRAPC). Embora estivesse inicialmente prevista a sua realização em formato presencial nas Instalações da Escola Superior Agrária de Coimbra (ESAC-IPC), o evento foi convertido numa modalidade exclusivamente online em resultado do agravamento na evolução da pandemia. Receberam-se 326 inscrições, com uma média de 135 visualizações em simultâneo, atingindo um máximo de 161 visualizações durante o período da tarde.

Com a sustentabilidade do sistema agroalimentar como elo de ligação ficou evidenciada, quer a complexidade, quer o desafio na procura de soluções.

"ALLEY CROPPING" E MELHORAMENTO GENÉTICO

Os sistemas agroflorestais em faixas ("*Alley Cropping*") são modelos relativamente recentes que têm vindo a ganhar popularidade no centro e norte da Europa, com especial relevo em França. Recentemente, têm sido alvo de crescente investigação devido à possibilidade de combinação de culturas arvenses e árvores, abrindo as portas à mecanização e, consequentemente, a ganhos de escala (Wolz e DeLucia, 2018). Durante a primeira sessão da manhã, a partilha de características comuns entre os SAFS e os modelos *Alley Cropping* foi fortemente valorizada e mostrou-se como esta aproximação pode permitir, por exemplo, o aproveitamento da já vasta informação científica disponível sobre estes sistemas para a otimização dos SAFS. Por outro lado, os SAFS foram também identificados como excelentes modelos para se estudarem as relações ecológicas de facilitação entre espécies vegetais quando em coexistência, no sentido do desenvolvimento de técnicas de *intercropping* mais eficazes e produtivas.

FIGURA 1. Mesa redonda virtual com agricultores e *stakeholders* pioneiros em SAFS em Portugal (Fotografia de Mariana Marques).

FIGURA 2. Quinta do Alecrim, Torres Novas. Campo de SAFS com foco na produção de hortícolas. Exemplo de combinação de SAFS com produção bio-intensiva de hortícolas (Market Garden). Data de implementação, janeiro de 2019. Fotografias tiradas do mesmo local: (A) Maio 2020, produção de beringela, alface e funcho entre as linhas de árvores de fruto; (B) junho 2020, Evolução das culturas após 2 meses (Fotografia de Denis Hickel, Quinta da Rainha).

«(...) os SAFS foram também identificados como excelentes modelos para se estudarem as relações ecológicas de facilitação entre espécies vegetais quando em coexistência, no sentido do desenvolvimento de técnicas de intercropping mais eficazes e produtivas»

Contudo, ainda se verificam limitações nas produtividades atingidas pelas culturas nestes modelos *Alley Cropping*, nomeadamente em cereais, o que exige uma contínua procura de soluções. O melhoramento genético é uma das respostas mais recorrentes para fazer face a aumentos de produção, adaptação a sistemas de agricultura, qualidade nutricional ou resistência a doenças. Em sistemas agroflorestais, o efeito da disponibilidade da luz é talvez o fator mais limitante à produtividade e ao mesmo tempo uma das vantagens em climas mais extremos como é o caso do Mediterrânico (Dupraz *et al.*, 2018). Neste contexto, foi defendido mais investimento em "co-melhoramento" genético em ambientes com grande sombreamento e condições de forte competição interespecífica (por oposição ao melhoramento na modalidade de monocultura clássica), para se conseguirem aumentos de produtividade nas espécies anuais com potencialidade de inclusão nos variadíssimos modelos agroflorestais, passando pelas hortícolas até às culturas arvenses. Será igualmente de esperar que, nesta mesma vertente, o melhoramento genético na componente arbórea (nomeadamente no caso dos frutos secos, pelo seu potencial para a inclusão em modelos agroflorestais estratificados), permita ganhos substanciais no desempenho produtivo, em articulação com o trabalho em resistência a doenças e na qualidade do fruto que já se encontra mais desenvolvido (Wolz *et al.*, 2017).

O SOLO E OS SERVIÇOS AMBIENTAIS

O solo desempenha um papel chave na produtividade dos sistemas agrícolas, em geral, e agroflorestais, em particular. Tendo sido o alvo principal da segunda sessão da manhã, foram inumeradas as funções do solo nas quais o impacto positivo dos sistemas agroflorestais é maior: produção de alimento, sequestro de carbono, regulação de clima, armazenamento de água, reciclagem de nutrientes e promoção de *habitat* para os inúmeros organismos que dele dependem (Pantera *et al.*, 2021). Partindo de literatura científica disponível em sistemas multiestrato, (Marsden *et al.*, 2020), no qual os SAFS se incluem, é possível prever uma aumento da disponibilidade de nutrientes nos SAFS pela redução da lixiviação dos nutrientes e pela sua reciclagem. Nos sistemas multiestrato, estes processos são otimizados através de uma ocupação mais completa do volume do solo pelas raízes, resultando numa competição limitada entre as espécies consociadas. Foi referido que um dos aspetos mais relevantes poderá ser a grande diversidade de raízes em diferentes estratos, contribuindo para o melhor aproveitamento dos recursos (água e nutrientes). A concorrência modesta entre espécies leva a que, enquanto uma espécie se encontra a aumentar a absorção de nutrientes, outra espécie, em fim de ciclo, a estará a reduzir, promovendo desta forma a estabilização da absorção dos nutrientes ao longo do tempo. Pode, neste sentido, constituir uma vantagem, uma vez que existirá como que uma "autorregulação" desejável. Neste contexto, a prática da poda intensiva, tão característica dos SAFS, e a cobertura morta promovida pelo *mulching*, permitem reciclar a biomassa das árvores e reduzir a imobilização dos nutrientes.

«(...) foram inumeradas as funções do solo nas quais o impacto positivo dos sistemas agroflorestais é maior: produção de alimento, sequestro de carbono, regulação de clima, armazenamento de água, reciclagem de nutrientes e promoção de habitat para os inúmeros organismos que dele dependem»

Por outro lado, a poda também reduz a transpiração das árvores, especialmente em climas e em estações mais quentes, diminuindo por essa via a competição das culturas pela água do solo. Uma das soluções de base ecológica ("Nature-based solutions") que os SAFS propõem é a incorporação de árvores e arbustos "multifuncionais" consociadas com hortícolas e fruteiras, tendo como principal função a produção de matéria orgânica *in loco*. Este tipo de estratégia pode servir de base ao desenvolvimento de soluções inovadoras no campo da fertilização para outros modelos em Agricultura Biológica, e não só, diminuindo a sua dependência de fertilização externa. Apesar do evidente acréscimo de custos e volume de trabalho adicional com a incorporação destes elementos lenhosos "multifuncionais" e da área cultivável útil que podem ocupar, o recente galopar do preço dos fatores de produção faz com que estas estratégias de base circular possam aumentar a rentabilidade em cenários futuros.

Um dos temas trazidos para a discussão foi o da saúde do solo. O Conselho de Missão sobre Saúde do Solo e Alimentação da União Europeia (European Commission *et al.*, 2020) refere que «a saúde do solo, ou qualidade, pode ser amplamente definida como: a capacidade de um solo vivo funcionar, dentro dos limites do ecossistema, natural ou gerido, para sustentar a produtividade de plantas e animais, manter ou melhorar a qualidade da água e do ar e promover a saúde das plantas e animais». Neste campo, foi referido que os SAFS, pela sua biodiversidade conceptual e pela inclusão de árvores multifuncionais, podem ser considerados como sistemas com grande propensão ao desenvolvimento de solos com elevada qualidade. Contudo, perante as atuais dificuldades na rigorosa avaliação da qualidade do solo (Bünemann *et al.*, 2018), o recurso à investigação científica e ao diálogo entre investigadores, técnicos, agricultores e outros *stakeholders*, é imprescindível para produzir evidência robusta às múltiplas práticas agrícolas sustentáveis e garantir, inclusive, uma adequada atribuição dos fundos europeus neste contexto.

«Ficou ainda registada a necessidade de um esforço de clarificação da opinião pública e dos legisladores, de modo a promover medidas igualitárias para os agricultores que optem por esta via de transição para uma maior sustentabilidade»

A discussão em torno dos serviços ambientais (serviços de ecossistema) centrou-se na sua exequibilidade e no seu significado político e ético em alternativa à tradicional perspetiva técnico-científica. Procurou-se responder a duas questões-chave: a) Qual é o valor de mercado de um serviço ambiental? e b) Quem é que tem direito a receber esse montante? Para além da confirmação do papel destes serviços como ferramenta de valorização ambiental e de se encontrarem geralmente favorecidos em contexto agroflorestal (Torralba *et al.*, 2016) foi também identificada a urgente necessidade do seu enquadramento na legislação nacional

FIGURA 3. Lugar da Terra, Torres Vedras, dezembro 2021. Campo de SAFS de pequena escala com foco na produção bio-intensiva de hortícolas (Market Garden) em intercropping. Data de implementação, setembro 2020 (Fotografia de Tânia Carvalho).

em vigor, sob o risco de o seu uso ser desvirtuado e se perder uma oportunidade de favorecimento de práticas sustentáveis e promotoras de uma bioeconomia circular. Ainda no âmbito dos serviços ambientais foi exemplificado o potencial dos SAFS na prevenção de incêndios quando aplicado às áreas periféricas das aldeias em zonas rurais.

ECONOMIA, SOCIEDADE E A AGROECOLOGIA

O final da manhã e primeira sessão da tarde focaram-se em aspetos socioeconómicos com especial destaque para a agroecologia. Numa ótica económica, e quando devidamente enquadrados, os SAFS revelaram a potencialidade para serem sistemas rentáveis e com grande complementaridade com o modo de produção biológico. No contexto da pequena agricultura familiar, com forte expressão em Portugal, o novo sistema de certificação de grupos, previsto na atual legislação europeia em matéria de produção biológica, poderá permitir ultrapassar alguns dos constrangimentos associados aos custos de certificação. De referir ainda, neste domínio, a emergência de outras formas de garantia da qualidade que, embora a dar os primeiros passos em Portugal, trilharam já um longo caminho noutras partes do mundo. É o caso dos sistemas participativos de garantia que, sendo diferentes das certificações de base pública, se adequam particularmente bem a sistemas de produção agroecológicos, como é frequentemente o caso dos SAFS. A opção por formas de escoamento mais próximas dos consumidores finais pode, também, ser uma via para valorizar os produtos. Tendo em conta a diversidade de produções normalmente presente nos SAFS, existe espaço para a utilização de circuitos de comercialização diferentes dos mais habituais, nomeadamente circuitos curtos, através dos quais é possível obter preços mais elevados ao produtor e mais baixos ao consumidor.

«A relação entre SAFS e a Agricultura Biológica foi exemplificada com a apresentação de explorações e projetos implementados no nosso país, ficando em cima da mesa a necessidade de expansão da escala e de mecanização, um caminho já a ser trilhado por alguns agricultores e *stakeholders* portugueses»

No âmbito da agroecologia, os vários exemplos apresentados, desde a caravana agroecológica, ao contributo das universidades e politécnicos e ao exemplo de associações locais em territórios de baixa densidade, como a Associação Terra Sintrópica, mostraram que há lugar para a convivência dos vários modos de produção e uma vontade crescente da sociedade em contribuir para a valorização do setor agrícola e para a adaptação às alterações climáticas. Um dos pontos identificados pelos representantes da Rede Rural Nacional (RRN) e do Gabinete de Planeamento, Políticas e Administração Geral (GPP) prende-se com a atual legislação e processos de atribuição de fundos que tem, em certa medida, acompanhado a entrada em cena de novos modelos de atividade agrícola, nomeadamente modelos assentes em técnicas agroecológicas cujo objetivo é obter retorno financeiro e sustentabilidade económica, de que são exemplo os múltiplos sistemas agroflorestais. Ficou ainda registada a necessidade de um esforço de clarificação da opinião pública e dos legisladores, de modo a promover medidas igualitárias para os agricultores que optem por esta via de transição para uma maior sustentabilidade. A importância da componente social e do seu enquadramento na investigação em agrofloresta (e na agricultura em geral) não pode ser descurada residindo muitas vezes aí a chave do sucesso da implementação de medidas de sucesso, como foi possível entender a partir de um exemplo concreto apresentado (Costanzo *et al.*, 2008). Uma última palavra foi para a importância dos conceitos de Gestão da Paisagem e de Aptidão, para os quais os modelos de agricultura tradicional têm muito a contribuir com a sua visão holística e ênfase na necessidade de gerirmos o que herdamos e iremos deixar às gerações vindouras.

PARTICIPAÇÃO DOS AGRICULTORES E *STAKEHOLDERS*

A relação entre SAFS e a Agricultura Biológica foi exemplificada com a apresentação de explorações e projetos implementados no nosso país, ficando em cima da mesa a necessidade de expansão da escala e de mecanização, um caminho já a ser trilhado por alguns agricultores e *stakeholders* portugueses. A complementaridade com modelos bio-intensivos de hortícolas (popularmente conhecidos por "Market Garden" ou "Horta para o Mercado") foi apresentada como uma solução viável em pequena escala e foi demonstrada a dinâmica (e ao mesmo tempo a dificuldade) de usar os SAFS para uma produção continuada no tempo com as mesmas culturas (**Figura 2** e **Figura 3**). Os SAFS são sistemas muito dinâmicos, também numa lógica temporal, necessitando de um reajuste constante com novos produtos produzidos e consequentemente sujeitos a uma adaptação contínua ao mercado. Contudo, como ficou bem demonstrado ao longo do evento, a crescente divulgação da agroecologia no nosso país, seja no mundo académico, seja em iniciativas locais, tem permitido uma aproximação entre produtores e consumidores, encurtando os circuitos de distribuição e valorizando modos de produção diversificados. Aliás, a inclusão dos agricultores e outros *stakeholders* ligados ao setor agrícola, bem como de decisores políticos, num evento de carácter marcadamente científico, foi unanimemente aplaudida e indicada como um exemplo a seguir em futuros eventos.

CONCLUSÕES

Os SAFS podem ser encarados em diferentes perspetivas, o que coloca a sua plasticidade como uma vantagem a considerar. Ao longo das sessões do I Encontro dos SAFS foi ficando evidente que os SAFS têm potencialmente inúmeras vantagens, a par com um conjunto de limitações, e que o seu sucesso depende muito do objetivo com que são utilizados. Mais do que um sistema agroflorestal por si só, os SAFS podem contribuir para a expansão da área de agrofloresta na Europa, incrementar os serviços de ecossistema, contribuir para a expansão da área de Agricultura Biológica, promover a diversificação, a adaptação climática e a mitigação dos impactos de outros modelos agrícolas e, simultaneamente, promover o usufruto dos futuros mecanismos europeus de premiação do sequestro de carbono, como a "Agricultura de Carbono" (European Commission, 2021).

Concluído um dia de intensa partilha e debate, ficou-se com a firme certeza de que o diálogo entre os diferentes agentes, de biólogos a ecólogos, agrónomos, florestais, arquitetos paisagistas, sociólogos e economistas, entre outros, deve ser promovido, desde o processo de investigação até à implementação e gestão de sistemas agrícolas complexos, de modo a tirar o máximo proveito do conhecimento já existente. É imperativa a promoção da fusão do conhecimento, passível de ser transferido de sistemas agrícolas pouco conhecidos, com o desenvolvimento mais recente em tecnologia, de forma a recorrer-se a toda a informação disponível e fazer-se face a um mundo cada vez mais hostil à prática da agricultura e, no limite, à subsistência dos próprios agricultores e à sobrevivência de toda a sociedade.

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CONCLUSÃO

Os SAFS são modelos agroflorestais de recente implementação em Portugal encontrando-se ainda numa fase pioneira e em transformação. Do ponto de vista do desenho dos campos é de salientar a constante a presença de linhas de arvores espaçadas por alguns metros, um modelo muito similar aos modelos agroflorestais *alley-cropping*, o que permite já no presente, mas também futuramente uma grande operacionalidade e ganhos na organização do sistema. A utilização de técnicas agroecológicas é, como seria de esperar, largamente promovida e consensual e identifica-se uma grande compatibilidade com o modo de produção biológico (algumas das quintas já tinham a certificação aquando das visitas) o que deixa a antever uma facilidade na transferência de conhecimento na área da hortifruticultura em AB. Apesar de se tratar de um modelo agroflorestal assente em premissas bem definidas, a estratificação vertical e a sucessão natural, os SAFS estudados em território de Portugal continental apresentaram uma grande heterogeneidade de áreas, combinações de espécies e estratégias de gestão, inclusive entre campos dentro da mesma quinta. Tal não é alheio ao facto dos sistemas estudados ainda se encontrarem em experimentação com vista à escolha e otimização das espécies a incluir e das combinações mais favoráveis, em particular das espécies perenes cuja função é o apoio direto e indireto às espécies produtivas (espécie multifuncionais). É de salientar que a procura no uso de espécies autóctones é generalizada verificando também uma grande utilização de espécies nativas de climas não temperados inspirando-se nos modelos tropicais originais. Todos os sistemas estudados, com uma única exceção, são constituídos por um pomar convencional, mono ou multicultural, como desenho base, variando depois a exploração das áreas entre as linhas de árvores entre modelos mais assentes em produção biointensiva de hortícolas ou para produção de matéria orgânica para alimentar as linhas de árvores. Os SAFS estudados caracterizaram-se ainda por uma elevada biodiversidade planeada quando comparados com modelos agrícolas e agroflorestais o que permite antever uma grande promoção de serviços de ecossistema e uma consequente redução no uso de fatores de produção. Neste sentido, e tendo em conta as alterações climáticas previstas para as próximas décadas bem como os problemas já identificados na reduzida sustentabilidade que afeta a agricultura moderna e que se reflete em parte das explorações em modo de produção biológico europeias, conclui-se que poderá haver benefício na procura e transferência de conhecimento dos SAFS para construção de modelos agrícolas e agroflorestais mais resilientes e circulares. Em particular poderá ser de grande utilidade considerar a conversão de modelos agrícolas hortícolas ou frutícolas em modelos agroflorestais mais ou menos complexos e inspirados nos SAFS como uma solução prática a adotar, inclusive numa perspetiva de novas oportunidades de financiamento ao abrigo da Política Agrícola Comum e das recentes estratégias da União Europeia. Cabe à ciência, pela necessidade de validação das questões levantadas não só pelos SAFS, mas também pelos inúmeros modelos agrícolas e agroflorestais assentes em soluções baseadas na natureza, um papel central na adaptação da agricultura aos desafios ambientais e socioeconómicos do nosso tempo. Acresce ainda a urgente necessidade de recolha, sistematização e difusão da informação gerada em sistemas agrícolas de cunho agroecológico, papel que a ciência pode e deve desempenhar pela natural apetência na geração e partilha de conhecimento. Para isso a divulgação entre pares é sempre um primeiro caminho a ser percorrido, com a apresentação em congressos para uma primeira avaliação e crítica e posteriormente com a publicação de artigos científicos nas revistas de especialidade. A comunicação de ciência para a sociedade civil é outra esfera que está cada vez mais valorizada e em que se procura não apenas dar os resultados da investigação mais recente, mas também contribuir para a criação de tecnologia e soluções inovadoras onde elas são necessárias. Foi este percurso que se procurou de certa forma recriar ao longo deste trabalho de dissertação. Teve como início um trabalho inicial de recolha exaustiva de informação nas diversas explorações selecionadas, onde a participação do autor nos trabalhos diários foi sempre que possível promovida como forma de envolvimento e melhor compreensão das dinâmicas dos SAFS e ao mesmo tempo como promoção de condições para a clarificação e integração na investigação em curso por parte dos agricultores e responsáveis pela quinta. Posteriormente foi feita a apresentação dos primeiros resultados e conclusões preliminares em congressos internacionais científicos da especialidade Em concreto foram apresentadas duas comunicações em congressos internacionais, uma comunicação oral e um poster, realizadas com base nos dados disponíveis até a altura. (Anexos 1 e 3). Na etapa final foi promovida a comunicação em ciência para um publico alvo preferencialmente constituído por agricultores e técnicos com a publicação de artigos numa revista nacional de caracter técnico cientifico que culminou com a organização do "I Encontro de Sistemas Agroflorestais de Sucessão". Muitas das potencialidades em inovação sugeridas na presente dissertação são acompanhadas por uma igual necessidade de confirmação e validação servindo acima de tudo para gerar futuras linhas de investigação que permitam quer o aumento da resiliência e sustentabilidade dos modelos agrícolas, em modo de produção biológico (preferencialmente), a sua integração com as inovações tecnológicas e digitais e a sua promoção junto dos agricultores que são no fundo os principais beneficiários diretos e a quem se espera que este trabalho contribua para a melhoria das sua condição de vida.

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ANEXOS

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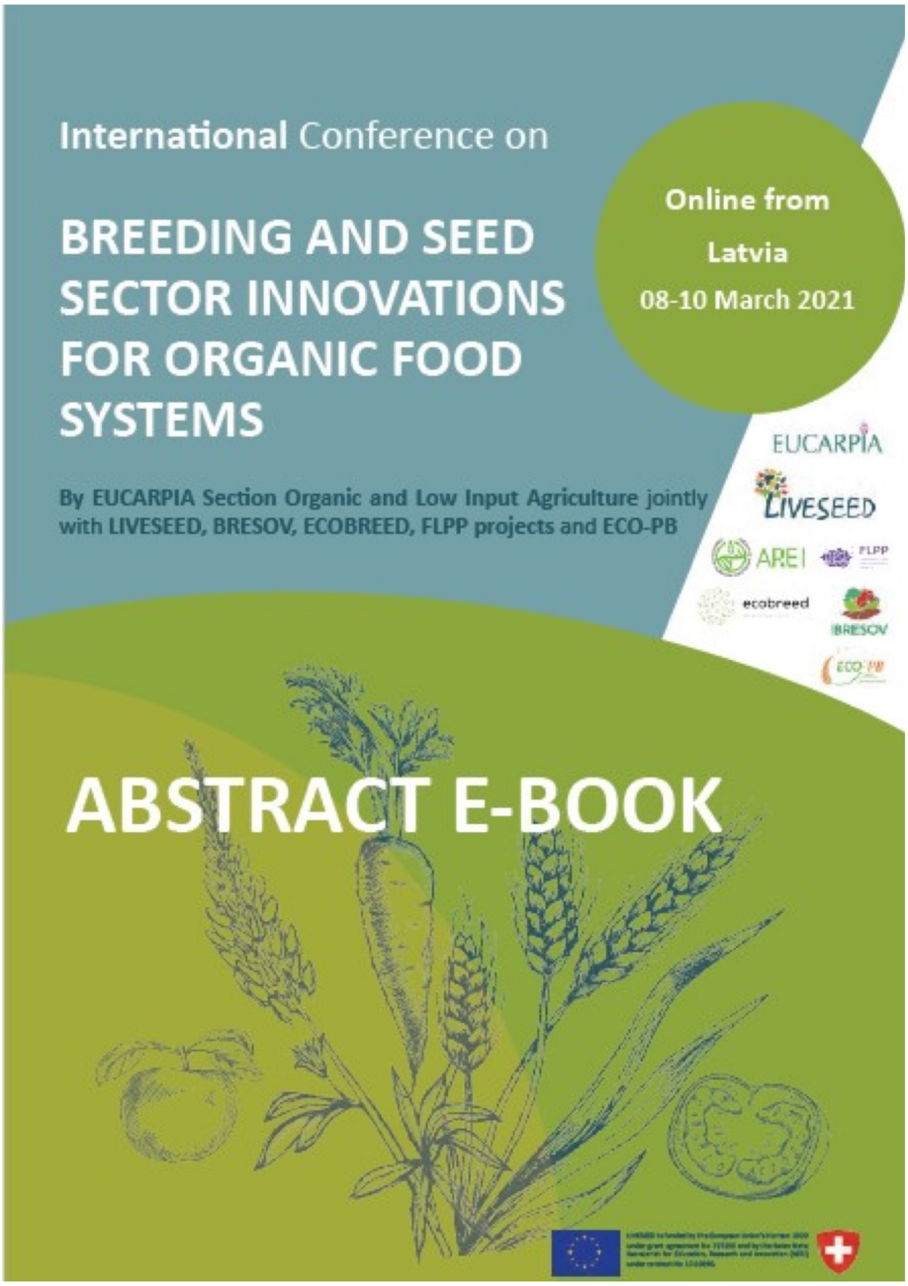
Anexo 1: Comunicação oral

ANEXO 1

É apresentado o abstract da comunicação oral que consta no livro de resumos da conferência:

- “Successional Agroforestry Systems for Europe: the Portuguese example” na Conferência Internacional ”Breeding and Seed Sector Innovations for Organic Food Systems” pela European Association for Research on Plant Breeding (EUCARPIA), Março 8-10, 2021, em Cēsis, Letónia (evento on-line)



EUCARPIA Breeding and seed sector innovations for organic food systems, March 8-10, 2021, AREI **T50**

SUCCESSIONAL AGROFORESTRY SYSTEMS FOR EUROPE: THE PORTUGUESE EXAMPLE

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Keywords: Agroecology, Successional Agroforestry, Mediterranean, Syntropy

Agroforestry is an agroecological practice with a long tradition in European Mediterranean countries and is recently getting more attention from political and scientific communities (Mosquera-Losada et al. 2018). Agroforestry is mentioned in several places in the CAP post 2020 draft Strategic Plan Regulation, and in the Farm to Fork Strategy and Biodiversity Strategies, which are all part of the European Green deal. Compelled by climatic changes, the search for innovations in agroecological practices is seen as a part of the solution to mitigate Agriculture's impact. The concept of successional agroforestry systems (SAFs) has been developed and tested by Ernst Götsch since 1982 in the state of Bahia in Brazil. These systems are managed to accelerate the succession processes in order to create an agro-ecosystem with structure, function and dynamics similar to the local natural ecosystem. This agroforestry practice has in the last few years evolved to a design inspired in alley cropping systems and named Syntropic Agriculture. It relies on ecological succession and stratification as a replacement for fertilizers and pesticides and pretends to be process-based, as opposed to many conventional or organic practices that are input-based (Andrade et al. 2020).

Our project was designed to identify and describe the SAFs initiatives in Portugal mainland with the main purpose of understanding how these systems are being implemented in a Mediterranean climate, what similarities share with the designs from tropical contexts and what solutions are being develop by farmers to adapt to local conditions.

Between September and December of 2020 all farms located in Portuguese mainland territory that had implemented and maintained SAFs, according to the main principles of Syntropic Agriculture, were tried to be identified, contacted and after selection the site was visited and information collected. An inquiry was applied to the person responsible for the SAFs and the complete list of species planted during the current year were registered, namely trees, shrubs and herbaceous plants. Focus on commercial purpose was favored for selection and an effort to cover the most part of the territory was made.

So far 8 farms were included in the project. All have a direct or indirect connection with Ernst Götsh and the oldest system was implemented 3 years ago. Great heterogeneity was found with system's areas reaching from 2ha to 500m2 but with a predominance of small-scale fields. Indeed scalability has already been identified as a major limitation of this practice (Andrade et al. 2020) and labor costs and lack of specialized machinery was also pointed out by farmers as major difficulties. Apart from the complexity of management, with highly skill pruning and consortia composition decisions demanded, other difficulty observed was the unavailability to meet amount of plant material to required to implement a system. Fertilization is still applied in all fields and almost all systems used irrigation. Plant pests and diseases were reported as minimal what could be the result of the multicity of ecosystem services provided by the great plant biodiversity planted. All farms adopted organic farming practices with a few having organic agriculture certification.
With no exception, large numbers of trees, shrubs and herbaceous plants are planted in small areas, with perennials' layout lined up 3 or 4 m apart usually with heavy annual production between lines. In general financial results are still far from desired, with some farms getting income from direct sell of grocery boxes and others more fruit oriented. Interestingly all involved expect financial return in the short or medium term. There are resemblances between the pant species presented in the farms included in the project although a great influence from tropical designs is observed. Some native species, mainly tress and shrubs, were intentionally planted and managed with clear benefits reported. There is a general will to increase the number and variety of tree species in what should be seen as a major opportunity to increase the carbon sequestration potential and also the ecologically intensity of these systems.
Considering the expansion of SAFs throughout the world, Europe included, there is an opportunity to study and better understand these systems in order to optimize them to different climates and soil conditions and improve either the similarity with native forests, in complexity and function, as well as the productivity and financial return.

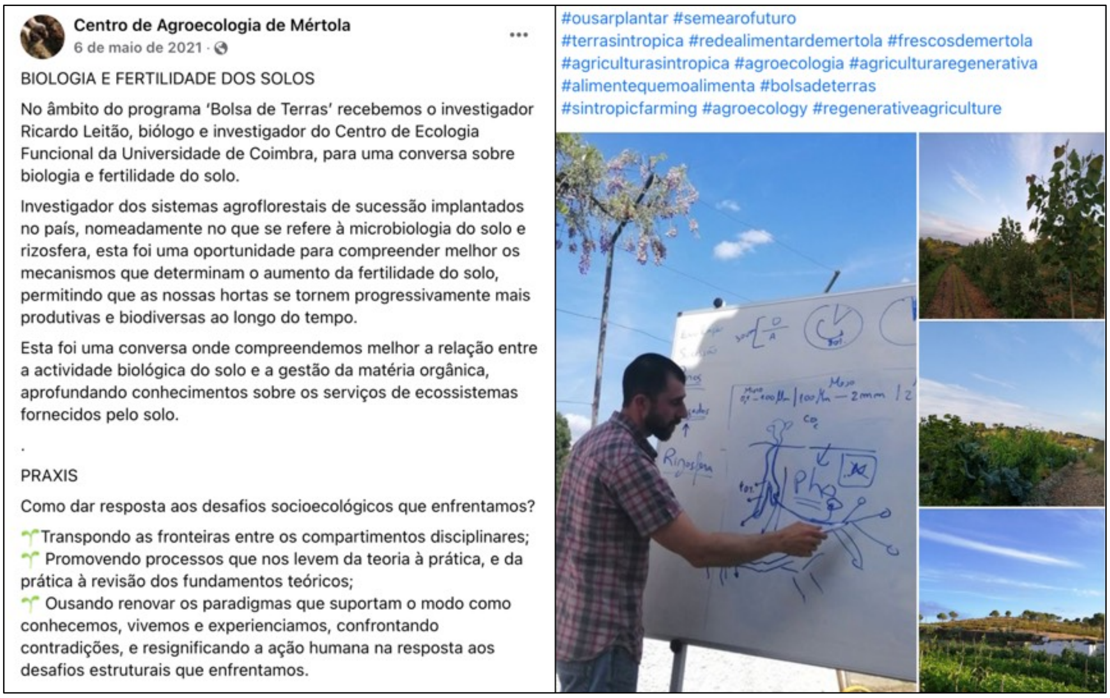
Andrade D, Pasini F, Scarano FR (2020) Syntropy and innovation in agriculture. Current Opinion in Environmental Sustainability 45, p20–24. doi: 10.1016/j.cosust.2020.08.003

Mosquera-Losada MR, Santiago-Freijanes JJ, Pisanelli A, et al (2018) Agroforestry in the European common agricultural policy. Agroforestry Systems 92, p1117–1127. doi: 10.1007/s10457-018-0251-5

Schulz B, Becker B, Götsch E (1994) Indigenous Knowledge in a Modern Sustainable Agroforestry System - a Case-Study From Eastern Brazil. Agroforestry Systems 25 p59–69. doi: 10.1007/BF00705706

Anexo 2. Outras atividades desenvolvidas

Cartaz da tertúlia “O Impacto das Práticas Agrícolas Sustentáveis na Biodiversidade, Solos e Ciclos da Água” na qual o autor foi um dos oradores convidados.



Publicação do Workshop "Biologia e Fertilidade dos Solos" ministrado pelo autor no âmbito do projeto "Bolsa de Terras" promovido pela Associação Terra Sintrópica em Mértola a 2 de Abril de 2021

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Anexo 3: Poster

ANEXO 3

É apresentado o abstract do poster e o modelo de 5 diapositivos (por ser um evento realizado totalmente on-line os posters tiveram esse formato).

- "Successional Agroforestry Systems for the Mediterranean-Temperate transition: the Portuguese case" na 5a Conferência Europeia de Agrofloresta "Agroforestry for the transition towards sustainability and bioeconomy" pela Federação Europeia de Agrofloresta (EURAF), Maio-17-19, 2021, em Nuoro, Sardinia, Itália (evento on-line)

1) Abstract

Successional Agroforestry Systems for the Mediterranean-Temperate transition: the Portuguese case

EURAF 2020
Agroforestry for the transition towards sustainability and bioeconomy
Abstract
Corresponding Author: rjleitao@ua.pt

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Theme: Agroforestry innovations toward innovative agroforestry systems

Keywords: Succession agroforestry, Syntropic agriculture, Agroecological practices, Ecosystems services

Abstract

Agroforestry is an agroecological practice with a long tradition in European countries and is recently getting more attention from both political and scientific communities (Mosquera-Losada et al. 2018). The recognition of Agroforestry importance can be found in the future "CAP strategic plans – Proposal for a regulation COM (2018)" and in the "Farm to Fork Strategy (2020)" and "EU Biodiversity Strategy for 2030 (2020)".

The concept of successional agroforestry systems (SAFs) has been developed and tested by Ernst Götsch since 1982 largely in Brazil. This agroforestry practice relies on ecological succession and stratification as a replacement for fertilizers and pesticides (Andrade et al. 2020).

The aim of our work is to try to identify and describe the most representative SAFs initiatives in mainland Portugal with the main purpose of understanding how these systems are being implemented in a Mediterranean-Temperate transition climate, what similarities they share with the designs from South-America tropical contexts and what solutions are being develop by farmers to adjust to Southern European edaphoclimatic conditions and social-economic reality.

From September 2020 to January of 2021, an update inventory of SAFs farms was attempted. An effort was made to try to seek for minimum representative features such as direct or indirect connexion with Ernst Götsh and an alley cropping design like. A total of nine farms were visited, field data was documented and additional information was collected using a semi-structured questionnaire.

Studied farms were distributed over Portuguese territory, with a bigger predominance in the centre and southern with a more Mediterranean influence. The oldest system was implemented nine years ago. The field areas ranged from 250m2 to 2ha with farms having a minimum of one and a maximum of four fields each. Indeed scalability has already been identified as a major limitation of this practice and labour costs and lack of specialized machinery was also pointed out by farmers as major difficulties. All farms adopted organic farming practices, with exclusion of synthetic agrochemicals from their practices, with four farms having organic agriculture certification and one being in conversion period.

Planned diversity was extremely high in most systems with an average of total 30 species per field of which 13 were trees. Tree densities were highly variable between systems with a median around 1500

trees per hectare. All systems have an alley cropping design like, with perennials, namely fruit trees, non commercial trees and shrubs densely planted in lines with minimum 2 to 8 m apart and the majority of systems having intense horticultural annual production between lines (Figure 1). Although horticultural annuals were present in almost all systems only one farm was considered by its responsible as profitable, based exclusively SAFs cultures with income coming from direct sell of grocery boxes. Interestingly almost all farms involved expected financial return with SAFs in the short or medium term.

Apart from agroforestry with timber, fruit or nut trees, other agroecological crop management practices such as organic fertilization, drip irrigation, intercropping, living cover crops or mulch and reduced tillage (Wezel et al. 2013), which are intrinsic to SAFs' concept, were also common to all study farms. Moreover some farms also included other agroecological practices such as the use of biofertilisers, crop choice and rotations and integration of semi-natural landscape elements at field scale. Consequently, the potential for provide enhanced ecosystems services are high. According with farmers' experience, less irrigation, decreased fertilization and almost no interventions to control pest and diseases were presented in comparison with conventional systems. These facts can be explained due to climate regulation, water flow regulation, enhanced nutrient cycling and natural pest control, also described by other authors in alley cropping systems in Europe (Quinkenstein et al. 2009).

Considering the expansion of SAFs throughout the world, Europe included, there is an opportunity to study and better understand these systems in order to optimize them to different climates and soil conditions. Additional financial return, either via the CAP measures, such eco-schemes, or other public or private initiatives such as carbon market could also be explored and be used as a model.

References:

Andrade D, Pasini F, Scarano FR (2020) Syntropy and innovation in agriculture. Current Opinion in Environmental Sustainability 45:20–24. doi: 10.1016/j.cosust.2020.08.003

Mosquera-Losada MR, Santiago-Freijanes JJ, Pisanelli A, et al (2018) Agroforestry in the European common agricultural policy. Agroforestry Systems 92:1117–1127. doi: 10.1007/s10457-018-0251-5

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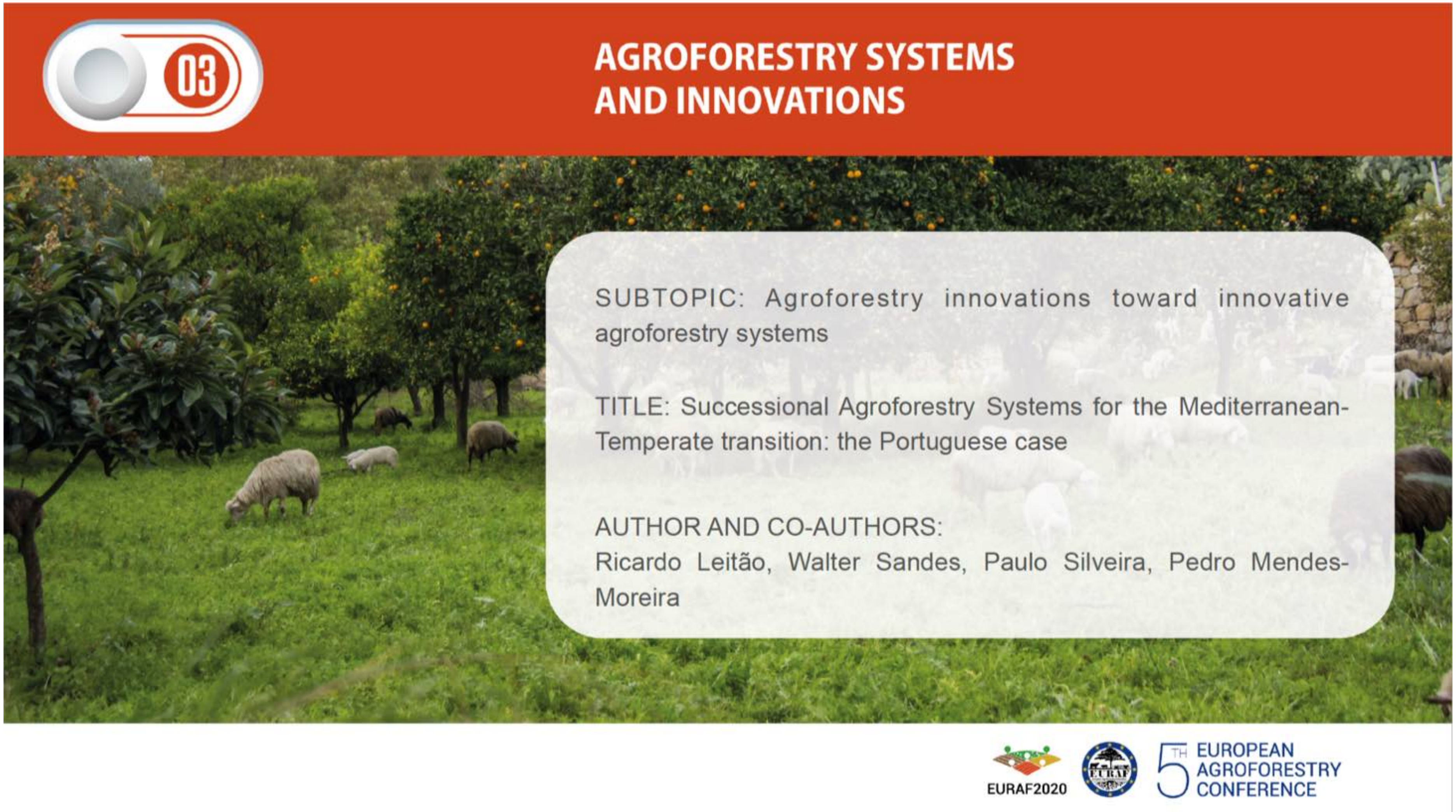
Wezel A, Casagrande M, Celette F, et al (2013) Agroecological practices for sustainable agriculture. A review. Agronomy for Sustainable Development 34:1–20. doi: 10.4141/CJSS07102

Figure 1. A Successional Agroforestry System from northern Portugal (Photo by Ricardo Meireles, Santo Tirso, 2020)

ANEXO 3

2) Poster



Successional Agroforestry Systems for the Mediterranean - Temperate transition: the Portuguese case

POLITÉCNICO DE COIMBRA
ESCOLA SUPERIOR AGRÁRIA

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Introduction

Agroforestry is an agroecological practice with a long tradition in European countries and is recently getting more attention from both political and scientific communities [1]. The countries of the Mediterranean basin are characterized by climatic variability fluctuations and unpredictability (particularly rainfall) what combined with the low economic viability of wood and crop productions, contributed to explaining the traditional multi-purpose land uses of the Iberian Peninsula. Portugal has a high diversity of agroforestry systems, like other Mediterranean ,

- Olive tree system
- Chestnut system
- Pyrenean oak system
- The Stone Pine system
- *Bocage* system
- *Hanged Vineyard* system (endangered)

The recognition of Agroforestry importance can be found in the future "CAP strategic plans – Proposal for a regulation COM (2018)" and in the "Farm to Fork Strategy (2020)" and "EU Biodiversity Strategy for 2030 (2020)". The benefits and opportunities offered by agroforestry can only be realized with substantial investments and coordinated efforts in research, education, knowledge transfer and appropriate national policies across Europe [1].

Successional Agroforestry Systems

The concept of Successional Agroforestry Systems (SAFSs) has been developed and tested by Ernst Götsch since 1982 largely in Brazil. This agroforestry practice relies on ecological succession and stratification as a replacement for fertilizers and pesticides [2].

Objectives

The aim of our work is to try to identify and describe the most representative SAFs initiatives in mainland Portugal with the main purpose of:

- understanding how these systems are being implemented in a Mediterranean-Temperate transition climate
- what similarities they share with the designs from South-America tropical contexts
- what solutions are being develop by farmers to adjust to Southern European edaphoclimatic conditions and social-economic reality
- how can the knowledge be transferred to other organic and conventional systems

Photo 1 – SAFSs' plot from the center of Portugal (farm 5), with a successful combination of bio-intensive market garden in the alleys with high intensity fruit trees and biomass shrubs and tress in the hedgerows

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Figure 1 - Study farms distribution in Portugal mainland

Methods

From September 2020 to January of 2021, an update inventory of Portuguese SAFSs farms was attempted. An effort was made to try to seek for minimum representative features such as direct or indirect connexion with Ernst Götsch and an alley cropping design like. A total of nine farms were included in the study, field data was documented and additional information was collected using a semi-structured questionnaire.

Photo 2 – SAFSs' plot from a stronger Mediterranean climate influence (farm 7), where hedgerows are densely planted and alleys are used to provide biomass to cover hedgerows (mulching) during the winter.

Table 1 – Field's design and composition of the 9 farms include in the study.

* Although fruit trees follow fixed patters, with defined distances between each tree, biomass trees are usually heavily planted in the hedgerows making the accountability difficult. Estimated numbers are below real numbers in most of the fields. With pruning and thinning being major management operations these numbers vary greatly over time.

Farm	Field	Implemen-tation Year	Alley width (m)	Estimated number of trees/ha*	Headgrow design	Planned diversity (nº species)**	Area (m²)
1	A	2017	4	1600	A-B-C	16	480
	B	2018	4	1700	A-B-A-C-A	33	1350
	C	2019	4	2000	A-A-A...	36	2000
2	A	2019	3	2800	Random	51	324
3	A	2020	6	1700	A-B-C	49	500
4	A	2018	3	6000	A-B-A-B...	80	1000
	B	2020	1,6	4800	A-A-A...	14	500
5	A	2019	4,5	2100	A-A-A...	15	9750
	B	2020	4,5	2000	A-B-C-B-A...	17	10000
	C	2020	6	2400	A-A-A...	20	20000
	D	2020	6	2400	A-A-A...	46	20000
6	A	2017	5,5	680	A-B-C-D...	40	2800
	B	2018	7	215	A-A-A...	15	6000
	C	2019	4	750	A-A-A...	32	3000
	D	2020	4	750	A-A-A...	34	3000
7	A	2020	2	8400	A-B-C-B-A...	60	2500
8	A	2019	4	2000	A-A-A...	17	225
	B	2019	4	3400	A-B-B-A-A	25	900
	C	2020	4	2700	A-A-A...	17	450
9	A	2011	4	1400	A-B-C-D...	67	2500
					Total	684	87279

Photo 3 – SAFSs' plot from the north of Portugal (farm 1), where hedgerows have a common design A-B-A-B-A

Current Agroforestry classification typology according to EURAF

Tree Location	Agroforestry System	Type of "Land"	
		Agricultural Land	Forest Land
Trees inside parcels	Silvopastoral agroforestry	1 Wood pasture	9 Forest grazing
	Silvoarable agroforestry	2 Tree alley cropping 3 Coppice alley cropping 4 Multi-layer tree-gardens	10 Multi-layer tree gardens
	Permanent crop agroforestry	5 Orchard intercropping, 6 Orchard grazing.	
	Agro-silvo-pasture	7 Alternating cropping and grazing	
Trees between parcels	Tree Landscape Features (protected by CAP Conditionality Rules)	8 Tree-Landscape-Features: (protected hedges, scattered individual trees, trees in line, small groups of trees)	
Trees in settlements	Urban agroforestry	homegardens, allotments, etc.	

European Successional Agroforestry Systems:

- Trees inside parcels
- Silvoarable/Permanent crop agroforestry
- Agricultural Land
- Orchard as a base design

Proposed classification between nº 4 and 5

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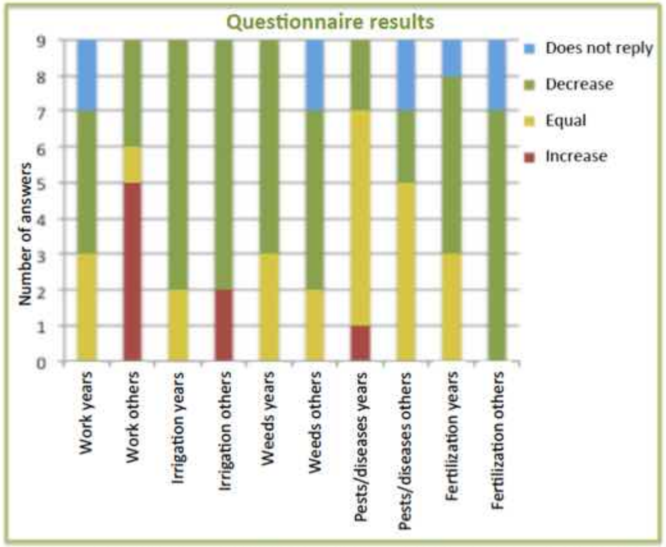

Figure 3 – Semi-structured questionnaire results. 5 major topics are represented: Work volume, Irrigation needs, Weeds control, Pests/diseases control and fertilization needs. For each of the major topics 2 questions were made: compare over the years and compare with farmers' previous experiences (different systems)

Photo 4 – Typical vegetable bed from an SAFSs' alley from the north of Portugal (farm 1), where straw was used as mulch

Photo 5 – SAFSs' plot from the highest Mediterranean climate influence (farm 8) . Alley's vegetable beds in fully production

Table 2 - Agroecological practices, according to Wezel et al (2013), identified in the study farms. A great number of potential Eco-Schemes can be extrapolated from these practices (e.g. High nature value farming, Carbon farming and Protecting water resources)

Agroecological Practices [4]		Farms								
		1	2	3	4	5	6	7	8	9
Efficiency increase and substitution agroecological practices	Crop choice									
	Splitting fertilisation									
	Biofertilisers	x		x		x	x		x	x
	Organic fertilisation	x	x	x	x	x	x	x	x	x
	Drip irrigation	x	x	x	x	x	x	x	x	*
	Biological pest control									
	Natural pesticides									
Redesign agroecological practices	Crop choice and rotations	x	x	x	x	x	x		x	
	Intercropping and relay intercropping	x	x	x	x	x	x	x	x	x
	Agroforestry with timber, fruit, or nut trees	x	x	x	x	x	x	x	x	x
	Allelopathic plants									
	Direct seeding into living cover crops or mulch	x	x	x	x	x	x	x	x	x
	Reduced tillage	x	x	x	x	x	x	x	x	x
	Integration of semi-natural landscape elements at field or farm scale						x	x	x	
	Management of landscape elements at landscape scale.									

References

[1] Mosquera-Losada MR, Santiago-Freijanes JJ, Pisanelli A, et al (2018) Agroforestry in the European common agricultural policy. Agroforestry Systems 92:1117–1127. doi: 10.1007/s10457-018-0251-5

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[4] Wezel A, Casagrande M, Celette F, et al (2013) Agroecological practices for sustainable agriculture. A review. Agronomy for Sustainable Development 34:1–20. doi: 10.4141/CJSS07102

[5] Quinkenstein A, Wöllecke J, Böhm C, et al (2009) Ecological benefits of the alley cropping agroforestry system in sensitive regions of Europe. Environmental Science & Policy 12:1112–1121. doi: 10.1016/j.envsci.2009.08.008

Conclusions

- There is a great level of heterogeneity in the SAFSs implemented in Portugal mainland
- In Mediterranean influence climates, with water scarcity and degraded soils, SAFSs can create added value
- The potential for SAFSs to provide enhanced ecosystems services are high, in particular climate regulation, water flow regulation, enhanced nutrient cycling and natural pest control, also described by other authors in alley cropping systems in Europe [5]
- More studies are needed to overcome labour demand limitation and to promote scalability of these systems
- There is a great potential for knowledge transfer to less complex organic farming systems, particularly to organic orchards and to organic vegetable farms

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AGROFORESTRY SYSTEMS AND INNOVATIONS

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Anexo 4: Modelo de Questionário

ANEXO 4

Questionário sobre a experiência com a Sistemas Agroflorestais de Sucessão / Agricultura Sintrópica

Destinatários: Produtores/Agricultores com Sistemas de Agricultura Sintrópica em Portugal
Duração aproximada do questionário: 30 minutos

Caro produtor/agricultor, o presente questionário destina-se exclusivamente à dissertação final do Mestrado em Agricultura Biológica e pretende a caracterização das iniciativas em solo português de Sistemas Agroflorestais de Sucessão - SAFs (em particular de Agricultura Sintrópica, inspiradas no trabalho de Ernest Götsch). A informação solicitada será de carácter essencialmente descritivo e permitirá comparar as várias iniciativas do país e assim conhecer melhor a realidade portuguesa deste modo de produção agroflorestal. Caso pretenda será assinado um memorando relativo ao respeito pela legislação de partilha de dados.

Agradecemos a sua colaboração.

Responsável: Ricardo Leitão – Biólogo, aluno de mestrado em Agricultura Biológica – ESAC, Coimbra.
Orientadores: Professor Doutor Pedro Mendes Moreira (ESAC) e Professor Doutor Paulo Silveira (Universidade Aveiro)
Data:______/_______/______
Nome da Exploração:____

Questionário:

-------------------------- CARACTERIZAÇÃO DA EXPLORAÇÃO --------------------------

1. Ano de início da agricultura sintrópica na exploração: ________________
2. Área total da exploração agrícola: ______________ (ha/metros)
3. Nº de parcelas da exploração agrícola: ___________
4. Nº de parcelas em agricultura sintrópica: ___________
5. Área total das parcelas em agricultura sintrópica: _____________ (ha/metros)
6. Certificação de modo de produção biológico nas parcelas com agricultura sintrópica: S/N
7. Outros sistemas de produção na exploração: S/N

☐	Agricultura biológica: ________ ha, OTE:___________________
☐	Modo de Produção Integrada: ________ ha, OTE:__________________
☐	Agricultura Intensiva: ________ ha, OTE:___________________
☐	Agricultura Tradicional/Familiar: ________ ha, OTE:________________
☐	Agricultura Biodinâmica: ________ ha, OTE:___________________

☐ Outro: __________________: ________ ha, OTE:__________________

8. Qual o foco principal da exploração:

☐ Hortícolas
☐ Plantas aromáticas/medicinais/condimentares
☐ Fruta
☐ Frutos secos
☐ Pequenos frutos/bagas
☐ Madeira
☐ Outro: ________________

9. Qual o foco principal a curto prazo da área com agricultura sintrópica:

☐ Hortícolas
☐ Plantas aromáticas/medicinais/condimentares
☐ Fruta
☐ Frutos secos
☐ Pequenos frutos/bagas
☐ Madeira
☐ Outro: ________________

10. Qual o objectivo final da área com agricultura sintrópica:

☐ Hortícolas
☐ Plantas aromáticas/medicinais/condimentares
☐ Fruta
☐ Frutos secos
☐ Pequenos frutos/bagas
☐ Madeira
☐ Outro: ________________

11. Tem algum tipo de produção animal associado ao sistema de agricultura sintrópica: S/N
12. Tem algum tipo de produção animal associado à exploração: S/N
13. Qual o sistema de produção antes da implementação da agricultura sintrópica:

☐ Agricultura Biológica, OTE:___________________
☐ Modo de Produção Integrado, OTE:___________________
☐ Agricultura Intensiva, OTE:___________________
☐ Agricultura Tradicional/Familiar, OTE:___________________
☐ Pousio
☐ Floresta
☐ Abandonado/degradado
☐ Outro:________________________

14. Caracterização das áreas adjacentes às parcelas com agricultura sintrópica:

☐ Agrícola
☐ Florestal
☐ Urbana
☐ Outra: _________________________

15. Qual a principal dificuldade enfrentada na <u>implementação</u> da agricultura sintrópica na exploração agrícola:

____

15.1.1. Enumere outras dificuldades:

____

____

16. Qual a principal dificuldade enfrentada na <u>manutenção</u> das parcelas em agricultura sintrópica:

____

16.1.1. Enumere outras dificuldades:

____

____

17. Nº de trabalhadores dedicados à área da agricultura sintrópica (UTA): ____________

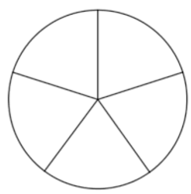
17.1. Nº médio de dias da semana dedicados à agricultura sintrópica: _______

17.2. Nº médio de horas por dia dedicados à agricultura sintrópica: _______

18. Verifica diferença no volume de trabalho nas parcelas com agricultura sintrópica com o passar do tempo/anos:

- ☐ Não tem diferença
- ☐ Requer mais trabalho
- ☐ Requer menos trabalho

19. Qual a **percepção** acerca do volume de trabalho com a agricultura sintrópica comparativamente com o sistema de produção anterior ou <u>outro</u>* (para equivalentes):



☐	> +100%: ________ %	☐	Idêntico (0%)
☐	O dobro (100%)	☐	-25%
☐	+75%	☐	metade (-50%)
☐	+50%	☐	-75%
☐	+25%	☐	Já não ocorre (-100%)

*____

20. Utilizou trator na implementação da agricultura sintrópica: S/N

20.1. Alfaia principal utilizada:____________________

21. Utiliza trator na manutenção da agricultura sintrópica: S/N

21.1. Alfaia principal utilizada:____________________

22. Utiliza motocultivador na área de agricultura sintrópica: S/N

23. Outra maquinaria utilizada:______________________________

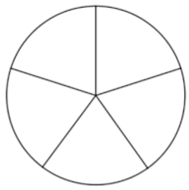
24. Qual o tipo de rega utilizado na área de agricultura sintrópica:

- [ ] Sem rega
- [ ] Gota-a-gota
- [ ] Aspersão
- [ ] Inundação/encharcamento
- [ ] Manual
- [ ] Outra: ________________

25. Verifica diferença na necessidade de rega nas parcelas com agricultura sintrópica com o passar do tempo/anos:

- [ ] Não tem diferença
- [ ] Requer mais água
- [ ] Requer menos água

26. Qual a **percepção** acerca da necessidade de rega nas parcelas com agricultura sintrópica mais antigas comparativamente com o sistema de produção anteri (para áreas equivalentes)



☐	> +100%: _________ %	☐	Idêntico (0%)
☐	O dobro (100%)	☐	-25%
☐	+75%	☐	metade (-50%)
☐	+50%	☐	-75%
☐	+25%	☐	Já não ocorre (-100%)

*____

-------------------------- INFESTANTES --------------------------

27. Considera que, de uma forma geral, as plantas infestantes são um problema nas parcelas com agricultura sintrópica: S/N
28. Como é feito o controlo de infestantes nas parcelas com agricultura sintrópica:

- [ ] Não faz qualquer tipo de controlo
- [ ] Químico
- [ ] Mecânico manual
- [ ] Mecânico com motoroçadora
- [ ] Mecânico com trator + alfaia:______________________________
- [ ] Cobertura de plástico
- [ ] "Mulching"
- [ ] Outro: __________________

28.1. Qual o material utilizado no "mulching":________________________________

28.2. Qual a origem dos materiais utilizados no "mulching":

- [ ] Interno à exploração, parcelas com agricultura sintrópica:__________%
- [ ] Interno à exploração, outras parcelas que não AS: __________%

☐ Externos à exploração: __________%

28.3. Utiliza alguma cultura com o único objectivo de produzir "mulching" entre as linhas de árvores nas parcelas com AS: S/N
Qual:____

28.4. Utiliza alguma cultura com o único objectivo de produzir "mulching" fora das parcelas com AS: S/N
Qual:____

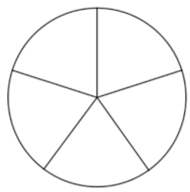
29. Quantos dias ocupa por semana no controlo de infestantes nas parcelas com agricultura sintrópica: _______dias
30. Quanto tempo ocupa por dia/por intervenção no controlo de infestantes nas parcelas com agricultura sintrópica: _______horas
31. Verifica diferença na necessidade de intervenção relativamente às plantas infestantes nas parcelas com agricultura sintrópica com o passar do tempo/anos:

☐ Não tem diferença
☐ Requer mais controlo
☐ Requer menos controlo

32. Verifica diferença na necessidade de controlo de infestantes nos canteiros com as linhas de árvores, comparativamente com os outros canteiros:

☐ Não tem diferença
☐ Requer mais controlo
☐ Requer menos controlo

33. Qual a **percepção** acerca da necessidade de controlar as infestantes nas parcelas com agricultura sintrópica mais antigas comparativamente com o sist)
anterior ou <u>outro</u>* (para áreas equivalentes)



☐	> +100%: _________ %	☐	Idêntico (0%)
☐	O dobro (100%)	☐	-25%
☐	+75%	☐	metade (-50%)
☐	+50%	☐	-75%
☐	+25%	☐	Já não ocorre (-100%)

*____

------------------------- **FITOSSANIDADE** -------------------------

34. Qual a praga/doença e respetiva cultura mais frequente/mais difícil de combater que afetou as parcelas com agricultura sintrópica:

____

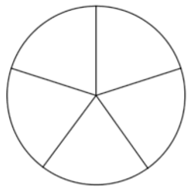
35. Métodos utilizados para combater as pragas/doenças nas parcelas com agricultura sintrópica:

- [ ] Não usa nenhum método de combate
- [ ] Químico sintético
- [ ] Químico "natural"
- [ ] Biológico
- [ ] Mecânico/Manual
- [ ] Outra: ______________________

36. Verifica diferença da necessidade de combater as pragas/doenças nas parcelas com agricultura sintrópica com o passar do tempo/anos: S/N

- [ ] Não tem diferença
- [ ] Necessita de mais intervenção
- [ ] Necessita de menos intervenção

37. Qual a **percepção** acerca da presença de pragas e/ou doenças nas parcelas com agricultura sintrópica mais antigas comparativamente com o sist[illegible]o anterior ou <u>outro</u>* (para áreas equivalentes)



[ ]	> +100%: _________ %	[ ]	Idêntico (0%)
[ ]	O dobro (100%)	[ ]	-25%
[ ]	+75%	[ ]	metade (-50%)
[ ]	+50%	[ ]	-75%
[ ]	+25%	[ ]	Já não ocorre (-100%)

*____

38. Utiliza algum tipo de maquina/mecanização no controlo de pragas e/ou doenças: S/N
39. Existe alguma área da exploração reservada para produção de plantas utilizadas no controlo de inimigos das culturas: S/N
    39.1. Fica localizada dentro das parcelas com agricultura sintropica: S/N
40. Existe alguma área da exploração reservada/protegida para manutenção dos auxiliares: S/N
41. Existem/constrói abrigos/estruturas ecológicas/colmeias para proteção dos auxiliares/fauna local: S/N
42. Não existe/já existia/construiu algum lago ou pequena barragem próximo nas parcelas com agricultura sintrópica: S/N

------------------------- FERTILIZAÇÂO -------------------------

43. Utilizou cal (ou <u>outro</u>* corretivo mineral) na <u>implementação</u> de um sistema de agricultura sintrópica: S/N *____
44. Utiliza cal (ou <u>outro</u>* corretivo mineral) na <u>manutenção</u> de um sistema de agricultura sintrópica: S/N *____

44.1. Com que frequência:________________________

45. Qual/Quais os tipos de fertilizantes (adubos e/ou corretivos) utilizados na <u>implementação</u> de um sistema de agricultura sintrópica:

- [ ] Não utilizou
- [ ] Sintético: ____________________________________
- [ ] Mineral de origem natural: _______________________
- [ ] Composto
- [ ] Estrume de origem animal: _______________________
- [ ] Sideração:____________________________________
- [ ] Outro: ______________________________________

45.1. Usou biofertilizantes na implementação? S/N

Qual:____

46. Qual/Quais os tipos de fertilizantes (adubos e/ou corretivos) utilizados na <u>manutenção</u> de um sistema de agricultura sintrópica durante os primeiros anos:

- [ ] Não utiliza
- [ ] Sintético: ____________________________________
- [ ] Mineral de origem natural: _______________________
- [ ] Compostagem
- [ ] Estrume de origem animal: _______________________
- [ ] Sideração:____________________________________
- [ ] Outro: _______________________________________

46.1. Usou biofertilizantes na implementação? S/N

Qual:____

47. Utiliza algum fertilizante com origem na própria exploração: S/N

47.1. Qual/Quais:______________________________________

47.2. Qual a percentagem dos fertilizantes usados com origem na própria exploração: _________%

48. Utiliza alguma cultura com o único objectivo de produzir matéria orgânica entre as linhas de árvores nas parcelas com AS: S/N
Qual:____

49. Utiliza alguma cultura com o único objectivo de produzir matéria orgânica fora das parcelas com AS: S/N
Qual:____

50. Com que frequência aplica adubo durante o primeiro ano nas parcelas com agricultura sintrópica:________________

51. Com que frequência aplica adubo após o primeiro ano nas parcelas com agricultura sintrópica:________________

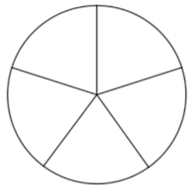
52. Verifica diferença da necessidade de aplicar adubo nas parcelas com agricultura sintrópica com o passar do tempo/anos: S/N

- [ ] Não tem diferença
- [ ] Necessita de mais fertilização

☐ Necessita de menos fertilização

53. Qual a **percepção** acerca da necessidade de fertilização nas parcelas com agricultura sintrópica mais antigas comparativamente com o sistemas de produção anterior ou <u>outro</u>* (para áreas equivalentes)

☐	> +100%: _________ %	☐	Idêntico (0%)
☐	O dobro (100%)	☐	-25%
☐	+75%	☐	metade (-50%)
☐	+50%	☐	-75%
☐	+25%	☐	Já não ocorre (-100%)



*____

54. Utiliza algum tipo de maquina/mecanização na aplicação de fertilizantes: S/N

------------------------- COMPOSIÇÃO E ESTRUTURA -------------------------

55. Segue algum tipo de esquema de rotação anual das culturas nos diferentes canteiros: S/N
    55.1. Fixo ou aleatório:____________________________
56. Dê exemplos de consociações de plantas que tenha obtido resultados positivos:

____
____
____

57. Dê exemplos de consociações de plantas que tenha obtido resultados negativos:

____
____
____

------------------------- ANÁLISE SOCIO/ECONÓMICA -------------------------

58. Tem algum tipo de mecanização na colheita dos produtos produzidos nas parcelas de agricultura sintrópica: S/N?
59. Qual/Quais os principais canais de escoamento dos produtos produzidos nas parcelas de agricultura sintrópica:

- ☐ Venda/Entrega de cabazes
- ☐ Venda direta ao consumidor na própria exploração
- ☐ Mercados locais
- ☐ Pequenas lojas urbanas
- ☐ Grandes superfícies comerciais
- ☐ Outro:____________________________

60. Qual a distancia da exploração ao ponto de venda mais distante: _________ km
61. Acha que seus consumidores conhecem a Agricultura Sintrópica: S/N

62. Sente que os seus consumidores apoiam/apoiariam a Agricultura Sintrópica: S/N

63. Porquê optou por Agricultura Sintropica:

____

64. Tem planos para iniciar novas parcelas com agricultura sintrópica: S/N
65. Está satisfeito com os resultados obtidos nas parcelas com agricultura sintrópica: S/N
66. Pretende manter a agricultura sintrópica: S/N
67. A agricultura sintrópica neste momento geral resultados económicos positivos na sua exploração: S/N
    67.1. Porque motivo não é rentável:

____

68. Considera a agricultura sintrópica rentável:

☐	A curto prazo (1-2 anos)
☐	A médio prazo (5 anos)
☐	A longo prazo (10 anos)
☐	Não rentável

69. Outro tipo de rendimento associado à AS:

☐	Workshops
☐	Consultadoria
☐	Outro:____

70. Nome do responsável:____
71. Idade do responsável:____
72. Tem alguma experiência prévia com agricultura sintrópica: S/N
    72.1. Anos de experiência:_____________________________
73. Qual a formação do responsável?
    73.1. Tem alguma formação em agronomia?
74. Tem alguma experiência em agricultura prévia à AS?
    74.1. Anos de experiência:_____________________________
75. Como teve conhecimento da agricultura sintrópica:

____

76. Qual a ligação a Ernst Gotsch:____
77. Que nome atribui ao tipo de agricultura praticado:_____________________________

78. Considerações adicionais:

Muito obrigado pela sua participação!

Anexo 5: Palestrantes e moderadores do I Encontro de SAFS – Notas bibliográficas

Sessão de abertura:

Oradores:

João Noronha

João Freire de Noronha é Professor na Escola Superior Agrária do Politécnico de Coimbra onde, desde 2014, exerce o cargo de Presidente. Licenciado em Bioquímica pela Universidade de Coimbra (1990) é Doutor em Ciências Biológicas Aplicadas pela Universidade Católica de Leuven, Bélgica (1996). Trabalhou na empresa Campden & Chorleywood Food and Drink Research Association onde atualizou o software de avaliação de Processos térmicos (CTemp) e realizou trabalho de consultoria na avaliação de processos térmicos. No Centro de Tecnologia Alimentar da AESBUC coordenou vários trabalhos de consultoria em empresas agroalimentares. Na ESAC tem lecionado unidade curriculares nas áreas da segurança alimentar, tecnologia alimentar, gestão da qualidade, análise sensorial de alimentos, entre outras. Liderou e participou em vários projetos de investigação aplicada.

Vanda Batista

Diretora Regional Adjunta da Direção Regional de Agricultura e Pescas do Centro. Mestre em Engenharia Agronómica pela Universidade de Trás-os-Montes e Alto Douro. Especialista na área da fitossanidade e qualidade alimentar, tendo exercício funções na Estação de Avisos do Dão como Inspetora Fitossanitária e Certificadora Oficial no âmbito de processos de importação e exportação de géneros alimentícios de origem não animal. As suas principais áreas de interesse e experimentação relacionam-se com os inimigos das culturas, nomeadamente, com os organismos de quarentena e aplicação de metodologias de previsão e controlo, integrados em modelos de produção sustentáveis.

Sessão 1

Moderador:

Pedro Mendes Moreira

Professor Adjunto no IPC-ESAC e Investigador na Unidade I&D CERNAS. Doutorado na Área Científica das Ciências Agrárias – Genética Quantitativa pelo ITQB/UNL Licenciado em Engenharia Agronómica e Mestre em Agricultura e Horticultura Sustentáveis, ambas pelo Instituto Superior de Agronomia, Lisboa. É Coordenador do Mestrado em Agricultura Biológica do IPC-ESAC. Tem vindo a ser responsável pelo IPC em inúmeros projetos europeus (e.g. SOLIBAM FP7, DIVERSIFOOD e LIVESEED ambos H2020) e nacionais (FCT e PDR2020). É atualmente o responsável (Chair) da secção da EUCARPIA de Melhoramento de plantas em Agricultura Biológica e Baixo Consumo de Fatores Externos e Membro da Eco-PB. Tem como interesse de investigação científica a produção de sementes em Agricultura Biológica e Agroecológica, Melhoramento Participativo de Milho (iniciado no anos 1980) e Estratégias de gestão e valorização dos Recursos Genéticos onde o trabalho dos SAFS se insere. Tem mais de 20 publicações ISI e mais de 180 comunicações orais e painéis em congressos nacionais e internacionais.

Oradores:

Ambrogio Costanzo

Principal crops researcher at Organic Research Centre (UK) since 2016, and since 2020 deputy head of research. Specialising in crop diversification, his main area of work is integrating breeding and agronomy through participatory approaches. PhD in Agrobiosciences at Sant'Anna School of Advanced Studies in Pisa (Italy). His research career started with an action-research project on agroforestry systems with local communities in Mali, as part of his master degree, which is was presented in I Encontro de SAFS.

Ricardo Leitão

Biólogo e Farmacêutico. Especialista em Agricultura Biológica e Mestre em Ecologia. É Investigador do Centro de Ecologia Funcional (CFE) do Departamento de Ciências da Vida - Universidade de Coimbra. Atualmente está a trabalhar em Sistemas Agroflorestais Sucessivos no clima de transição Atlântico-Mediterrâneo e a terminar o Mestrado em Agricultura Biológica, na Escola Superior de Agricultura de Coimbra, Portugal.

Luís Cunha

Licenciado em Biologia pela Universidade dos Açores (2005), com mestrado em Biologia de invertebrados pela Bangor University (2006) e doutoramento em Biologia Celular e Molecular pela Universidade dos Açores (2012). Atualmente, ele trabalha como investigador no Centro de Ecologia Funcional (Universidade de Coimbra). A sua investigação concentra-se no estudo da biodiversidade e no funcionamento do ecossistema, com foco no uso de ferramentas moleculares.

Pedro Bingre do Amaral

Pedro Bingre do Amaral (n. 1973), professor adjunto do Instituto Politécnico de Coimbra, é licenciado em Engenharia Florestal, mestre em Planeamento Regional e Urbano pela Universidade Técnica de Lisboa e especialista em Urbanismo. Leciona e investiga nas temáticas do Ambiente, Conservação da Natureza e Ordenamento do Território. Foi autor de diversos artigos, livros e capítulos de livros sobre os temas como a botânica, o ordenamento urbano e florestal, e a conservação da biodiversidade. Além disso, é coautor de diversos instrumentos de gestão territorial do território português (planos diretores municipais, planos de pormenor, planos de gestão florestal, planos sectoriais, &c)

Sessão 2

Moderador:

Rosa Guilherme

Técnica superior da Direção Regional de Agricultura e Pescas do Centro na Divisão de apoio à agricultura e pescas. Licenciada em Engenharia Agropecuária pela Escola Superior Agrária de Coimbra. Mestre em Ecologia pela Faculdade de Ciências e Tecnologia da Universidade de Coimbra. Doutora em Tecnologias Agroindustriais pela Faculdade de Ciências da Universidade Nova de Lisboa. Especialista na área de produção agrícola e animal. As suas principais áreas de interesse e investigação relacionam-se com os sistemas de produção sustentáveis, destacando-se a agricultura biológica, a agroecologia, os sistemas alimentares locais e os circuitos curtos agroalimentares

Oradores:

Daniela Santos

Licenciada e Doutorada em Engenharia Agronómica pelo Instituto Superior de Agronomia, docente na ESAC desde 1998 e responsável pela área de Solos e Fertilidade desde 2012. Na investigação tem participado de projetos nacionais e europeus no âmbito dos sistemas de Agricultura Sustentável (Agricultura Biológica e Agricultura de Conservação – tradicional e de baixos inputs), bem como na avaliação da sustentabilidade de sistemas agrícolas. É a responsável da ESAC nos projetos nacionais de Agricultura Sustentável do grupo Jerónimo Martins, de Agricultura Biológica na Madeira (projeto Probiomadeira) e de produção de compostos e substratos orgânicos a partir da invasora jacinto d’água (projeto Biocomp).

ANEXO 5

José Gaspar

José Gaspar é doutorado em Ciências Aplicadas ao Ambiente em 2005 pela Universidade de Aveiro (2005), Mestrado em Environmental Remote Sensing pela University of Aberdeen (1995) e Licenciado em Engenharia Florestal pela Universidade de Trás-os-Montes e Alto Douro (1990). É Professor Coordenador (2016) na Escola Superior Agrária do Instituto Politécnico de Coimbra (onde leciona desde 1990) e Investigador no Centro de Ecologia Funcional. Desenvolve a sua atividade docente na área das Ciências Florestais, e nas áreas das Ciências da Terra e do Ambiente. No seu currículo Ciência Vitae os termos mais frequentes na contextualização da investigação e da produção técnico-científica, são: Fogo Controlado; Inventário Florestal; Planeamento do Uso do Solo; Sistemas de Informação Geográfica, e Deteção Remota. Foi Vice-Presidente da Escola Superior Agrária entre 2007 e 2008, Presidente da mesma Escola entre 2010 e 2014, e é Vice-Presidente do IPC desde 2017 até ao momento. Para além destas funções mantem uma ligação continuada ao movimento associativo florestal através da participação na direção de uma OPF (APFAM), e na direção da FORESTIS-Associação Florestal de Portugal.

Isabel Dinis

Professora Coordenadora no Instituto Politécnico de Coimbra - Escola Superior Agrária. É licenciada em Agronomia, mestre em Economia Agrária e Sociologia Rural e doutorada em Economia, com especialização na área da Economia do Ambiente e dos Recursos Naturais. As suas principais áreas de ensino e de investigação relacionam-se com a Economia Agrária e a Economia dos Recursos Naturais, focando-se em particular nos sistemas alimentares sustentáveis.

Denis Hickel

Agricultor, farm designer e consultor em agrofloresta, "Market Garden" e design ecológico. Em 2010 recebeu uma bolsa da FCT (Portugal) para desenvolver um projeto de doutoramento em Design e Ecologia nas Escolas do Município de Torres Novas, Portugal, integrando o Centro de Investigação em Arquitectura, Urbanismo e Design (CIAUD) da Universidade Técnica de Lisboa e com o apoio do Centro de Estudos de Desenho Natural da Universidade de Dundee. Em 2011 e durante o doutoramento, fundou a Quinta do Alecrim, em Alcorochel, Portugal, uma experiência em curso envolvendo agricultura e habitação ecológicas, design e literacia ecológica. O objetivo é traduzir as lições aprendidas no trabalho local com a agricultura ecológica para os sistemas humanos e a paisagem natural. Atualmente está a iniciar um novo projeto agrícola em maior escala, a Quinta da Rainha, também na região de Torres Novas.

Sessão 3

Moderador:

Jaime Capitão

Engenheiro Agrónomo com especialização em Agroindústrias pelo Instituto Superior de Agronomia (ISA) em 1994. Pós graduado em Gestão Financeira pela Escola Superior de Tecnologia e Gestão de Portalegre – Instituto Politécnico de Portalegre em 2004. Mestre em Engenharia Alimentar pelo Instituto Superior de Agronomia (ISA), em 2015. Foi Diretor Regional Adjunto de Agricultura e Pescas na Direção Regional de Lisboa e Vale do Tejo do Ministério da Agricultura de Portugal. Foi também Perito de Qualidade e Segurança da Produção Agrícola da Confederação dos Agricultores de Portugal (CAP) de 1999 até 2011 e Vice-Presidente do grupo para a promoção dos produtos agrícolas e COPA (Committee of Professional Agricultural Organisations) em Bruxelas de 2005 a 2011. Desenvolveu também atividades na área de formação e consultoria de higiene e segurança alimentar bem como na elaboração de projetos de Engenharia e soluções de refrigeração comercial. Atualmente é doutorando em Ciências da Sustentabilidade pela Universidade de Lisboa e Consultor.

Oradores:

Sara Magalhães

Professora Associado da Universidade de Lisboa e trabalho na intersecção entre Ecologia e Evolução, principalmente usando ácaros herbívoros como modelo de investigação. Abordo tópicos como seleção sexual, competição ou a interação com simbiontes bacterianos. Gosto de projetar experimentos fortemente enraizados em previsões teóricas e trabalhar com alunos motivados. Atualmente, estou executando uma bolsa ERC para compreender o papel da variação individual e feedbacks eco-evolutivos no resultado da competição entre os ácaros. Tem um papel ativo nas sociedades, em particular na ESEB onde fui vice-presidente (2019-2021) e pertenço ao Conselho Editorial da Oikos e do The American Naturalist. Também se dedica a aproximar a ciência da sociedade. Em particular, lançou a Caravana Agroecológica em 2019, uma série de iniciativas que visam construir pontes entre pesquisadores, produtores e consumidores comprometidos com a agricultura sustentável.

Pedro Nogueira

Pedro Nogueira é natural de Seia. Arquiteto paisagista pela Faculdade de Ciências da Universidade do Porto, do seu percurso profissional destaca-se a colaboração com o Centro Nacional de Cultura e a Fundação de Serralves, em projetos de divulgação e promoção de literacia científica. Atualmente é colaborador da Associação Terra Sintrópica e coordenador do Centro de Agroecologia de Mértola / Horta da Malhadinha.

Helena Freitas

Helena Freitas é bióloga, doutorada em Ecologia e tem um pós-doutoramento na Universidade de Stanford, nos EUA, tendo construído uma sólida carreira ligada à Academia, na investigação, docência e liderança de projetos, e à causa pública, onde exerceu funções parlamentares e governativas, tendo coordenado a Unidade de Missão para a Valorização do Interior. Atualmente é Professora Catedrática na área da Biodiversidade e Ecologia no Departamento de Ciências da Vida da Faculdade de Ciências e Tecnologia da Universidade de Coimbra e é detentora da Cátedra Unesco em Biodiversidade e Conservação para o Desenvolvimento Sustentável, na mesma universidade. É ainda Coordenadora da unidade de investigação Centre for Functional Ecology – science for people and the planet e coordenadora científica do FitoLab – Laboratório de Fitossanidade do Instituto Pedro Nunes. Em Julho de 2019 foi selecionada para o Mission Board for Climate Change Adaptation, including Societal Transformation da Comissão Europeia, Programa Horizonte Europa, e em Agosto de 2019 foi nomeada Ponto Focal de Portugal para o IPBES – Intergovernmental Platform for Biodiversity and Ecosystem Services (ONU).

Maria Custodia Correia

Licenciada em Engenharia Agrícola pela Universidade de Évora. Detentora do Grau de Mestre em Produção Vegetal, pela Universidade Técnica de Lisboa – Instituto Superior de Agronomia. Coordenadora Nacional da Rede Rural Nacional, estrutura de ligação entre agentes com papel ativo no desenvolvimento rural e plataforma de divulgação e partilha de informação, de experiência e de conhecimento. Colabora com a Parceria Europeia de Inovação para a Produtividade e Sustentabilidade Agrícolas (European

Innovation Partnership Agricultural Productivity and Sustainability - EIP-AGRI), promovendo a participação dos seus membros no desenvolvimento de atividades em prol do desenvolvimento rural e da inovação na agricultura. Nas suas funções de Chefe de Divisão de Diversificação Agrícola, Formação e Associativismo, da Direcção-Geral de Agricultura e Desenvolvimento Rural:

- participa e contribuí na definição de medidas de apoio ao desenvolvimento rural;
- assegura a coordenação da formação técnica setorial do Ministério da Agricultura, em articulação como os organismos centrais e regionais;
- e atualmente colabora na implementação do Plano de Recuperação e Resiliência, ao nível dos apoios no âmbito da Agenda de inovação “Terra Futura”, do Ministério da Agricultura.

<u>Eduardo Diniz</u>

Licenciatura em Engenharia Agronómica, especialidade Economia Agrária e Sociologia Rural, Instituto Superior de Agronomia, Universidade Técnica de Lisboa. Diretor Geral do Gabinete de Planeamento e Políticas e Administração Geral (GPP) do Ministério da Agricultura do Ministério do Mar desde 2012. Exerceu diversos cargos na área coordenação técnica das atividades do ministério de âmbito estratégico, das relações internacionais bem como, as funções de coordenador do programa orçamental. Longa experiência no acompanhamento das questões comunitárias e multilaterais, nomeadamente na negociação, coordenação técnica e avaliação das regras da Política Agrícola Comum, conceção do Programa de Desenvolvimento Rural, e acompanhamento dos mercados agroalimentares e da Presidência portuguesa da UE de 2021 na área da agricultura.

Sessão 4

<u>Moderador:</u>

<u>Ricardo Leitão</u>

<u>Oradores:</u>

<u>Tânia Carvalho</u>

Agricultora, fundadora do 2Lugar da Terra” juntamente com o Job seu marido, uma pequena quinta periurbana no concelho de Torres Vedras cujo principal foco é a venda de hortícolas com a entrega semanal de cabazes. A Tânia Carvalho é nutricionista e tem já uma experiência com cerca de 10 anos em SAFS. De referir que a Tânia e o Job são agricultores a tempo inteiro e que vivem sem rede, sem qualquer tipo de subsídios pela pequena escala que têm. Coragem não lhes falta.

Marc Leiber

Agricultor, fundador da Quinta das Abelhas em Montemor-o-Novo. É alemão, agrónomo e é um aluno direto do Ernst Götsch. Já passou várias temporadas na famosa fazenda do Ernst no Brasil e de momento esta a desenvolver um projeto pioneiro de SAFS em contexto de Montado

João Mendes Ferreira

Licenciado em Engenharia Biológica e Mestrado em Processos Químicos e Biológicos pelo Instituto Superior de Engenharia de Coimbra. Responsável da Área de Bioprocessos do Departamento de Investigação e Desenvolvimento da Mendes Gonçalves S.A. desde 2015 acompanha desde o início (2019) do Projeto Vila Feliz Cidade (Mendes Gonçalves) onde se insere a parte agrícola de agroflorestas regenerativas da Mendes Gonçalves S.A..

Ricardo Meireles

Fotojornalista de profissão e agricultor no restante tempo disponível. Foi produtor de aromáticas em modo de produção biológico e recentemente enveredou pelos SAFS, atualmente numa fase experimental. É o fundador da Quinta da Manguela em Santo Tirso e tem dos SAFS mais antigos em pleno funcionamento em Portugal.

Walter Santes

Eng. Agrónomo e agricultor. Mestre em agricultura biológica, com mais de 20 anos de experiência em agrofloresta e SAFS no Brasil. Já acumula alguns anos de pratica em Portugal onde exerce a profissão de consultor estando atualmente a desenvolver o seus trabalhos na herdade da Preguiça Ativa, uma herdade com mais de 400 ha na região de Évora.

António Coelho

Agricultor. Atualmente é o agricultor residente na Horta da malhadinha, em Mértola e responsável pela parte a agrícola do centro de agroecologia de Mértola Está por isso diretamente ligado à Associação Terra Sintrópica e à Rede Alimentar de Mértola.

Começou a sua carreira na produção de aromáticas em modo de produção biológico, passou pelas hortícolas também em modo de produção biológico e atualmente o seu foco é a produção de hortícolas nos SAFS, também com certificação biológica.

Sessão de encerramento

Moderador:

Pedro Mendes Moreira

Oradores

Leonardo Collier

Mestre em Ciência do Solo, Doutorado em Solos e Nutrição de Plantas, atuo na área de Pedologia e Manejo (no Brasil escrevemos assim) da fertilidade do Solo em Agroecossistemas na UFG. Atualmente licenciado trabalho como especialista de produção no Solo no Food4Sustainability.

Joana Amaral Paulo

Licenciada em Engenharia Florestal e um mestre em Estatística._Doutorada em Eng. Florestal e dos Recursos Naturais, é professora do Instituto Superior de Agronomia nas temáticas de Matemática e Estatística e dos sistemas agroflorestais, produtos florestais não lenhosos e modelação de recursos naturais.. Desde janeiro de 2017 coordena o projeto Europeu AFINET dedicado à transferência e disseminação de conhecimento sobre práticas agroflorestais e inovação. Coordena também o projeto nacional da FCT Corkneighbors: "Compreender a interação entre os sobreiros e a vegetação do seu bairro" e o projeto Incredible FP7 dedicado à transferência e divulgação de conhecimento sobre gestão de produtos florestais não madeireiros e cadeia de valor. É membro fundador e delegado nacional por Portugal da Federação Agroflorestal Europeia (EURAF) desde 2011, secretária entre 2016 e 2018 e presentemente delegado nacional por Portugal.

Jorge Cancela

É Arquiteto Paisagista, Mestre em Gestão Ambiental pelo Imperial College, Reino Unido e Doutorado em Urbanismo pela Faculdade de Arquitetura da Universidade de Lisboa, Portugal. Diretor Técnico de um dos mais conceituados gabinetes de arquitetura paisagista (Biodesign, Lda.), de 1991 a 2015, foi distinguido com vários prémios nacionais e internacionais. Professor Auxiliar de Arquitetura Paisagista/Design

Urbano/Planeamento Urbano Os interesses de pesquisa incluem planeamento, restauração, design e gestão da paisagem; eco-agricultura e permacultura; planeamento urbano, agricultura urbana, corredores azuis e verdes; avaliações de impacto ambiental; conservação da natureza e áreas protegidas. É também agricultor biológico e gestor de paisagens rurais. Passa boa parte do tempo entre organizar papéis e carregar estrume.

Anexo 6: Tabela de espécies

ANEXO 6

Tabela 2. Espécies identificadas durante os trabalhos de recolha de informação. Estes espécies dizem respeito à biodiversidade planeada pelo agricultores pelo que foram todas elas colocadas propositadamente nos campos de SAFS pelos agricultores. A identificação foi feita exclusivamente com recurso à informação fornecida pelos agricultores. (Function: A – acorn, A/M/S – aromatic/medicinal/condimental, Be – berries, C/A – cork/acorn, F – fruit, MF - multifunction , MG – market garden, N – nut; Type: C – climber, H – herbaceous, S – shrub, T – tree; Life cycle: A – annual, B – biannual, P –perennial; Leaf: D – deciduous, E – evergreen; n.a. – not applicable)

Nº	Species	Family	Common Name (english)	Common Name (portuguese)	Function	Type	Life cycle	Autochthonous	Woody	Leaf	N fixing	Farm 1			Farm 2	Farm 3	Farm 4		Farm 5				Farm 6				Farm 7			Farm 8			Farm 9	Nº fields/ specie	Nº farms/ specie
												1	2	3	1	1	1	2	1	2	3	4	1	2	3	4	1	2	3	1	2	3	1		
1	*Abelmoschus esculentus*	Malvaceae	Okra	Quiabo	MG	H	A	n	n	n.a.	n																						x	1	1
2	*Acca sellowiana*	Myrtaceae	Pineapple guava	Feijoa	F	T	P	n	y	E	n					x																		1	1
3	*Acer spp..*	Aceraceae	Maple	Bordo	MF	T	P	n	y	D	n						x																	1	1
4	*Achillea millefolium*	Asteraceae	Yarrow	Milefólio	MF	H	P	y	n	E	n																						x	1	1
5	*Actinidia deliciosa*	Actinidiaceae	Kiwifruit vine	Kiwi	F	C	P	n	y	D	n																						x	1	1
6	*Aesculus hippocastanum*	Sapindaceae	Horse chestnut tree	Castanheiro-da-Índia	N	T	P	n	y	D	n																x							1	1
7	*Ailanthus altissima*	Simaroubaceae	Tree of heaven	Espanta-lobos	MF	T	P	n	y	D	n						x																	1	1
8	*Albizia lebbeck*	Fabaceae	Lebbeck	Albízia	MF	T	P	n	y	D	y					x	x																	2	2
9	*Allium ampeloprasum*	Amaryllidaceae	Leek	Alho-francês	MG	H	A	n	n	n.a.	n			x	x	x	x	x	x		x	x											x	9	6
10	*Allium cepa*	Amaryllidaceae	Onion	Cebola	MG	H	A	n	n	n.a.	n				x	x			x		x	x		x		x	x	x	x					10	5
11	*Allium sativum*	Amaryllidaceae	Garlic	Alho	MG	H	A	n	n	n.a.	n			x		x			x		x	x				x	x	x						8	4
12	*Alnus cordata*	Betulaceae	Italian alder	Amieiro-de-Nápoles	MF	T	P	n	y	D	n					x																		1	1
13	*Alnus glutinosa*	Betulaceae	Common alder	Amieiro	MF	T	P	y	y	D	y					x					x	x				x				x	x		x	7	5
14	*Aloe vera*	Asphodelaceae	Aloe	Aloé	A/M/S	H	P	n	n	E	n						x																x	2	2
15	*Aloysia citrodora*	Verbenaceae	Lemon verbena	Lucia-lima	A/M/S	S	P	n	y	D	n			x	x		x														x			4	4
16	*Annona reticulata*	Annonaceae	Custard apple	Anoneira	F	T	P	n	y	D	n					x	x																x	3	3
17	*Apium graveolens*	Apiaceae	Celery	Aipo	A/M/S	H	B	n	n	E	n																						x	1	1
18	*Arachis hypogaea*	Fabaceae	Peanut	Amendoim	MG	H	A	n	n	n.a.	y					x																		1	1
19	*Arbutus unedo*	Ericaceae	Strawberry tree	Medronheiro	Be	S	P	y	y	E	n	x	x		x		x						x			x		x		x	x	x	x	11	7
20	*Artemisia vulgare*	Asteraceae	Mugwort	Artemísia	A/M/S	H	P	y	n	E	n																						x	1	1
21	*Asparagus officinalis*	Asparagaceae	Asparagus	Espargo	MG	H	A	n	n	n.a.	n						x									x		x						3	3
22	*Atriplex halimus*	Chenopodiaceae	Mediterranean saltbush	Salgadeira	MF	S	P	y	y	E	n																						x	1	1
23	*Avena sativa*	Poaceae	Oat	Aveia comum	MF	H	A	n	n	n.a.	n		x	x			x		x	x										x	x			7	4
24	*Berberis vulgaris*	Berberidaceae	Common barberry	Uva-Espim	Be	S	P	n	y	E	n				x																			1	1
25	*Beta vulgaris*	Chenopodiaceae	Red beet	Beterraba	MG	H	A	y	n	n.a.	n	x		x	x	x		x	x		x	x			x		x							10	7
26	*Beta vulgaris var. cicla*	Chenopodiaceae	Chard	Acelga	MG	H	B	y	n	E	n			x		x			x		x	x		x		x					x		x	9	6
27	*Betula celtiberica*	Betulaceae	Birch	Bétula	MF	T	P	y	y	D	n														x	x								2	1
28	*Borago officinalis*	Boraginaceae	Borrage	Borragem	A/M/S	H	A	y	n	n.a.	n																x	x	x					3	1
29	*Brassica oleracea*	Brassicaceae	Cabbages*	Couve**	MG	H	P	n	n	E	n	x	x	x	x	x	x	x	x		x	x				x	x	x	x		x	x	x	17	9
30	*Brassica rapa*	Brassicaceae	Turnip	Nabo/Nabiça	MG	H	A	n	n	n.a.	n	x		x	x				x		x	x									x			7	4
31	*Buxus sempervirens*	Buxaceae	European box	Buxo	MF	S	P	y	y	E	n															x								1	1
32	*Calendula officinalis*	Asteraceae	Pot marigold	Calendula	MF	H	P	n	n	E	n																x		x				x	3	2
33	*Canna indica*	Cannaceae	Indian shot	Cana-índica	MG	H	P	n	n	E	n																						x	1	1
34	*Capsicum annuum*	Solanaceae	Bell pepper	Pimento	MG	H	A	n	n	n.a.	n			x	x	x		x	x		x	x			x	x	x							10	7
35	*Capsicum chinense*	Solanaceae	Chilly pepper	Malagueta	MG	H	A	n	n	n.a.	n		x			x			x		x	x					x						x	7	5
36	*Casimiroa edulis*	Rutaceae	White sapote	Sapota Branca	F	T	P	n	y	E	n																						x	1	1
37	*Castanea sativa*	Fagaceae	Sweet chestnut tree	Castanheiro	N	T	P	y	y	D	n		x		x		x						x				x	x	x					7	5
38	*Casuarina spp.*	Casuarinaceae	CoastSheoak	Casuarina	MF	T	P	n	y	E	y					x							x			x							x	4	3
39	*Celtis australis*	Cannabaceae	European nettle tree	Lodão-bastardo	MF	T	P	y	y	D	n						x																	1	1
40	*Ceratonia siliqua*	Fabaceae	Carob	Alfarrobeira	F	T	P	y	y	E	y					x											x						x	3	3

ANEXO 6

41	*Chamomilla recutita*	Asteraceae	Chamomile	Camomila	A/M/S	H	A	y	n	n.a.	n						x		x		x	x												4	2
42	*Citrullus lanatus*	Cucurbitaceae	Water melon	Melancia	MG	H	A	n	n	n.a.	n														x	x	x							3	2
43	*Citrus australasica*	Rutaceae	Australian finger lime	Limão-caviar	F	T	P	n	y	E	n															x								1	1
44	*Citrus japonica*	Rutaceae	Kumquat tree	Cumquat	F	T	P	n	y	E	n															x								1	1
45	*Citrus reticulata*	Rutaceae	Mandarin orange tree	Tangerineira	F	T	P	n	y	E	n			x			x																	2	2
46	*Citrus x aurantiifolia*	Rutaceae	Key lime tree	Lima	F	T	P	n	y	E	n															x								1	1
47	*Citrus x limon*	Rutaceae	Lemon tree	Limoeiro	F	T	P	n	y	E	n		x		x		x						x	x		x	x		x				x	9	6
48	*Citrus x sinensis*	Rutaceae	Orange tree	Laranjeira	F	T	P	n	y	E	n			x			x									x	x		x					5	4
49	*Coriandrum sativum*	Apiaceae	Coriander/Cilantro	Coentro	A/M/S	H	A	n	n	n.a.	n										x	x			x		x	x				x		6	4
50	*Corylus avellana*	Betulaceae	Common hazel	Aveleira	N	T	P	y	y	D	n				x	x	x		x						x	x								6	5
51	*Crataegus monogyna*	Rosaceae	Common hawthorn	Pilriteiro	MF	S	P	y	y	D	n																						x	1	1
52	*Cucumis melo*	Cucurbitaceae	Honey melon/Cantaloupe	Melão/Meloa	MG	H	A	n	n	n.a.	n															x	x							2	2
53	*Cucumis sativus*	Cucurbitaceae	Cucumber	Pepino	MG	H	A	n	n	n.a.	n					x			x		x	x					x							5	3
54	*Cucurbita pepo*	Cucurbitaceae	Pumpkin/Courgette	Abóbora/Courgete	MG	H	A	n	n	n.a.	n		x	x	x	x		x	x		x	x				x	x						x	11	7
55	*Cupressus lusitanica*	Cupressaceae	Teotlate	Cedro do Bussaco	MF	T	P	n	y	E	n					x										x								2	2
56	*Cupressus sempervirens*	Cupressaceae	Cypress tree	Cipreste	MF	T	P	n	y	E	n																x	x	x					3	1
57	*Cydonia oblonga*	Rosaceae	Quince tree	Marmeleiro	F	T	P	n	y	D	n					x							x								x		x	4	4
58	*Cymbopogon citratus*	Poaceae	West Indian lemon grass	Erva-príncipe	A/M/S	H	P	n	n	E	n		x				x																x	3	3
59	*Cynara cardunculus*	Asteraceae	Artichoke	Alcachofra	MG	H	P	n	n	E	n						x			x						x	x	x			x		x	7	4
60	*Cytisus proliferus*	Fabaceae	Tagaste/tree Lucerne	Árvore-luzerna	MF	T	P	n	y	E	y																x	x	x				x	4	2
61	*Cytisus striatus*	Fabaceae	Hairy-fruited broom	Giesta amarela	MF	S	P	y	y	E	y								x															1	1
62	*Dactylis glomerata*	Poaceae	Cock's-foot	Dactila	MF	H	P	y	n	E	n						x			x														2	2
63	*Daucus carota*	Apiaceae	Carrot	Cenoura	MG	H	A	n	n	n.a.	n	x			x	x								x										4	4
64	*Daucus muricatus*	Apiaceae	Wild carrot	Cenoura Brava	MF	H	B	y	n	E	n																x							1	1
65	*Diospyros kaki*	Ebenaceae	Oriental persimmon tree	Diospireiro	F	T	P	n	y	D	n				x	x	x		x											x	x			6	5
66	*Elaeagnus commutata*	Elaeagnaceae	Silverberry	Amora Prateada	MF	S	P	n	y	E	n					x																		1	1
67	*Eleagnus umbellata*	Elaeagnaceae	Japanese silverberry	Baga Japonesa	Be	S	P	n	y	D	n															x								1	1
68	*Eriobotrya japonica*	Rosaceae	Loquat	Nespereira	F	T	P	n	y	E	n						x										x			x	x		x	5	4
69	*Eruca sativa/vesicaria*	Brassicaceae	Argula	Rúcula	MG	H	A	y	n	n.a.	n			x		x			x		x	x		x			x					x		8	6
70	*Eucalyptus globulus*	Myrtaceae	Southern blue gum	Eucalipto	MF	T	P	n	y	E	n			x			x		x	x	x	x	x		x		x	x	x					11	5
71	*Eucalyptus urofolia*	Myrtaceae	Timor white gum	Eucalipto-timorense	MF	T	P	n	y	E	n						x																	1	1
72	*Eugenia uniflora*	Myrtaceae	Pitanga	Pitanga	Be	S	P	n	n	E	n															x								1	1
73	*Festuca arundinacea*	Poaceae	Tall fescue	Festuca-alta	MF	H	P	y	n	E	n									x														1	1
74	*Ficus carica*	Moraceae	Fig tree	Figueira	F	T	P	n	y	D	n		x	x		x	x	x	x		x		x		x		x		x	x	x	x	x	15	8
75	*Foeniculum vulgare*	Apiaceae	Bulb Fennel	Funcho	A/M/S	H	A	y	n	n.a.	n		x						x		x	x				x	x					x		7	5
76	*Foeniculum vulgare (Wild*	Apiaceae	Fennel	Funcho selvagem	MF	H	A	y	n	n.a.	n																x	x	x					3	1
77	*Fragaria spp.*	Rosaceae	Strawberries	Morangueiro	Be	H	P	n	n	E	n			x	x		x							x	x	x								6	4
78	*Fraxinus angustifolia*	Oleaceae	Narrow leaved ash	Freixo	MF	T	P	y	y	D	n				x		x	x			x	x		x			x	x	x			x	x	11	7
79	*Ginkgo biloba*	Ginkgoaceae	Maidenhair tree	Ginkgo biloba	MF	T	P	n	y	D	n																						x	1	1
80	*Gleditsia triacanthos*	Fabaceae	Honey locust	Espinheiro-da-Virgínia	MF	T	P	n	y	D	y						x																	1	1
81	*Gomphrena globosa*	Amaranthaceae	Globe amaranth	Perpetua roxa	A/M/S	H	A	n	n	n.a.	n		x																					1	1
82	*Helianthus annuus*	Asteraceae	Sunflower	Girassol	MF	H	A	n	n	n.a.	n	x		x			x											x					x	5	4
83	*Helianthus tuberosus*	Asteraceae	Jerusalem artichoke	Tupinambo	MG	H	P	n	n	E	n				x																			1	1
84	*Hippophae rhamnoides*	Elaeagnaceae	Sea buckthorn	Espinheiro-marítimo	F	T	P	n	y	E	n															x								1	1
85	*Hordeum vulgare*	Poaceae	Barley	Cevada	MF	H	A	n	n	n.a.	n									x														1	1
86	*Hydrangea macrophylla*	Hydrangeaceae	Bigleaf hydrangea	Hortensia	MF	S	P	n	n	D	n		x																					1	1
87	*Ipomoea batatas*	Convolvulaceae	Sweet potato	Batata-doce	MG	H	A	n	n	n.a.	n			x		x																	x	3	3
88	*Jacaranda mimosifolia*	Bignoniaceae	Jacarandá	Jacarandá-mimoso	MF	S	P	n	y	E	n															x	x							2	2
89	*Juglans regia*	Juglandaceae	Walnut tree	Nogueira	N	T	P	n	y	D	n				x		x		x			x					x		x					6	4
90	*Lantana spp.*	Verbenaceae	Lantana	Lantana	MF	S	P	n	y	E	n						x																	1	1
91	*Lattuca sativa*	Asteraceae	Lettuce	Alface	MG	H	A	n	n	n.a.	n	x		x	x	x		x	x		x	x					x		x					10	6
92	*Laurus nobilis*	Lauraceae	Bay tree	Loureiro	MF	T	P	y	y	E	n		x		x		x										x							4	4
93	*Lavandula angustifolia*	Lamiaceae	English lavender	Lavanda	A/M/S	S	P	n	y	E	n						x													x	x		x	4	3
94	*Lavandula stoechas*	Lamiaceae	Spanish Lavender	Rosmaninho	A/M/S	S	P	y	y	E	n																				x			1	1
95	*Ligustrum lucidum*	Oleaceae	Broad-leaf privet	Ligustro	MF	T	P	n	y	E	n						x																	1	1

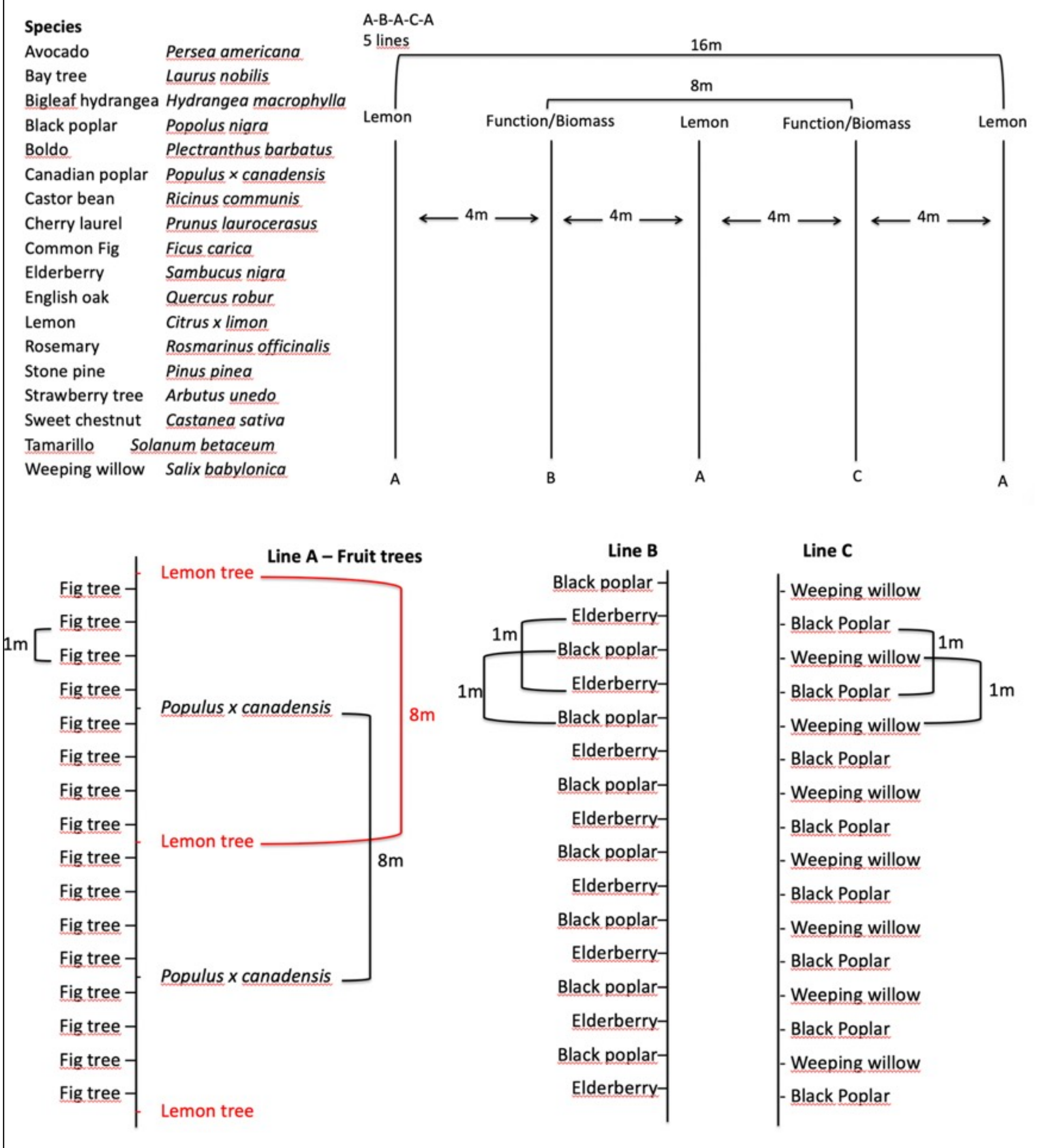
96	*Liquidambar styraciflua*	Altingiaceae	American sweetgum	Liquidâmbar	MF	T	P	n	y	E	n															x									1	1
97	*Lolium multiflorum*	Poaceae	Ryegrass	Azevém-anual	MF	H	A	y	n	n.a.	n						x			x								x						3	3
98	*Lolium perene*	Poaceae	Perennial ryegrass	Azevém-7-anos	MF	H	P	y	n	E	n	x	x							x														3	2
99	*Lupinus albus*	Fabaceae	White lupin	Tremoço-amarelo	MF	H	A	y	n	n.a.	y						x										x							2	2
100	*Lupinus luteus*	Fabaceae	European yellow lupin	Tremocilha	MF	H	A	y	n	n.a.	y																		x					1	1
101	*Lupinus polyphyllus*	Fabaceae	Large-leaved lupine	Tremoço de folha grande	MF	H	A	n	n	n.a.	y																x		x					2	1
102	*Lycium spp.*	Solanaceae	Goji berries	Gogi	Be	S	P	n	y	D	n															x							x	2	2
103	*Macadamia spp.*	Proteaceae	Macadamia nut tree	Macadâmia	N	T	P	n	y	E	n																						x	1	1
104	*Malus domestica*	Rosaceae	Apple tree	Macieira	F	T	P	n	y	D	n			x	x	x	x		x				x	x	x	x	x			x	x		x	13	8
105	*Malva sylvestris*	Malvaceae	Mallow	Malva	A/M/S	H	A	y	n	n.a.	n																x	x	x				x	4	2
106	*Medicago arborea*	Fabaceae	Tree medic	Luzerna arbórea	MF	T	P	n	y	E	y																						x	1	1
107	*Medicago sativa*	Fabaceae	Alfafa	Luzerna/Alfafa	MF	H	P	n	n	E	y									x		x												2	1
108	*Melaleuca spp.*	Myrtaceae	Tea-tree	Melaleuca	MF	T	P	n	y	E	n					x																		1	1
109	*Melia azedarach*	Meliaceae	Chinaberry tree	Amargoseira	MF	T	P	n	y	D	n																					x		1	1
110	*Melilotus spp.*	Fabaceae	Melilot	Melilotus	MF	H	A	y	n	n.a.	y								x	x		x												3	1
111	*Melissa officinalis*	Lamiaceae	Lemon balm	Cidreira	A/M/S	H	P	y	n	E	n		x													x		x						3	3
112	*Mentha spicata*	Lamiaceae	Common mint	Hortelã-verde	A/M/S	H	P	n	n	E	n		x		x	x	x		x											x			x	7	7
113	*Morus alba*	Moraceae	White mulberrie	Amoreira-branca	MF	T	P	n	y	D	n						x				x	x											x	4	3
114	*Morus nigra*	Moraceae	Black mulberry	Amoreira-negra	MF	T	P	n	y	D	n	x		x		x	x				x	x	x	x									x	9	6
115	*Musa spp.*	Musaceae	Banana tree	Bananeira	MF	H	P	n	n	E	n		x	x																			x	3	2
116	*Myrtus communis*	Myrtaceae	Myrtle	Murta	MF	S	P	y	y	E	n						x									x								2	2
117	*Ocimum basilicum*	Lamiaceae	Basil	Manjericão	A/M/S	H	A	n	n	n.a.	n				x				x		x	x			x										5	3
118	*Olea europea*	Oleaceae	Olive tree	Oliveira	F	T	P	y	y	E	n						x		x	x							x	x	x				x	7	4
119	*Opuntia ficus indica*	Cactaceae	Prickly pear	Piteira/Figueira-da-Índia	F	S	P	n	y	E	n																			x				1	1
120	*Origanum majorana*	Lamiaceae	Marjoram	Manjerona	A/M/S	S	P	n	y	E	n				x																			1	1
121	*Origanum vulgare*	Lamiaceae	Oregano	Orégãos	A/M/S	H	P	y	n	E	n			x	x		x		x														4	4
122	*Paulownia tomentosa*	Paulowniaceae	Princess tree	Kiri-japonês	MF	T	P	n	y	D	n						x																	1	1
123	*Persea americana*	Lauraceae	Avocadoctree	Abacateiro	F	C	P	n	y	E	n		x				x						x										x	4	3
124	*Petroselinum crispum*	Apiaceae	Parsley	Salsa	A/M/S	H	B	n	n	n.a.	n			x	x			x	x		x	x			x	x								8	5
125	*Phacelia spp.*	Boraginaceae	Phacelia	Facelia	MF	H	A	n	n	n.a.	n									x															1	1
126	*Phaseoulus vulgaris*	Fabaceae	Bean	Feijão	MG	H	A	n	n	n.a.	y		x	x	x	x			x		x	x					x		x					9	5
127	*Physalis spp.*	Solanaceae	Groundcherries	Fisális	Be	H	P	n	n	E	n						x																x	2	2
128	*Pinus pinea*	Pinaceae	Stone pine	Pinheiro-Manso	N	T	P	y	y	E	n	x	x	x																				3	1
129	*Pistacia lentiscus*	Anacardiaceae	Wild pistachio	Aroeira	MF	S	P	y	y	D	n																x	x	x				x	4	2
130	*Pistacia terebinthus*	Anacardiaceae	Terebinth	Cornalheira	MF	S	P	y	y	E	n																	x	x	x	x			3	2
131	*Pistacia vera*	Anacardiaceae	Pistachio tree	Pistachio	N	T	P	n	y	D	n					x													x					2	2
132	*Pisum sativum*	Fabaceae	Pea	Ervilha	MG	H	A	y	n	n.a.	y					x			x		x	x					x		x	x	x	x		9	4
133	*Plectranthus barbatus*	Lamiaceae	Boldo	Boldo-da-terra	A/M/S	S	P	n	y	E	n		x				x												x				x	4	4
134	*Popolus alba*	Salicaceae	White poplar	Choupo-branco	MF	T	P	y	y	D	n						x				x	x					x		x					5	3
135	*Popolus nigra*	Salicaceae	Black poplar	Choupo-negro	MF	T	P	n	y	D	n		x	x	x	x	x	x	x						x		x			x	x	x	x	14	9
136	*Populus × canadensis*	Salicaceae	Canadian poplar	Choupo-híbrido	MF	T	P	n	y	D	n		x				x						x	x		x			x					5	3
137	*Prunus armeniaca*	Rosaceae	Armenian plum tree	Damasqueiro	F	T	P	n	y	D	n						x														x		x	3	3
138	*Prunus avium*	Rosaceae	Sweet cherry tree	Cerejeira	F	T	P	n	y	D	n				x	x	x																3	3
139	*Prunus domestica*	Rosaceae	European plum tree	Ameixieira-europeia	F	T	P	n	y	D	n	x			x	x	x		x				x	x									x	8	7
140	*Prunus dulcis*	Rosaceae	Almond	Amendoeira	N	T	P	n	y	D	n					x	x																x	3	3
141	*Prunus laurocerasus*	Rosaceae	Cherry laurel	Louro-Cerejo	MF	T	P	n	y	E	n		x				x																2	2
142	*Prunus persica*	Rosaceae	Peach tree	Pessegueiro	F	T	P	n	y	D	n	x			x		x			x					x				x		x	x	x	9	8
143	*Prunus spinosa*	Rosaceae	Blackthorn	Abrunheiro	F	T	P	y	y	D	n	x				x																	x	3	3
144	*Psidium guajava*	Myrtaceae	Comon guava tree	Goiabeira	F	T	P	n	y	D	n																						x	1	1
145	*Punica granatum*	Lythraceae	Pommegranate tree	Romãzeira	F	T	P	n	y	D	n				x	x	x		x					x	x	x	x			x	x		x	11	8
146	*Pyrus communis*	Rosaceae	European pear tree	Pereira	F	T	P	y	y	D	n	x			x	x	x		x															5	5
147	*Pyrus pyrifolia*	Rosaceae	Nashi pear tree	Pereira-nashi	F	T	P	n	y	D	n																						x	1	1
148	*Quercus coccifera*	Fagaceae	Kermes oak	Carrasco	MF	S	P	y	y	E	n						x											x						2	2
149	*Quercus faginea*	Fagaceae	Portuguese oak	Carvalho-português	A	T	P	y	y	E	n																x							1	1
150	*Quercus pyrenaica*	Fagaceae	Pyrenean oak	Carvalho-negral	A	T	P	y	y	D	n				x																			1	1

151	*Quercus robur*	Fagaceae	English oak	Carvalho-alvarinho	A	T	P	y	y	D	n		x										x		x									3	2
152	*Quercus roduntifolia*	Fagaceae	Holm oak	Azinheira	A	T	P	y	y	E	n						x										x	x	x					x	5	3
153	*Quercus suber*	Fagaceae	Cork oak	Sobreiro	C/A	T	P	y	y	E	n					x	x									x	x	x	x	x						7	4
154	*Raphanus sativus*	Brassicaceae	Radish	Rabanete	MG	H	A	n	n	n.a.	n			x	x	x		x	x		x	x		x			x	x	x						11	7
155	*Retama sphaerocarpa*	Fabaceae	Retama	Retama	MF	S	P	y	y	D	y																					x		1	1
156	*Ribes rubrum*	Grossulariaceae	Red currant	Groselheira-vermelha	Be	S	P	n	y	E	n				x		x									x	x			x				x	6	5
157	*Rosmarinus officinalis*	Lamiaceae	Rosemary	Alecrim	A/M/S	S	P	y	y	E	n		x				x															x		3	3
158	*Rubus idaeus*	Rosaceae	Raspberry	Framboeseira	Be	S	P	n	y	E	n	x					x									x						x			4	4
159	*Rubus ulmifolius*	Rosaceae	Elmleaf blackberry	Silva/Amora	Be	S	P	y	y	E	n						x								x		x	x		x		x			6	4
160	*Rumex acetosa*	Polygonaceae	Sorrel	Azeda	MG	H	P	y	n	E	n																						x	1	1
161	*Salix alba*	Salicaceae	White willow	Salgueiro-branco	MF	T	P	y	y	E	n			x		x	x				x	x				x	x		x					8	6
162	*Salix atrocinerea*	Salicaceae	Grey willow	Salgueiro-preto	MF	T	P	y	y	D	n				x		x	x									x		x					5	3
163	*Salix babylonica*	Salicaceae	Weeping willow	Salgueiro-chorão	MF	T	P	n	y	E	n		x	x			x										x							4	3
164	*Salvia officinalis*	Lamiaceae	Common sage	Salvia	A/M/S	S	P	n	y	E	n				x		x															x		3	3
165	*Sambucus nigra*	Adoxaceae	Elderberry	Sabugueiro	Be	S	P	y	y	D	n		x	x	x	x			x				x		x	x	x		x				x	11	7
166	*Saponaria officinalis*	Caryophyllaceae	Soapwort	Erva-saboeira	A/M/S	H	P	y	n	E	n			x																				1	1
167	*Satureja hortensis*	Lamiaceae	Summer savory	Segurelha-anual	A/M/S	H	A	n	n	n.a.	n				x																			1	1
168	*Schinus molle*	Anacardiaceae	Pepper tree	Pimenteira	MF	T	P	n	y	E	n						x										x					x	x	4	4
169	*Secale cereale*	Poaceae	Rye	Centeio	MF	H	A	n	n	n.a.	n									x														1	1
170	*Sequoia sempervirens*	Cupressaceae	California Redwoods	Sequoia-vermelha	MF	T	P	n	y	E	n																						x	1	1
171	*Silybum marianum*	Asteraceae	Milk Thistle	Cardo-mariano	A/M/S	H	A	y	n	n.a.	n																x	x				x		3	2
172	*Sinapis alba*	Brassicaceae	White mustard	Mostarda-branca	MF	H	A	y	n	n.a.	n																x							1	1
173	*Solanum betaceum*	Solanaceae	Tamarillo	Tamarilho	F	T	P	n	y	E	n		x																					1	1
174	*Solanum lycopersicum*	Solanaceae	Tomato	Tomate	MG	H	A	n	n	n.a.	n	x	x	x	x	x		x	x		x	x			x	x	x		x					13	7
175	*Solanum melongena*	Solanaceae	Eggplant	Beringela	MG	H	A	n	n	n.a.	n			x	x	x			x		x	x			x									7	5
176	*Solanum pimpinellifolium*	Solanaceae	Currant tomato	Tomate-silvestre	MG	H	A	n	n	n.a.	n																						x	1	1
177	*Solanum tuberosum*	Solanaceae	Potatoes	Batata-da-terra	MG	H	A	n	n	n.a.	n			x	x									x		x		x	x	x				7	5
178	*Sorghum bicolor*	Fabaceae	Sorghum	Sorgo	MF	H	A	n	n	n.a.	y																x							1	1
179	*Sorgum x drummondii*	Poaceae	Sudan grass	Erva-do-Sudão	MF	H	A	n	n	n.a.	n																				x			1	1
180	*Spinacia oleracea*	Amaranthaceae	Spinach	Espinafre	MG	H	A	n	n	n.a.	n		x			x			x		x	x												5	3
181	*Symphytum spp.*	Boraginaceae	Comfrey	Consolda	MF	H	P	n	n	E	n																						x	1	1
182	*Tetragonia tetragonioide:*	Aizoaceae	New-Zeeland Spinach	Espinafre-tetragónia	MG	H	P	n	n	E	n		x		x														x				x	4	4
183	*Thymus mastichina*	Lamiaceae	Mastic thyme	Tomilho Bela-luz	A/M/S	S	P	y	y	E	n			x																				1	1
184	*Thymus vulgaris*	Lamiaceae	Thyme	Tomilho-comum	A/M/S	S	P	y	y	E	n				x		x																	2	2
185	*Thymus x citriodorus*	Lamiaceae	Lemon Thyme	Tomilho-limão	A/M/S	S	P	n	y	E	n				x																			1	1
186	*Trifolium repens*	Fabaceae	White clove	Trevo-branco	MF	H	A	y	n	n.a.	y						x			x														2	2
187	*Triticum aestivum*	Poaceae	Bread wheat	Trigo	MF	H	A	n	n	n.a.	n				x																			1	1
188	*Tropaelum majus*	Tropaeolaceae	Garden nasturtium	Capuchinas	MF	H	A	n	n	n.a.	n				x																		x	2	2
189	*Ulmus glabra*	Ulmaceae	Wych elm	Ulmeiro	MF	T	P	y	y	D	n															x								1	1
190	*Vaccinium corymbosum*	Ericaceae	Blueberry	Mirtilo	Be	S	P	n	y	D	n				x		x							x		x								4	3
191	*Vaccinium macrocarpon*	Ericaceae	American cranberry	Arando	Be	S	P	n	y	E	n						x																	1	1
192	*Verbascum thapsus*	Scrophulariaceae	Great Mullein	Verbascco	MF	H	B	y	n	E	n																x							1	1
193	*Viburnum tinus*	Adoxaceae	Viburnus	Folhado	MF	S	P	y	y	E	n						x																	1	1
194	*Vicia faba*	Fabaceae	Broad bean/Fava bean	Fava	MG	H	A	n	n	n.a.	y						x		x		x	x					x	x	x		x			8	4
195	*Vicia sativa*	Fabaceae	Vetch	Ervilhaca	MF	H	A	y	n	n.a.	y								x															1	1
196	*Vicia villosa*	Fabaceae	Hairy vetch	Ervilhaca-peluda	MF	H	P	y	n	n.a.	y																					x		1	1
197	*Vitis vinifera*	Vitaceae	Grapevine	Videira	F	C	P	n	y	D	n				x		x						x	x	x	x	x	x	x	x	x		x	12	6
198	*Zea mais*	Poaceae	Maize	Milho	MG	H	A	n	n	n.a.	n	x	x	x	x												x							5	3

*broccoli , cauliflower, leaf cabbage, etc. **brócolos, couve folhas, couve-flor, etc.,

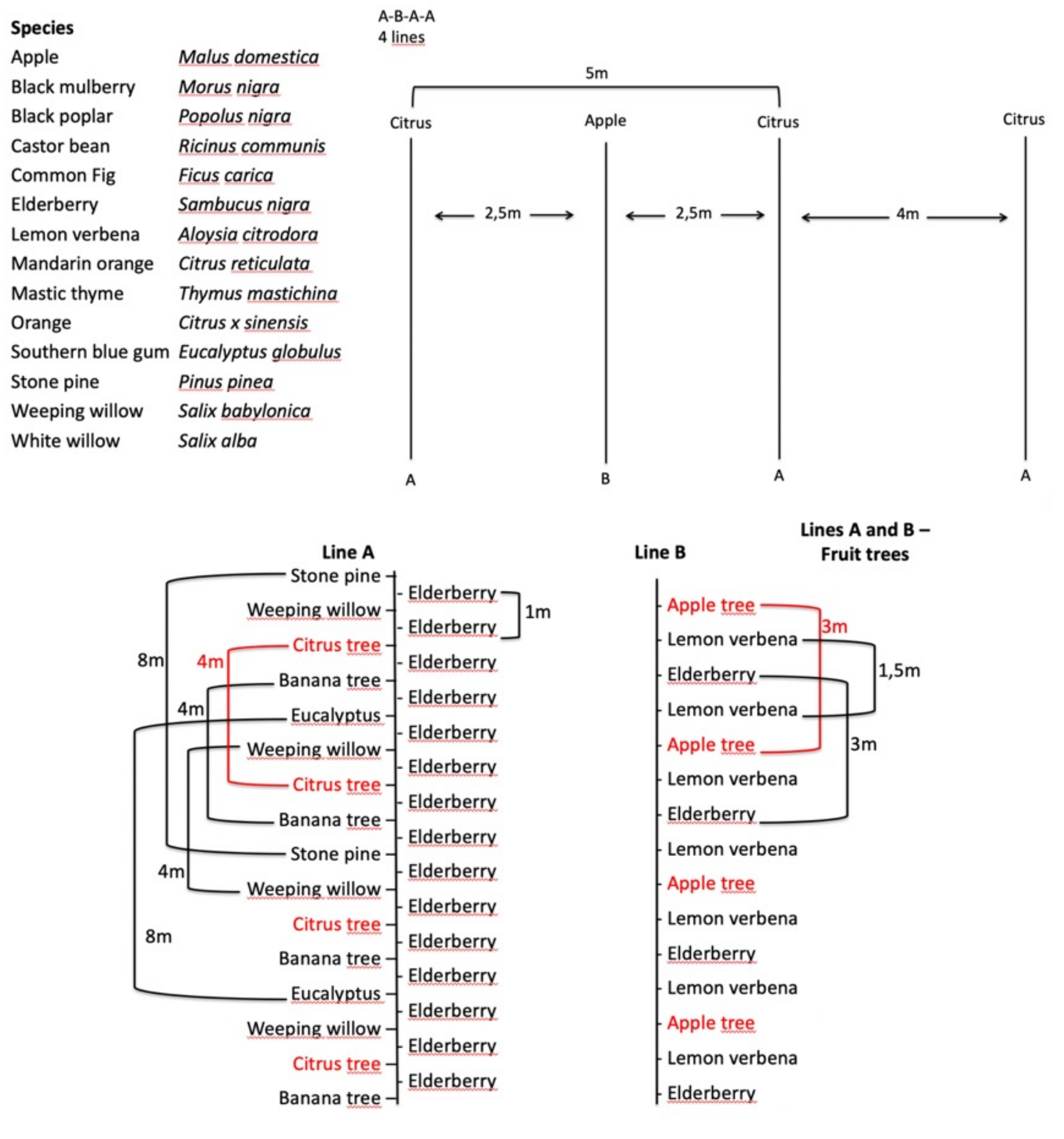
Anexo 7: Desenhos de alguns dos campos de SAFS incluídos no estudo

Quinta 1, Campo 2 – Data de implementação Janeiro 2018



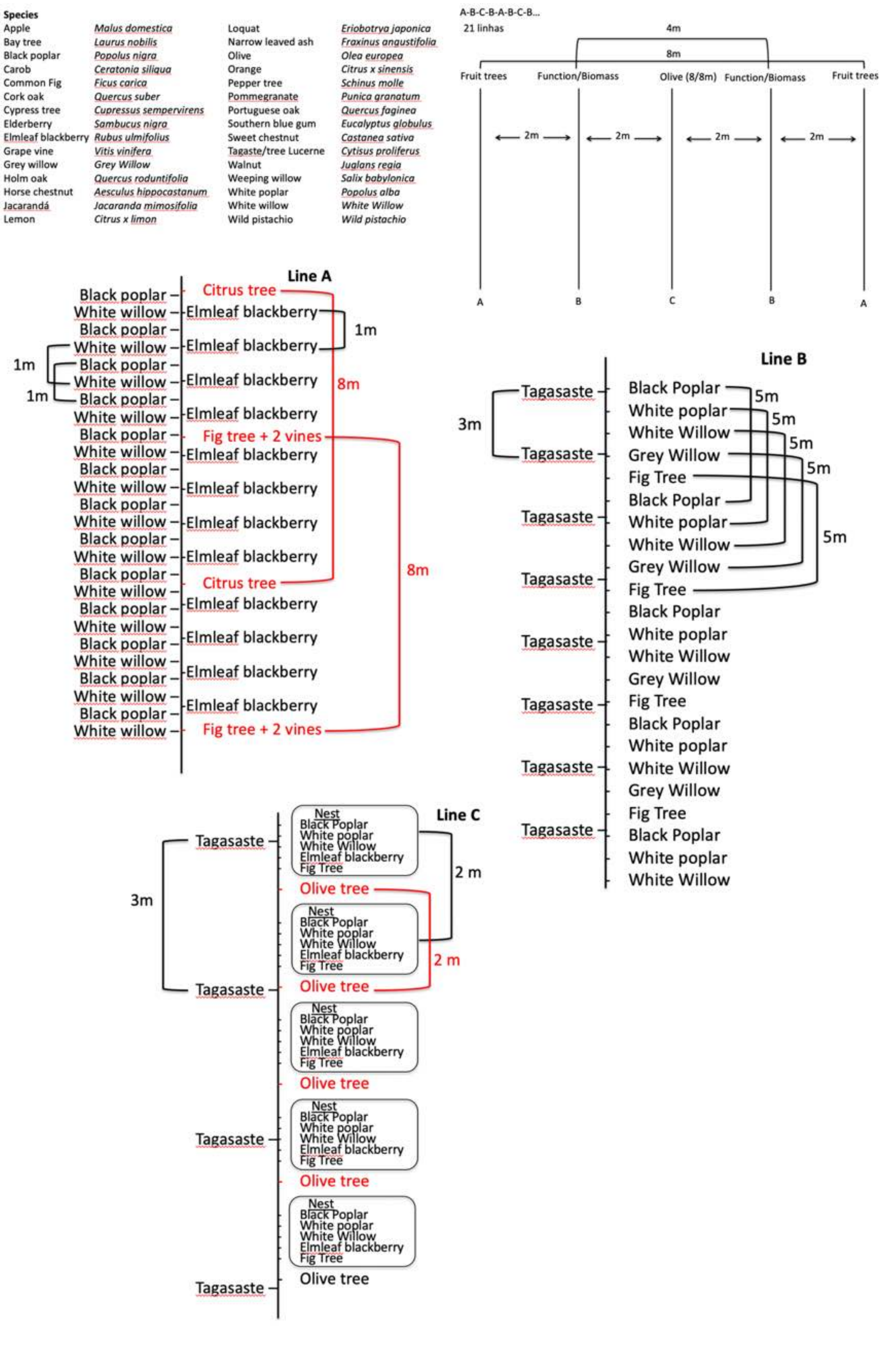
* a vermelho as principais árvores de fruto

Quinta 1, Campo 3 – Data de implementação Janeiro 2019



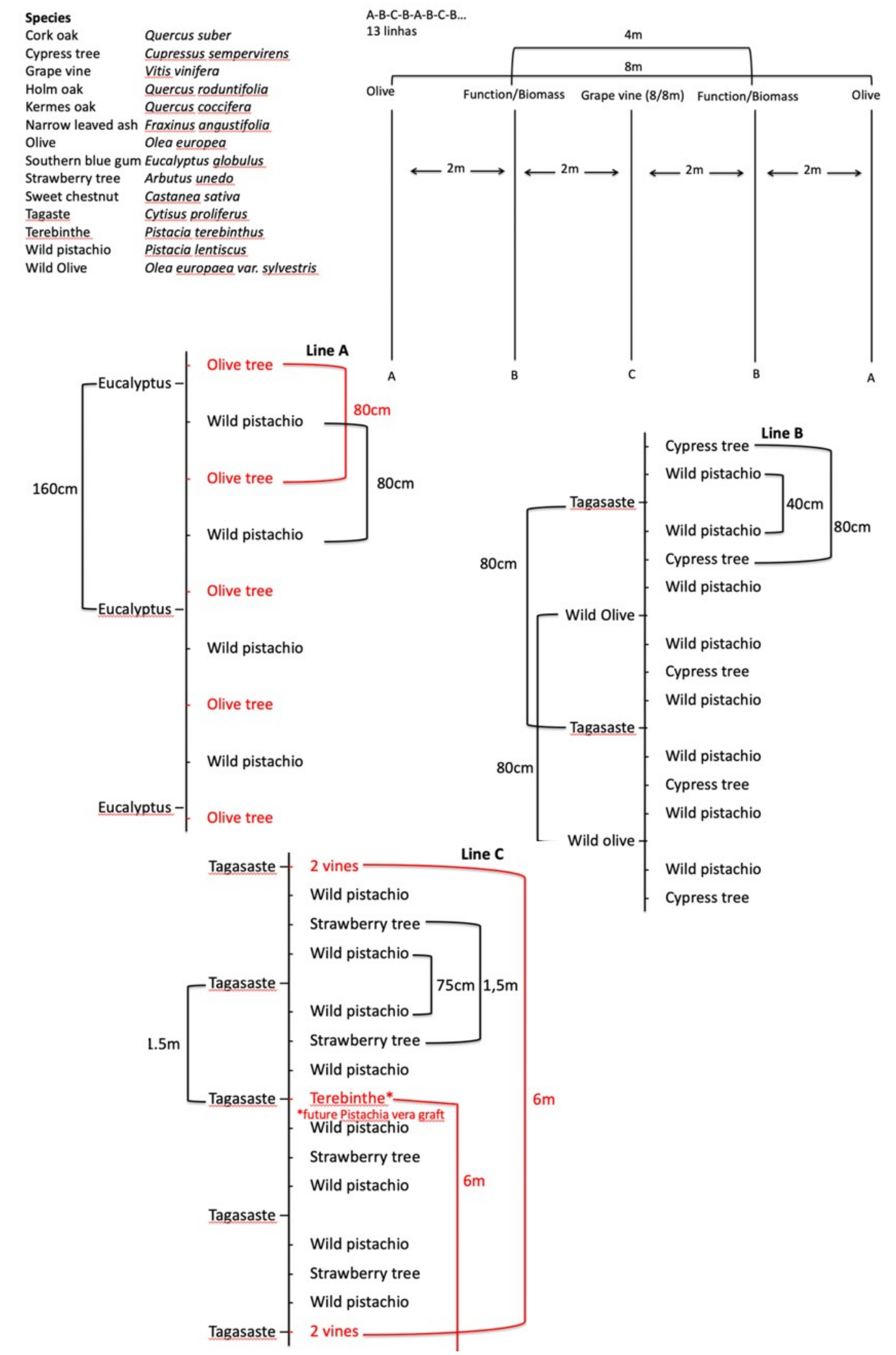
* a vermelho as principais árvores de fruto

Quinta 7, Campo 1 – Data de implementação Janeiro 2020



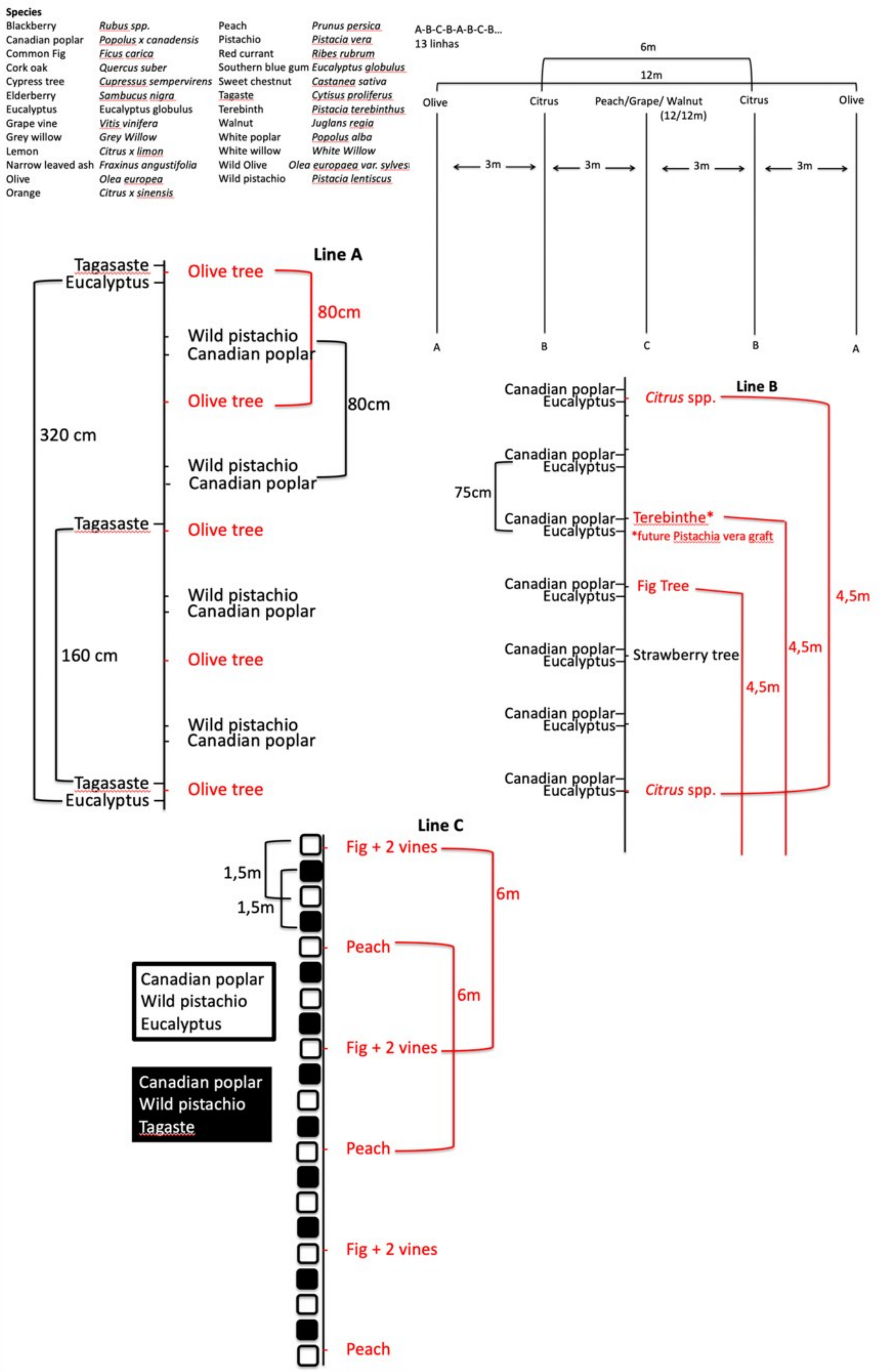
*a vermelho as principais árvores de fruto

Quinta 7, Campo 2 – Data de implementação Novembro 2020



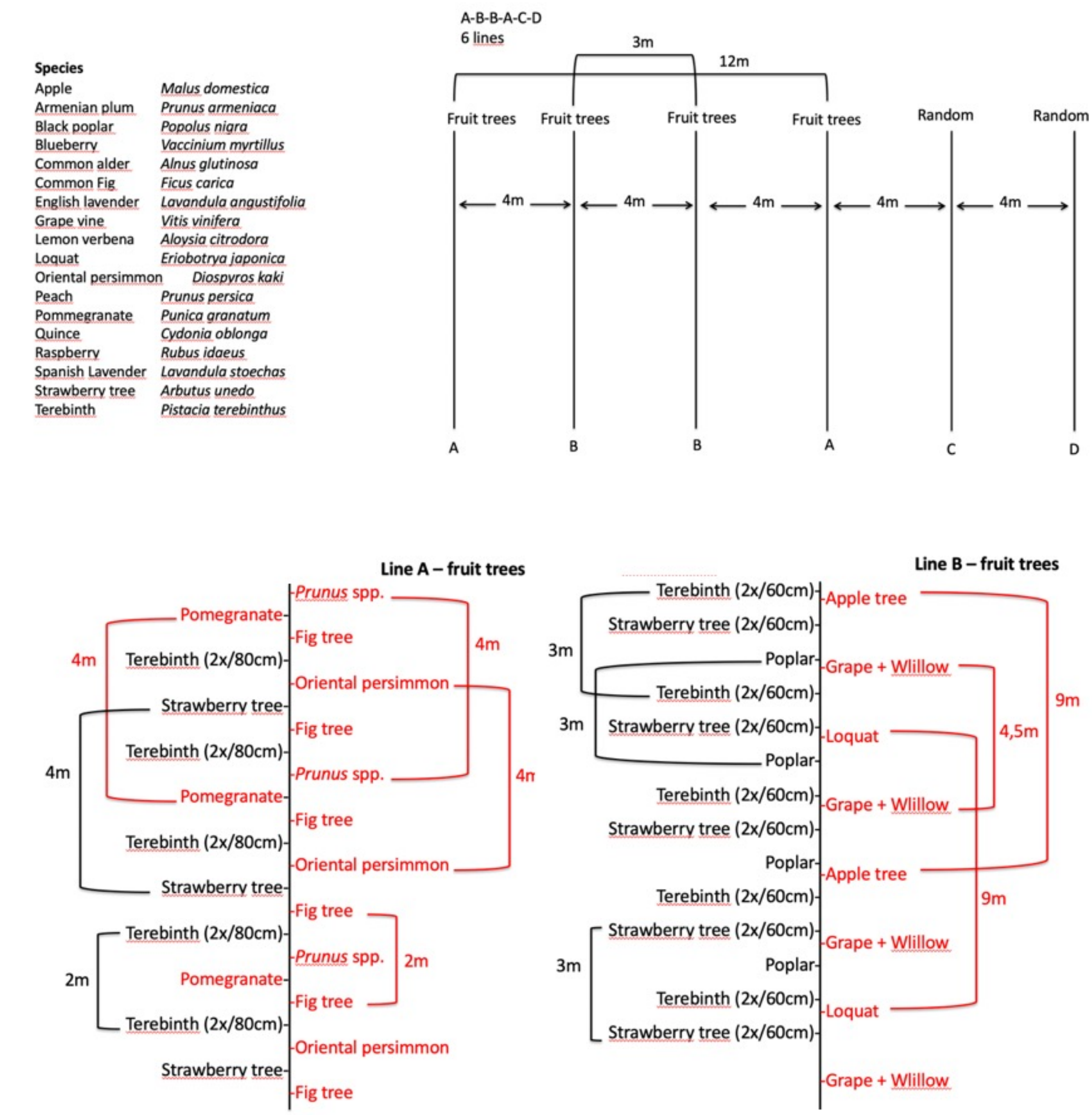
*a vermelho as principais árvores de fruto

Quinta 7, Campo 3 – Data de implementação Janeiro 2021



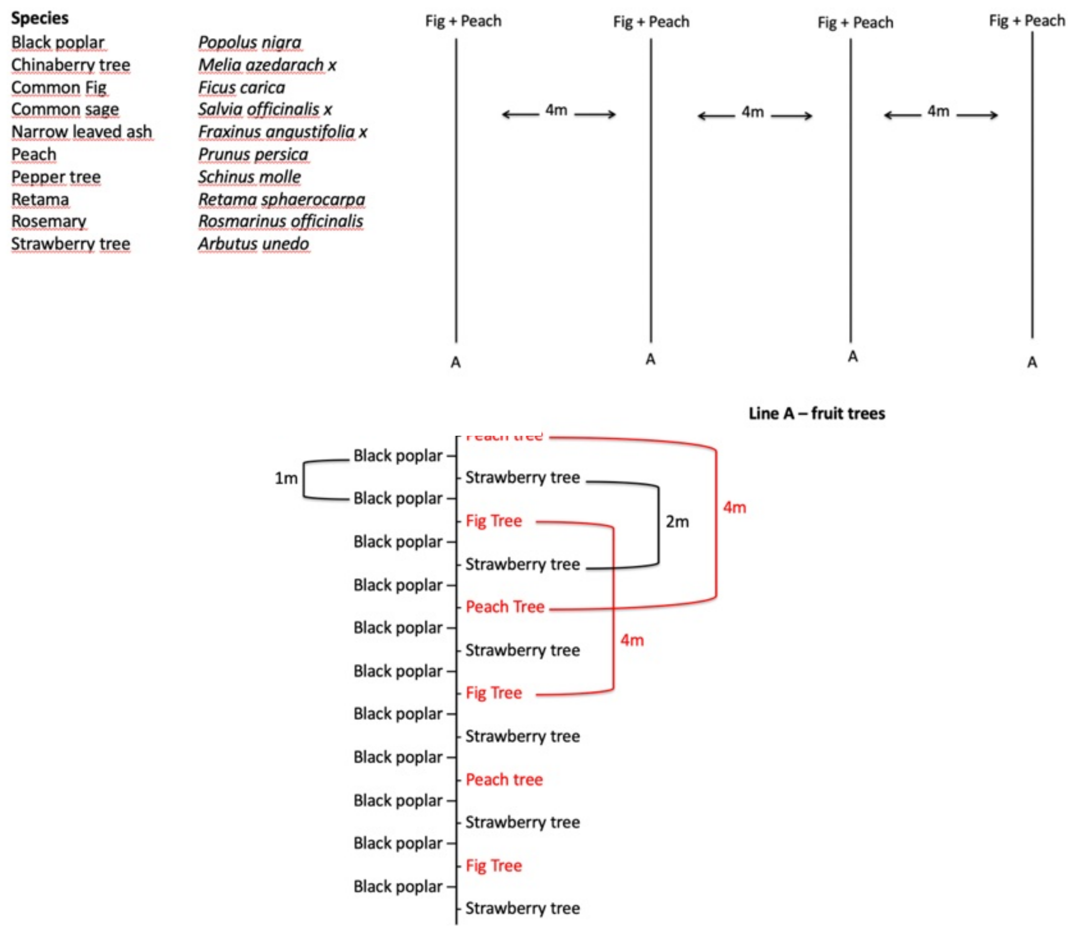
*a vermelho as principais árvores de fruto

Quinta 8, Campo 2 – data de implementação Novembro 2019



*a vermelho as principais árvores de fruto

Quinta 8, Campo 3 – data de implementação Novembro 2020



*a vermelho as principais árvores de fruta