Teagasc
Agriculture and Food Development Authority

Underpinning Organics

Abstracts of Selected Teagasc Research

Contents

Foreword

A considerable effort is required to achieve the government Organic Strategy target to increase organic production in Ireland from 2% to 7.5% of utilisable agricultural area by 2027. It will require a concerted, systemic approach, across all the actors, institutions and stakeholders that can influence the development of the organic sector, be that in the policy, knowledge, production, processing and marketing domains.

Teagasc has a key role in these efforts, in relation to knowledge transfer, education and research to underpin the development of the organic sector in Ireland. We are committed to increasing the resources allocated to assisting the development of the organic sector in Ireland. Teagasc is in the process of building additional specialised organic expertise, to upskill both advisers and farmers in relation to organic principles and technologies, to help to achieve the ambitious organic targets.

In terms of research, Teagasc is undertaking a strategic review of the long-term research needs of the sector. In the short-term, we have collated abstracts of some of the Teagasc research that is relevant for the organic sector. This booklet contains just a snap-shot of a rapidly growing research area that will be expanded on in the medium to long-term as the needs of this growing sector unfold.

Professor Frank O'Mara
Director, Teagasc
Friday, 1 April 2022

Title: Strategies to increase white clover use in intensive dairy production systems

Project start date: 01/01/2011 ***Project end date:*** 31/12/2014

Project Leader: Dr Deirdre Hennessy, Teagasc, Animal and Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Abstract:

White clover is the most widely sown legume in temperate regions including Ireland. It is ideally suited to grazing due to its stoloniferous growth habit. The main benefits of incorporating white clover in grass swards are its ability to fix atmospheric nitrogen (N) and make it available for plant growth, increased feed value and higher animal production compared to grass-only swards. White clover fixes atmospheric N through a symbiotic relationship with rhizobia bacteria in the soil. The bacteria infects the root hairs on the white clover plant, forming nodules. The plant supplies the bacteria with energy via photosynthesis and the bacteria fi x N and make it available for white clover growth. Over time, provided there is enough clover in the sward, the fixed N will become available for grass growth as white clover leaves, stolons and roots decompose and release the N into the soil.

The content of white clover in a grassland sward tends to be greater in swards receiving no or low N fertiliser input (0-60 kg N/ha) compared to swards receiving 200- 250 kg N/ha. White clover can fi x up to 200 kg N/ha, and sometimes more.

In grazed plots (grazed 8-10 times per year) containing high perennial ryegrass content with and without white clover at Teagasc Moorepark, grass-white clover swards receiving zero fertiliser N produced approx. 10.8 t DM/ha (range 8.3 – 13.3 t DM/ha) compared to grass-only swards receiving zero fertiliser N which produced approx. 8.2 t DM/ha (range 7.2 to 9.1 t DM/ha). Annual sward clover content in the grass-clover was 33%, and average crude protein content was 22% and digestibility 80%.

Grazing management is crucial to ensuring white clover persistence. Avoid allowing excessively high pre-grazing herbage masses to accumulate, graze swards at approx. 1,500 kg DM/ha and ensure swards are grazed to 4 cm sward height to allow light to the base of the sward for stolon production and hence white clover persistence.

Title: Grassland mixtures: resource use efficiency and yield stability in farmlet-and plot-scale study at Johnstown Castle

Project start date: 1/1/2019 ***Project end date:*** 31/3/2024

Project Leader: Dr John Finn, Teagasc, Crops, Environment and Land-Use Programme, Johnstown Castle, Co. Wexford

Abstract:

Research on grassland forage mixtures has provided strong evidence that clover-based mixtures with up to six species improve grassland performance (or compare well) relative to the respective monocultures. This has been observed in several responses, including forage yield, forage quality, weed suppression, nitrogen yield, yield stability, drought resilience and nitrous oxide emissions intensity.

Recent research by Guylain Grange from Teagasc, Johnstown Castle and Trinity College Dublin shows that multi-species mixtures receiving 150 kg/ha/year of nitrogen fertiliser, out-yielded perennial ryegrass monocultures receiving double that amount of fertiliser (300 kg/ha/year). Increases in plant diversity up to six species in intensively managed grasslands reduced the impact of drought, and produced more yield with less fertiliser. In related work, we investigated the legacy effect of multi-species mixtures on a following crop of Italian ryegrass (after shallow power harrowing). Not surprisingly, highest yields (and therefore legacy effects) of Italian ryegrass (with very low application of N fertiliser) were from plots that previously had highest proportions of clover. Legacy effects were lowest in the plots formerly with the perennial ryegrass monocultures receiving 300 kg/ha/year. Planned research will start to compare the performance of mixtures with low and zero use of inorganic nitrogen fertiliser.

A key issue for future research is to better assess the relative benefits of multi-species mixture in relation to two-species grass-clover swards. In the face of high economic and environmental costs of inorganic nitrogen fertiliser, the contribution of symbiotic N2 fixation by legumes to grassland N supply will only grow in importance as a key strategy to maintain levels of production and protein self-sufficiency in a more sustainable way.

Title: An investigation into reducing chemical N inputs and the environmental footprint of pasture based sheep production systems

Project start date: 1/1/2022 ***Project end date:*** 31/12/2026

Project Leader: Dr Philip Creighton, Teagasc, Animal & Grassland Research & Innovation Centre, Mellows Campus, Athenry, Co. Galway

Abstract:

Ireland's competitive advantage in sheepmeat production is based on the efficient production and utilisation of pasture. Challenges facing the agricultural sector are based on maintaining or improving current levels of production to maintain an economically viable sector but with an enhanced focus on environmental sustainability and a reduced dependence on chemical nitrogen use. A key focus of the DAFM Agri food strategy 2030 is to investigate the role of Grass, legumes and herbs that can deliver required sward yields and longevity at lower levels of nitrogen application.

Previous research investigating the incorporation of legumes (both white and red clover) and forage herbs (plantain and chicory) into sheep grazed swards have shown positive results. Binary sward mixtures containing perennial ryegrass and a companion forage (white clover, red clover, plantain or chicory) have the potential to support increased lamb performance above that of a perennial ryegrass monoculture in terms of pre-weaning, post-weaning and lifetime average daily gain and subsequent days to slaughter.

Reductions in chemical N requirements were also observed in swards with the addition of white clover which had positive effects from an economic and environmental perspective. The use of forage legumes and herbs in combination with perennial ryegrass warrants further investigation to determine their suitability relative to the traditional perennial ryegrass system in terms of their effect on animal performance and output; their physical production, utilisation and quality and to determine their potential to reduce the environmental footprint of Irish sheep production systems.

Further work is required concerning the management of both legumes and herbs within sheep systems to increase their contribution and persistence in grazed swards. Knowledge gained will support innovation, technology transfer and education.

Title: Breeding forage grass, legumes and herbs for Irish farm systems

Project start date: 1/1/2020 ***Project end date:*** 31/12/2022

Project Leader: Patrick Conaghan, Teagasc,
Crops Research Centre, Oak Park, Carlow

Abstract:

Clover is the cornerstone of organic farming and the engine that drives productivity through its ability to fix atmospheric Nitrogen (N) into a plant usable form thereby eliminating the need for inorganic N fertilizer. White clover (Trifolium repens L.) and red clover (Trifolium pratense L.) are the predominant clover species used in Ireland. White and red clover are complementary species with white clover contributing mainly to grazed swards and red clover mainly to silage swards. Together, they offer a more robust sward and greater flexibility for utilisation.

Evolving climate, pests, diseases and farming practices (as determined by economic and national policy, and new knowledge) mean new varieties are continually required. Sowing a new, improved variety offers a permanent increase in performance over the lifetime of the variety. In contrast, a management scheme designed to improve crop performance must be continually re-applied each year, at a recurring cost.

Teagasc has been breeding white clover for over 50 years at Oak Park, Carlow. The Teagasc white clover breeding programme is arguably the strongest in north-western Europe supplying the majority of new varieties to the Ireland and UK Recommended Variety Lists over the last decade. Present varieties include Galway, Coolfin, Iona, Buddy, Chieftain, Dublin and Aran. The programme has significant strength in depth with provisional results indicating the seven best candidate varieties currently in test in the official Ireland variety trials are Teagasc bred.

The Teagasc red clover breeding programme was initiated at Oak Park, Carlow in 2008 in light of the growing need for greater farm sustainability and lower inorganic N fertilizer use. From this programme, the first ever Irish red clover variety, named Fearga, was bred. While there are no official red clover variety trials in Ireland, Fearga is the highest yielding red clover in the official variety trials in England and Wales. Fearga is expected to dominant the market for years to come.

The ongoing incorporation of genomic selection as a routine breeding tool in the breeding programme is predicted to increase genetic gain by two-to-three-fold. The next generation of Teagasc clover varieties will be available to farmers from 2023.

Title: Developing a blueprint for low or zero nitrogen fertilizer use for low-emissions pasture-based dairy farming

Project start date: 4/1/2021 ***Project end date:*** 31/3/2026

Project Leader: Dr James Humphreys, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Abstract:

Dairy farms account for approximately 20% of agricultural land use and approximately 15% of national GHG emissions in 2020. The objective was to investigate the potential to lower the carbon and ammonia footprints of Irish pasture based dairy production. Three experimental systems were compared involving farm-scale systems with 27 cows on 10.8 ha per year over three years (2019-2021).

The control system was based on standard practice on intensive Irish dairy farms: fertilizer N input of 275 kg/ha, with a 10% clover content in pasture, fertilizer N was applied as calcium ammonium nitrate (CAN) and urea, slurry was applied using a splash-plate. In the clover+NBPT urea system, fertilizer N was applied solely as NBPT-protected urea at an average annual rate of 96 kg/ha, the clover content of herbage was 22% and slurry was applied using LESS trailing shoe.

In the third system (Clover-Zero) no mineral fertilizer N was applied and the clover content of pasture was 30%, slurry was applied using LESS. The average EBI of the cows in the latter herd was €195 compared with €165 for the two other herds (Table 1).

	Intensive Control	Clover + NBPT Urea	Clover-Zero
Fertilizer N (kg/ha)	275	96	0
Fertilizer N type	CAN and urea	NBPT urea	N/A
Clover content of pasture DM (%)	10	22	30
Slurry application	Splash-plate	Trailing shoe	Trailing shoe
Herd EBI (€)	165	165	195
Annual pasture DM production (t/ha)	15.7	15.2	15.1
Annual concentrates fed (kg/cow)	493	493	493
Milk yield (kg/cow)	6,018	6,075	6,090
Protein (%)	36.0	36.2	36.3
Fat (%)	46.5	45.8	46.6

	Modelled results scaled up to a 50 ha farm		
Stocking rate (cows/ha)	2.56	2.47	2.45
Cows per farm	128	124	123
Total milk sold (kg)	767,636	748,961	749,579
Milk sales (€)	259,039	251,801	254,490
Total sales (€)	283,996	275,921	278,200
Fertilizer N (€)	12,967	4,055	0
Total variable costs (€)	99,099	89,486	84,709
Gross margin (€)	184,898	186,435	193,491
Labour costs (€)	51,260	49,539	49,457
Other fixed costs (€)	59,492	58,044	58,092
Net Margin (€)	74,146	78,851	85,941
Net Margin (€/ha)	1,483	1,577	1,719
GHG (kg CO2eq./L FPCM)	0.88	0.75	0.69
GHG emissions (t CO2eq./ha)	12.3	10.1	9.5
Ammonia (kg/t milk)	4.00	3.17	2.81

For the purposes of comparison of the environmental and economic performance of the systems the results were scaled up to a farm area of 50 ha, which is similar to the average area of a dairy farm in Ireland. Stocking rates of dairy cows in the scaled up model were based on pasture production on each system. Replacement heifers were contract reared. Pasture dry matter (DM) production decreased with lower fertilizer N input (Table 1).

The total volume of milk sold, the value of milk sold and total sales (including livestock) from the farm declined with decreasing intensity of production. On the other hand, variable costs were also lower with decreasing intensity of production, particularly fertilizer N. The cost of fertilizer N was the average cost between 2019 and 2021. The full cost of labour was included at an annual rate of 27 hours per cow at a cost of €15 per hour. Greenhouse gas, quantified either per L of fat and protein corrected milk (FPCM) or per ha, and ammonia emissions decreased with decreasing intensity of production.

Relative to the Intensive Control the two clover-based systems lowered GHG emissions per ha by 18% and 23% for the Clover+NBPT and Clover-Zero systems, respectively. Likewise these systems lowered ammonia emissions by 21% and 30%, respectively. The volume of milk sold decreased by 2.4% for both clover systems relative to the control. The higher EBI of the cows on the Clover-Zero system compensated with higher milk yield per cow to offset the lower stocking rate on this system. The two clover systems improved profitability compared with the control.

Conclusion: Adoption of clover instead of fertilizer N and low emissions slurry spreading along with higher EBI can substantially lower the carbon and ammonia footprints of pasture based milk production while maintaining or improving profitability.

Title: Farming for soil health: assessing the impact of agricultural practice on soil biodiversity and functioning

Project start date: 1/9/2022 ***Project end date:*** 30/11/2027

Project Leader: Dr Fiona Brennan, Teagasc, Crops, Environment and Land-Use Programme, Johnstown Castle, Co. Wexford

Abstract:

Soils are home to a staggering abundance and diversity of living organisms that are integral to the health and productivity of our farming systems. Mainly hidden beneath our feet, these organisms are often unseen and forgotten, but there is an increasing awareness that soil life, and the myriad of processes it performs, are critical for delivering a whole range of vital ecosystem functions. Their importance to the sustainability, resilience and functioning of our farming systems cannot be overstated.

These organisms become even more vital in organic farming where the use of synthetic fertilisers and additives is severely restricted. The central role played by soil biota in nutrient transformations, climate regulation and plant health places them at the heart of global challenges around food security and climate change. As international efforts towards carbon neutrality and environmental sustainability intensify, a key focus is on development of climate-resilient agricultural systems that are capable of maintaining food production and farm incomes, while minimising environmental impacts.

Sustaining crop production against the backdrop of restricted inorganic fertiliser inputs and restricted plant protection products, within the context of a changing climate, represents a major challenge for farmers. Steering microbial communities towards nature-based nutrient provision, enhanced climate resilience and pest/disease suppression will be key to maintaining productivity on organic farms.

This project aims to assess the impact of management options on soil biodiversity within Irish grassland systems, providing the knowledge base that will underpin management advice towards enhancing soil health and functioning, and support policy implementation. Furthermore it will also evaluate the impact of management induced gradients of microbial diversity on the delivery of multiple functions within agricultural systems and identify any functional trade-offs under a range of conditions.

Title: Evaluating quality and shelf life of silicon enriched fresh salad leaves using alternative plastic packaging solutions

Project start date: 1/1/2021 ***Project end date:*** 30/04/2022

Funding: SFI Future Innovator Prize, 20/FIP/FD/8934

Project Leader in Teagasc: Dr Lael Walsh, Teagasc, Horticulture Development Dept., Ashtown Research Centre, Ashtown, Dublin & Dr Shivani Pathania, Teagasc, Food Research Centre, Ashtown, Dublin

Abstract:

This project examines ways to extend the shelf life of fresh salad, in particular spinach and micro greens. Research is being carried out into fortifying crops with silicon during growth which will help reduce drought stress, loss of chlorophyll, moisture and maintain fresh weight at harvest stage contributing to better shelf life of the packaged product.

Silicon compounds are classified as biostimulants within EU regulations. Silicon is a nutrient which accumulates in plant tissue and acts as a protective barrier in the epidermis. This characteristic is mostly associated with monocots, in particular rice, however there is some research to indicate it has varied effects on eudicots. Research has shown that it slows the rate of expiry of harvested leaves. For example, lamb's lettuce supplemented with silicon can delay leaf senescence by reducing the rate of chlorophyll degradation in harvested leaves. This crop fortification also appears to reduce the use of agrochemical inputs during production.

While traditionally shelf life interventions primarily focused on the post-harvest management of the product, they overlooked the importance of interventions taken in the field as well as during production.

In addition, the research will assess the shelf life of silicon-treated and untreated leaves contained within compostable packaging. Different packaging materials and interventions such as Modified Atmospheric Packaging (MAP) will be assessed for their effect on the shelf life of the treated and untreated spinach leaves and other crops. This will be novel as it addresses concerns raised by growers of loss in product quality when shifting to degradable or compostable packaging types, and creates a bench mark for compostable packaging quality.

With plant-based foods making up one-third of the population's dietary intake in Ireland, horticulture enterprises, like other sectors of agriculture, is facing pressure to adopt sustainable business practices. In other qualitative research carried out in the Horticulture Development Department interviewing both organic and non-organic growers, similar challenges regarding high costs and low product prices, as well as limited opportunities for diversification were highlighted. These challenges appear to be slowing adoption of sustainable practices and hindering investment, innovation, wages and growth. Research that helps growers deliver a better quality product in more sustainable packaging, at a lower cost and with a lower environmental footprint of production is hugely beneficial in supporting responsible consumption and production (SDG 12).

Title: Moorepark multispecies swards for intensive grazing systems

Project start date: 1/1/2020 ***Project end date:*** 31/12/2023

Project Leader: Ciarán Hearn, Teagasc

Abstract:

Irish dairy farmers have become increasingly interested in the use of multispecies (MS) swards for intensive grazing systems as they have been shown to maintain dry matter (DM) production at lower rates of nitrogen (N) fertiliser compared to grass only swards. A grazed plot experiment was established at Moorepark to investigate the DM production of MS swards containing three plant functional groups (grass, legume and herb) under three levels of N fertiliser application (N100, N150 & N200) compared to zero N (N0).

Ten sward types were established which included a perennial ryegrass (PRG) monoculture and sward mixtures of the following species: PRG, white clover (WC), red clover (RC), chicory (CH) and ribwort plantain (PL); with monoculture PRG N200 as the control. Plots were grazed by lactating dairy cows on eight and nine occasions in years one and two, respectively. Swards in the N200 treatment produced the highest level of DM with an average of 1337 kg DM/ha more than N0 swards ($P<0.001$).

The sward mixture of PRG, WC & PL produced the highest level of DM; 2916 kg DM/ha more than the PRG monoculture sward on average across all levels of N fertiliser. Swards including 3 plant functional groups produced similar levels of DM in the N0 treatment to those produced by the PRG monoculture in the N200 treatment.

Over the two evaluation years the inclusion of forage herbs and clover with PRG in sward mixtures was associated with increased DM production; inclusion of PL and WC in particular appear to contribute to increased DM production. The trial is ongoing and further work will be required to assess sward species content changes and DM production persistency over time.

Figure 1. Mean dry matter production for each sward across all N treatments over two production years of 2020 & 2021

Title: Low-input Farming and Territories

Project start date: 1/5/2018 ***Project end date:*** 30/4/2022

Project Leader: Dr Mary Ryan, Teagasc, Rural Economy & Development Centre, Mellows Campus, Athenry, Co. Galway

Abstract:

H2020 **LIFT**

(**L**ow **I**nput **F**arm & **T**erritorial agroecological approaches)

Goal:

To identify and understand how socio-economic and policy drivers impact on the development of ecological approaches to farming and assess the performance and sustainability of these approaches.

Selected Studies:

Interviews[1] of Irish conventional and organic farmers revealed considerable similarities in the underlying values of both groups of farmers, however the drivers of these values differ. While 'profit' is an important value for both groups, it is driven by 'developing the business'/'resource use efficiency' for conventional farmers and 'environmental concerns' for organic. Similarly, 'pride'/'satisfaction' are important for all the farmers but relate to 'efficiency' for conventional and 'low input' for organic farmers. 'Tradition' is also important, relating to a 'way of life' for conventional farmers and to a 'holistic' approach for organic farmers. These findings highlight the importance of language in devising and communicating policies as 'efficiency' and 'low input' may achieve the same policy goals but need to be targeted differently to take account of differences in conventional and organic farming values. Similarly, the use of the term 'traditional' could be seen as either as old-fashioned or as a desirable way of farming.

Barriers to the expansion of the Irish organic dairy farming were mapped[2] by comparing supports for conventional and organic dairy across the 'Innovation System', from EU and national policy, to research and advisory capacity, to farmers, processors and marketing and was backed up by in-depth interviews with organic stakeholders. The study showed that while demand for organic dairy produce is high, greater policy, research and advisory supports are needed to incentivise conversion, while capital investment is required to increase capacity. However, all of these factors need to be addressed simultaneously and the 'innovation system' stakeholders need to move together.

1 Means End Chain approach
2 Net-Map (World Bank)

Title: Integrated Systems Research of Agro-ecological Farming Systems

Project start date: 1/10/2022 ***Project end date:*** 30/09/2026

Project Leader: Kevin Kilcline, Teagasc, Rural Economy & Development Centre, Mellows Campus, Athenry, Co. Galway

Abstract:

The UN's food systems approach aims to deliver food security and nutrition to all in an economically, environmentally and socially sustainable manner, while the EU 'Farm to Fork' and national 'FOOD VISION 2030' strategies emphasise input reduction, agro-ecological approaches, value added creation and organic farming. Despite clear policy goals, growing global demand and financial supports for organic farming, uptake of organics in Ireland is low, with limited research on the performance of organic systems at farm level and barriers to organic food system growth at a wider value chain level.

These research gaps are addressed through a food systems approach incorporating both farm and sectoral level analyses.

1. Sectoral level - innovation systems analysis

The organic value chain stretches beyond farm production from 'farm to fork', and sectoral development and innovation is influenced by the interaction of diverse sectoral stakeholders. Qualitative interviews, interactive stakeholders workshops, and international comparative case-studies will explore how innovation currently occurs within emerging organic value chains, comparing them to the conventional food system both domestically and internationally. This will identify the structural changes and policy supports required to promote greater adoption of organic farming and expansion of the organic sector in Ireland.

2. Farm level – bio-economic analysis

Ruminant grass-based production systems contribute significantly to the rural economy, in terms of income generation and employment. At the same time, farming is coming under increased scrutiny to improve efficiency and demonstrate its environmental credentials. Environmental impacts, however, vary considerably across farms. Understanding these differences is crucial to developing resilient, sustainable production systems. The development of a farm-level modelling framework will enable the integrated financial and economic analysis of organic (beef) systems, facilitate comparison of cradle-to-farm-gate environmental impact assessment of beef systems and the financial impacts of organic conversion scenarios.

Title: Analyses of the organic value chain in Ireland

Project Leader: Dan Clavin, Dr Yan Jin, Teagasc

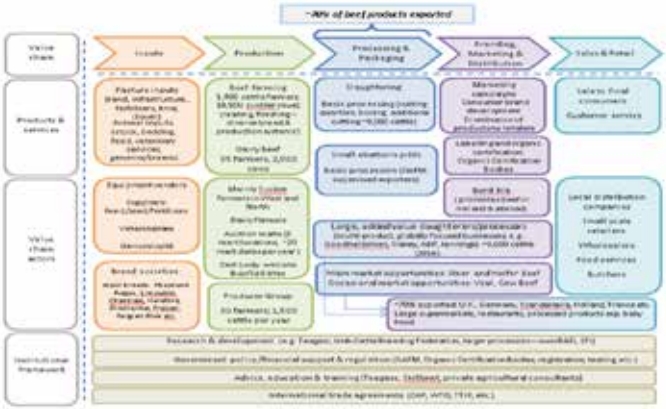
Abstract:

A value chain mapping approach was undertaken using organic administrative data to understand the structure of the organic value chain, examining the distribution of organic farms in relation to their production systems and categories of animals produced.

The study shows a disproportionately high share of suckler producers who rear and wean beef calves, selling them through marts and farm-to-farm sales. Relatively few farms have the capacity (land, facilities, knowledge, technical capacity re legumes and organic cereal crops), to specialise in fattening or finishing animals for the meat market, while few tillage farmers have converted to organic production, which may result in supply gaps for organic winter forage. In addition, organic processing capacity is limited with few dedicated organic cattle mart sales and processors within the primary organic production regions, leading to spatial value chain imbalances. The study confirms that these issues in combination result in 'leakage' of animals from the organic to the non-organic beef system.

Irish Beef Organic Value Chain Map

Scan the QR code to view the full published paper



Deeper analysis undertaken in the H2020 LIFT project quantified the level of organic leakage as 17% in 2015. However, leakage rate varies, as it depends on the livestock finishing capacity, feed prices, animal sale prices and processing capacity in any given year. Further LIFT analysis examines the economic impact of this leakage, showing that the organic value chain generates higher value than the conventional.

These analyses provide a basis to work with industry partners to consider institutional solutions to improve the effectiveness of the organic value chain to match unspecialized farms with finishers in better agronomic regions, spatially optimising
the development of production, processing and sales

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