Final Report EIP-Agri Project Wandernde Wiese

Baden-Württemberg

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AGRICULTURE & INNOVATION

funded by European Commission

Oliver Schmid

Agrarforschung Wandernde Wiese®

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1 Brief

1.1 Initial situation

Modern agriculture is characterized by a sharp increase in production volumes per area. However, this trend, driven by a growing world population and globalized markets, is increasingly at odds with the protection of biodiversity. The concentration of agriculture on ever larger farms and the associated cultivation of large-scale arable landscapes is seen as a further accelerator of species decline. This is because powerful machines enable a quick harvest and thus remove the habitats of many species in a short time. However, a complete conversion of these areas into fallow land and the associated renunciation of food production would lead to a relocation of the cultivated areas. The missing food would then have to be produced on other, possibly more ecologically valuable areas.

1.2 Project objective

The EIP-AGRI project Wandernde Wiese (engl. Mowing Meadow) takes an innovative approach by resetting priorities in agriculture. First, nature and climate protection will be promoted on a large scale, in order to then build up soil fertility and finally produce food. This approach thus offers the most sustainable way possible, as the ecological aspects have already been considered from the beginning, see Figure 1.

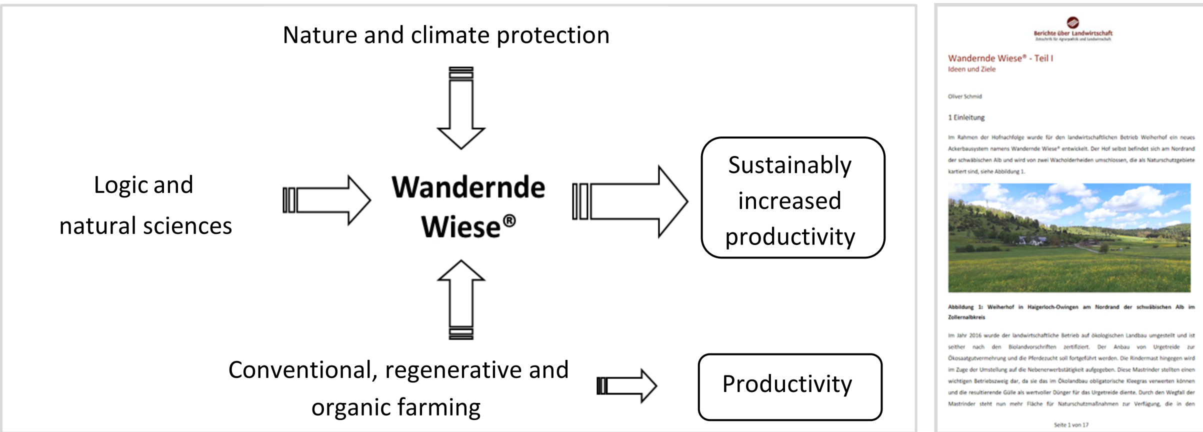


Figure 1: Translated schema from article Wandernde Wiese® Teil I – Ideen und Ziele [1]

The goals are achieved by alternating strip cultivation, in which field and field fodder strips alternate. For this purpose, field forage strips were created in different ways on three test fields and compared with each other. In order to promote native plant species as well as to establish a meadow population that is as close to nature as possible, both commercially available seeds and mowing material from species-rich FFH mowing meadows (Flora-Fauna-Habitat) were used and compared with each other. The growth of these forage strips can be used as hay or silage. Alternatively, it can also be applied as transfer mulch without any transport routes to the adjacent arable land in order to increase the humus content there. Within four years, the field forage strips are ploughed up and re-laid at the adjacent position. In this way, the forage strips migrate through the arable land and offer animals and plants valuable habitats and food sources over the years.

1.3 Project members

For the EIP-Agri project Wandernde Wiese, an operational group (OPG) of several farmers was put together. The practical work was again accompanied by a scientific advisory board representing the agricultural research institutions in Baden-Württemberg. The coordination and communication between the respective project members were coordinated by the lead partner throughout the entire duration.

Lead partner as main project partner and contact person

- Agrarforschung Wandernde Wiese, Oliver Schmid, Weiherhof 1, 72401 Haigerloch-Owingen

Agricultural or horticultural enterprises of primary production

- Wilfried Schmid, Weiherhof 1, 72401 Haigerloch-Owingen
- Contractor Härter, Johannes Härter, Immenhäuser Str. 11, 72127 Mähringen
- Südwestdeutsche Biosaaten GmbH & Co. KG, Estate Manager Christoph Stober, Seehof 1, 72401 Haigerloch

Consulting and service facilities

- Land-Lebensimpulse, Beate Leidig, Im Vogelsang 9/1, 74523 Schwäbisch Hall

Bachelor Thesis

- Sebastian Löffler, Bachelor's degree program in Agricultural Sciences, University of Hohenheim, Faculty of Agricultural Sciences, Center for Organic Farming

Scientific Advisory Board consisting of:

- University Hohenheim (UHOH), Schloss Hohenheim 1, 70599 Stuttgart,
  Executing institutions: Center for Organic Agriculture University of Hohenheim (ZÖLUH), Head of Department and Responsible Scientist Dr. Sabine Zikeli and Department of Landscape Ecology and Vegetation Science, Head of Department Prof. Dr. Schurr, Responsible Scientist Prof. Dr. Dieterich

- University of Economics and Environment Nürtingen-Geislingen (HfWU), Neckarsteige 6-10, 72622 Nürtingen, Executing Institution Institute for Applied Agricultural Research (IAAF) Head of department and responsible scientist Prof. Dr. Maria Müller-Lindenlauf

- Agricultural Technology Center Augustenberg (LTZ) - Reinstetten-Forchheim Branch Office, Neßlerstraße 25, 76227 Karlsruhe, Executive Facility Department 1 Crop Production and Production-Related Environmental Protection, department 12 Agroecology, head of division Dr. Jörn Breuer and responsible scientist Dr. Julia Walter

- Agricultural Centre for Cattle Husbandry, Grassland Farming, Dairy Farming, Game and Fisheries Baden-Württemberg (LAZBW), Atzenberger Weg 99, 88326 Aulendorf, Executive Institution Department 3 Grassland Agriculture and Fodder Production, responsible scientist Mr. Jörg Messner

1.4 Description

The Wandernde Wiese arable farming system was developed at the Weiherhof in Haigerloch-Owingen, which first promotes ecology and then generates economic benefits. The aim is to optimise this procedure so that it can be transferred to other farms and can serve as the basis for a new funding measure. The aim is to support farmers in implementing sustainable cultivation methods. In order to check the effectiveness, soil samples will be analyzed at the beginning and end of the project, the plant diversity on the forage strips will be recorded and the number of insects will be determined in comparison to permanent grassland areas.

The EIP project Wandernde Wiese was carried out from 19.10.2022 to 31.12.2024 at the farm Weiherhof in Haigerloch-Owingen. The original budget of 137,196.32 € had to be adjusted to 136,845.69 € due to an accounting error. Despite the challenging conditions as a marginal yield location, all project goals were achieved within the planned two years. Individual work steps were adapted during the course of the project for reasons of efficiency or due to changed framework conditions. In particular, the weather in the first year of the project affected the development of the newly created meadow strips, so that only six of eight planned insect counts could be carried out. Furthermore, the procedure in work package 4 has been revised. The goal of microbially inoculating the mowed growth of forage areas and thus preparing it as fertilizer for the subsequent crop was optimized and converted into the concept of crop cultivation on square bales, see Figure 2.

Work Packages (WP) Wandernde Wiese	Year and month																											
	2022				2023												2024											
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
WP1 Create stripes wth GPS RTK Tractor																												
Strip-shaped tillage (WS)	✓	✓										✓	✓	✓										×	×	×		
Sowing meadow strips 12.5 cm row spacing (WS)								✓	✓																			
Sowing meadow strips 25 cm row spacing (WS)								✓	✓																			
WP2 Transfer of species-rich permanent grassland																												
Mowing material transfer to meadow strips (WS)								✓	✓	✓	✓									✓	✓	✓	✓					
WP3 Transfermulch																												
Forage harvester solo (JH)										✓	✓		✓	✓								✓	✓		✓	✓		
Forage harvester + Side discharge spreader (JH + OS)										✓	✓		✓	✓								✓	✓		✓	✓		
Forage harvester + straw blower (OS + WS)			✓							×	×		×	×								×	×		×	×		
WP4 Crop Production in swuare bales																												
Demonstration on hay and silage bales								✓	✓	✓	✓	✓	✓	✓						✓	✓	✓	✓	✓	✓	✓		
WP5 Generate measurement data																												
Insect count (BL)										×	×		✓	✓								✓	✓		✓	✓		
Evaluation of species-rich plants in meadow strips(BL)										×	×		✓	✓								✓	✓		✓	✓		
Soil sampling (OS)		✓																								✓		
Transfer mulch sampling (OS)											×			×								✓	✓	✓		×		
Evaluation field strips for seed propagation (CS + OS)								✓				✓								✓				✓				
WP6 Plannes dissemination of results																												
OPG Wandernde Wiese Meeting (Alle)	✓		✓						✓			✓			✓	✓					✓			✓			✓	✓
Small field day													✓	✓														
Report																✓												✓

Figure 2: Schedule and work packages in the EIP project Wanderende Wiese

2 In-depth presentation

2.1 Detailed explanation of the situation at the beginning of the project

In recent decades, the number of full-time farmers has declined sharply. In order to ensure profitability, the remaining farms then preferred to combine the freed-up space into larger units and were thus able to use high-performance machines more efficiently. However, this development also leads to the fact that, for example, ever larger arable farming areas are cultivated with one and the same crop. The result is an intensification of agriculture, which harvests large areas in a short time and severely restricts the livelihoods of many creatures such as insects, birds and small game in the fields. The map comparison in Figure 3 shows how much the landscape between the two villages of Stetten and Owingen has changed over the last 183 years. In 1950, for example, there were still 258 farms in the villages of Stetten [2] and Owingen [3]. Today, there are still two full-time farms in this section of the map. Due to the particularly strong expansion of residential and industrial areas in recent decades, less and less agricultural land is available today, which further intensifies the competition between food production and natural habitats.

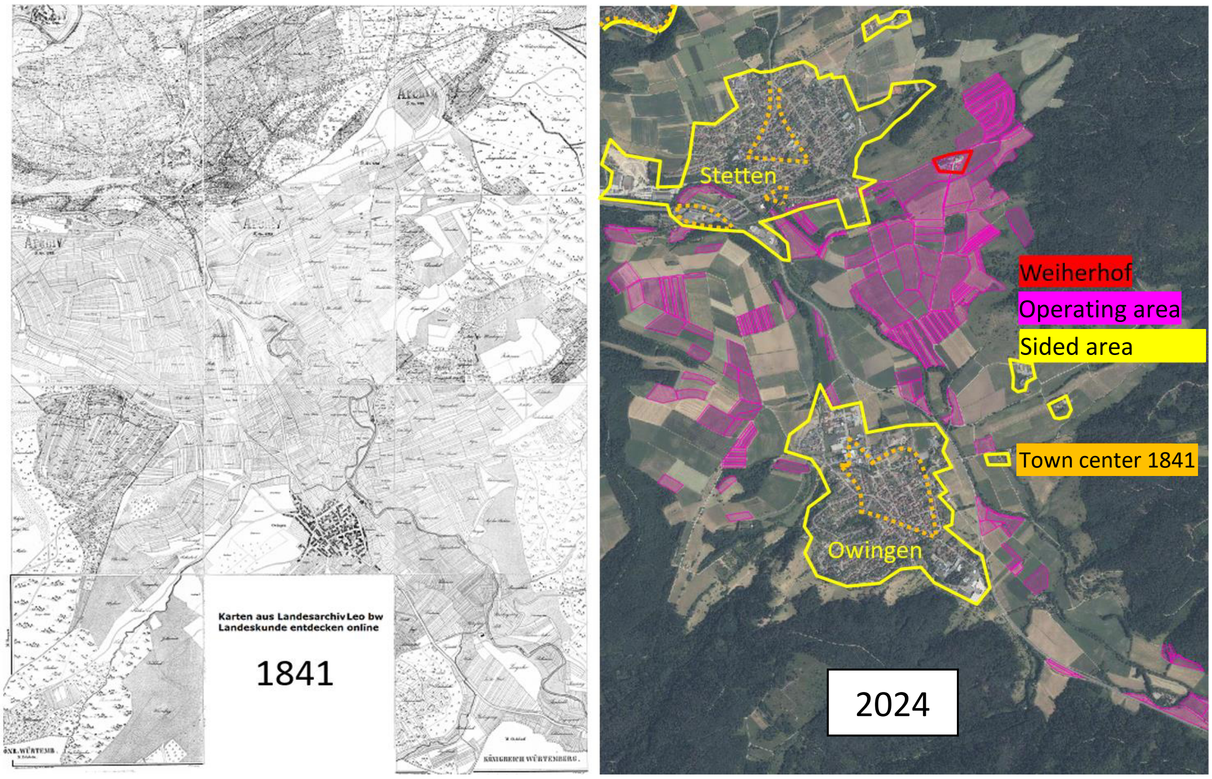


Figure 3: Development of the villages of Stetten and Owingen in a map comparison: 1841 [4] to 2024

Due to a lack of profitability, milk production at the Weiherhof was already discontinued in 2016. In order to keep the farm economically viable, it was decided to convert the existing cowshed for cattle fattening and convert to organic farming. Since this branch of business has also been discontinued again since 2022 for economic reasons, a new, more long-term use for the agricultural land had to be found. However, even after a long search, no suitable concept was available and so a separate farm concept was developed with the Wandernde Wiese® arable farming system, which is now being tested for its effectiveness with the EIP-Agri project of the same name.

2.2 Use of the grant

Personnel costs were the largest cost factor for EIP's Wandering Meadow project and made it possible to finance a 65% position over two years. This total working time was distributed to different people in order to optimally process the diverse work packages and benefit from their different expertise.

Due to the lack of availability of comparable rental machines, the purchase of a side manure spreader was indispensable for the implementation of the project. The side manure spreader represents a long-term investment that will be used both in the current project and in subsequent developments. The acquisition costs of the side manure spreader were refinanced by the wage income of Oliver Schmid and Wilfried Schmid.

The trial area of a total of 14 hectares planned in the project was also doubled to more than 28 hectares during the project period. The aim is to further expand the areas and to integrate the Wandernde Wiese arable farming system into the Weiherhof's operating cycle. For example, a two-hectare field was converted into extensive grassland in the second year of the trial with the findings from the EIP project in order to connect the adjacent nature conservation areas.

The remaining funds were used for analyses, contract orders, seeds and other materials. All costs that would otherwise have been incurred in the regular agricultural operation were not included in the calculation and no financial resources were needed for the scientific advisory board. Thus, the total funding amount of 136,531.58 € applied for could be kept relatively small compared to other EIP projects.

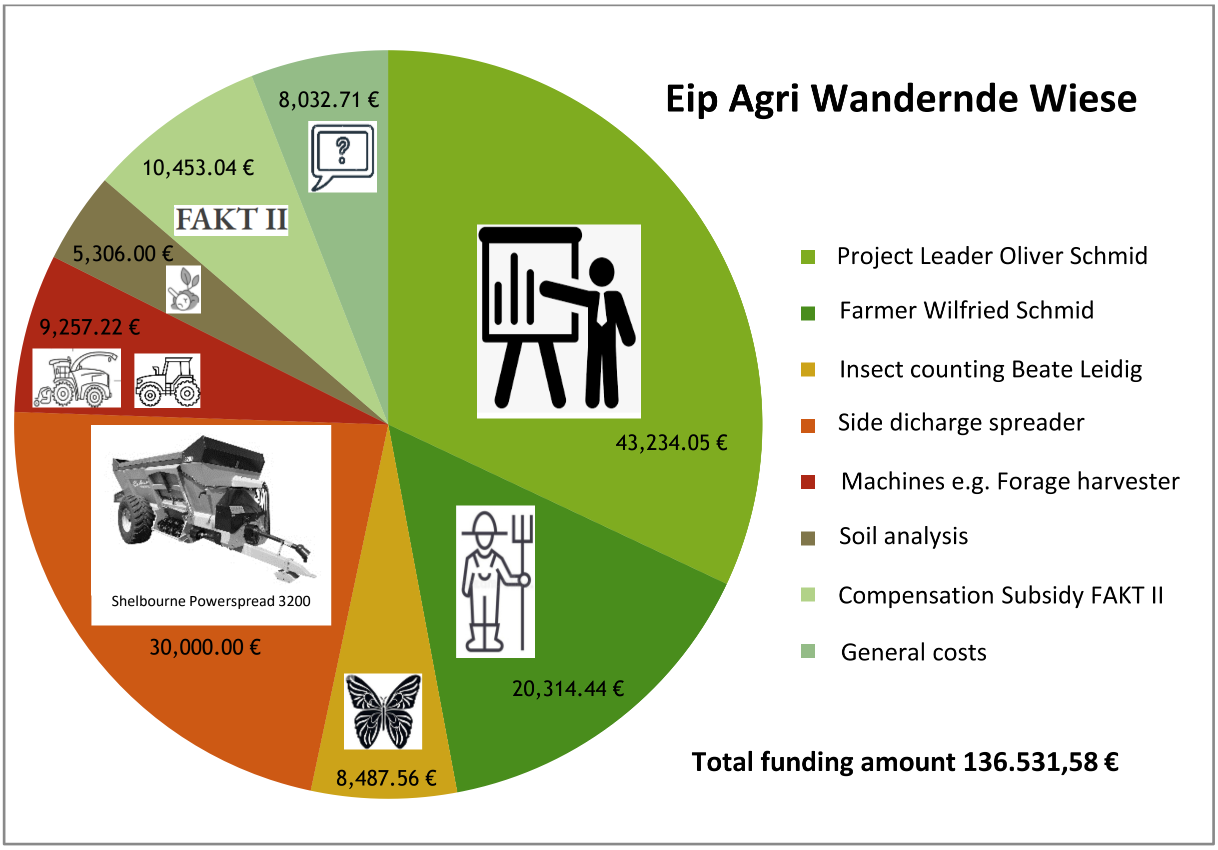


Figure 4: Distribution of the EIP Agri Wandernde Wiese funding volume

2.3 Results of cooperation within the project members

To implement the project, an operational group (OPG) was set up consisting exclusively of people with an agricultural background. This ensured a practical orientation and benefited from already existing contacts between the members. The Scientific Advisory Board, on the other hand, was ready to provide critical support for the project activities and also provided impetus from research. The cooperation between the OPG and the Scientific Advisory Board was coordinated by project manager Oliver Schmid, with the technical implementation always in the hands of the respective experts. This set-up also enabled a quick exchange between the project manager and the respective persons. The disadvantage is that if the project manager were to drop out, a lot of knowledge would be lost at once. In the course of the project, the cooperation between practice and research intensified. For example, Sebastian Löffler from the University of Hohenheim could be won over, who wrote his thesis on the topic of "Wandernde Wiese: Influence of the mowing time on the C/N ratio and the biomass yield". This enabled a partial assumption of work packages and closer supervision by the project manager. The final report bundles the complete knowledge and will be handed over to the Ministry of Food, Rural Areas and Consumer Protection (MLR) in Stuttgart at the end of the project.

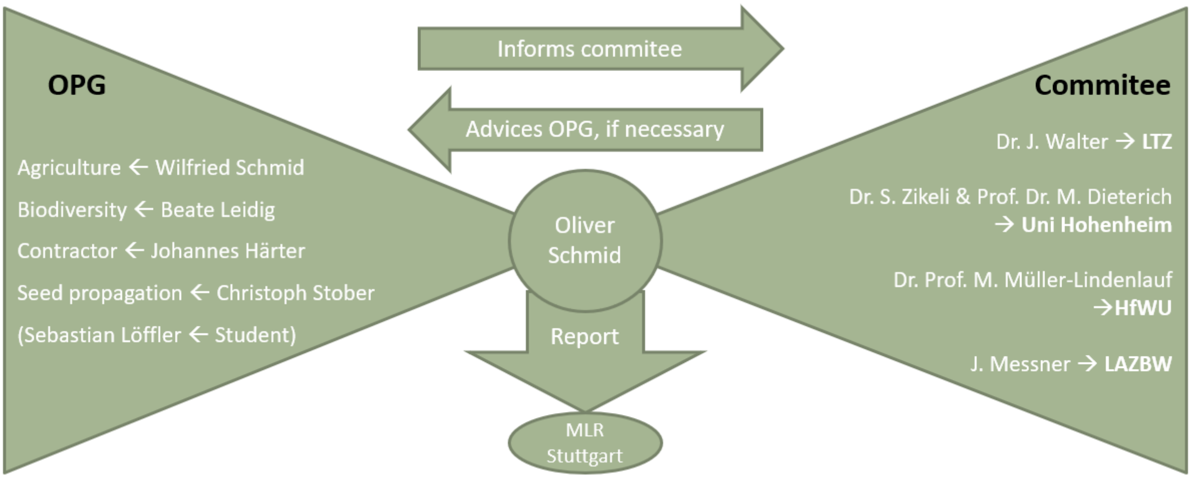


Figure 5: Cooperation between the Operational Group (OPG) and the Scientific Committee

In the course of the project, a total of three large meetings were organized to present the activities and results to all participants. The first and last meeting took place via online conferences, as it was extremely difficult to find a date together. To remedy this, the intermediate results were also distributed at regular intervals by e-mail and larger files were copied to a transfer drive. Thus, all participants always had the opportunity to catch up on the results with the recorded online meetings. The meeting on site gave the participants a deeper impression of the project's approach and offered an ideal opportunity to find out about the next steps and to exchange ideas.

The operational group is to remain in contact after the project so that the respective expert knowledge can always be accessed. The aim is also to further develop the individual sub-projects after the project period.

2.4 Results of the innovation project

At the beginning of the project, three experimental fields were selected on the Weiherhof, which represent a representative area of the Zollernalb district. These areas range from very low-yielding sage-oat meadows to higher-yielding soils with 40 soil points and reflect the diversity of the region. In addition, soil samples were taken from the test fields at the beginning and end of the two-year project period to quantify changes in humus content and concentrations of the macronutrients nitrogen, phosphorus and potassium.

The lowest-yielding site, experimental field 1, is characterized by heavy clay soil with a high tendency to waterlogging, which also dries out quickly in the absence of rain and thus forms deep cracks in the soil. Experimental field 2 is particularly affected by water erosion due to its hillside location and the runoff of water from the mountain. Experimental field 3, on the other hand, has an average yield of 0.5 t/ha higher than the other experimental fields due to the higher silt content and the soil structure is also more finely crumbled. In all test fields, the 18 m wide field fodder strips divide the arable land into 36 m wide arable land. In contrast to other strip cultivation systems, the same main crop such as einkorn, emmer or oats is grown on all strips of land in a given experimental field. Thus, there are two crops on each experimental field, with the field forage strip primarily contributing to increasing biodiversity, humus formation and soil regeneration.

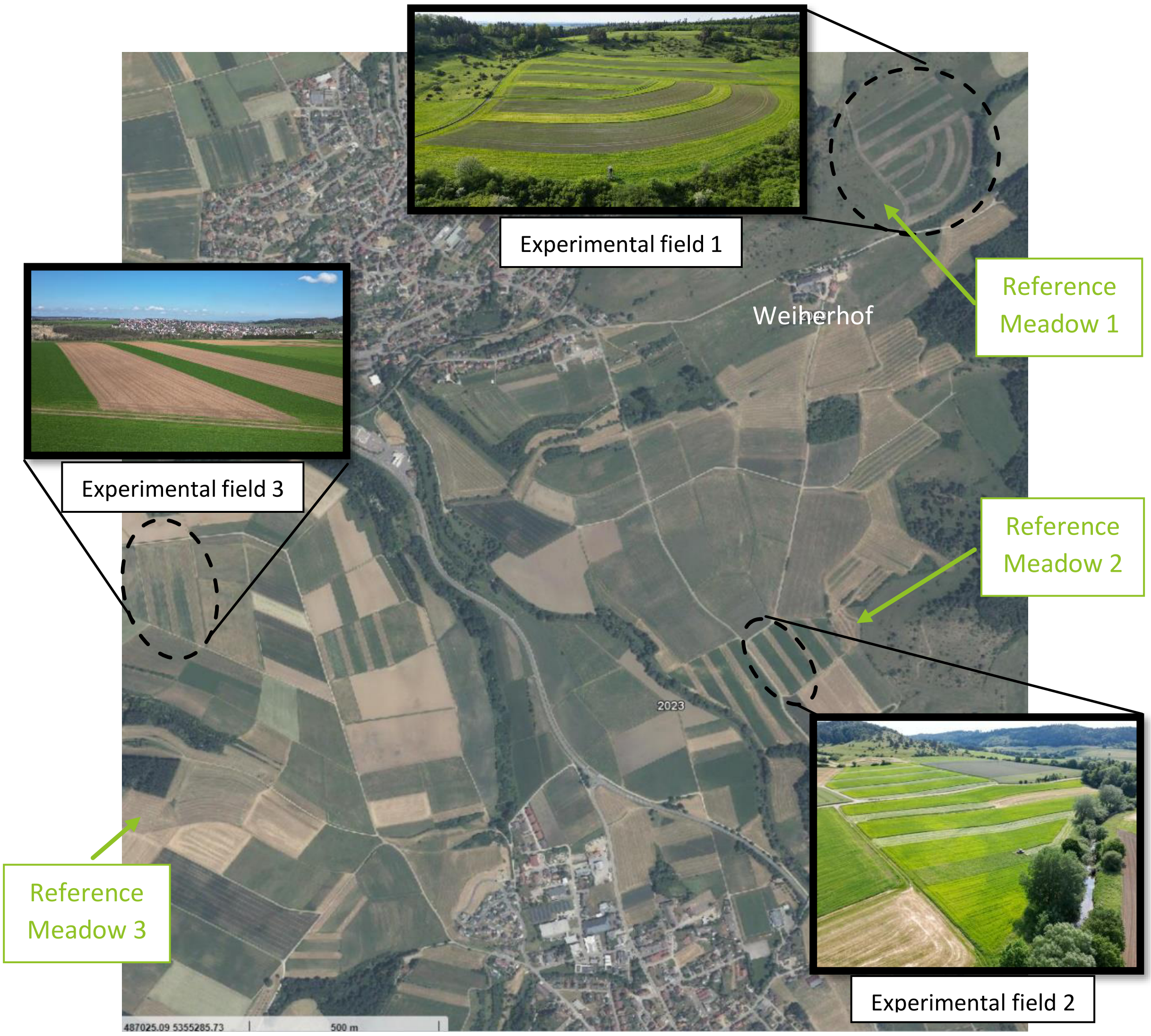


Abbildung 6: Übersicht Versuchsflächen Auszug aus Flächeninformation und Online-Antrag (FIONA) 2023

2.4.1 Alignment of the strips in the experimental fields

The strips in the field were created with the help of a satellite-controlled tractor equipped with a "Real Time Kinetic" (RTK) steering system. As a result, the tractor is able to keep the specified track accurate to 1-2 cm and continue in parallel. The respective track was again calculated from a starting track, for example, which can come from the field boundary, see Figure 7. Alternatively, the starting track can also be freely chosen in arable land, so that it leads through a central obstacle in the field and this is then centrally located between two stripes, see experimental field 2. If, on the other hand, the arable land has a large curve, curves for tracking are also conceivable, see experimental field 1. However, the creation of straight lines in the track system is preferable. Ideally, the strips run transversely to the slope, so that in the event of heavy rainfall, the runoff water can be better held by the alternating strips. For the joint application, each strip was recorded individually as arable field. The geometries may differ slightly from the actual satellite image of the joint application, as the slope of the arable land plays a role in how the stripes are finally represented in the two-dimensional satellite image.

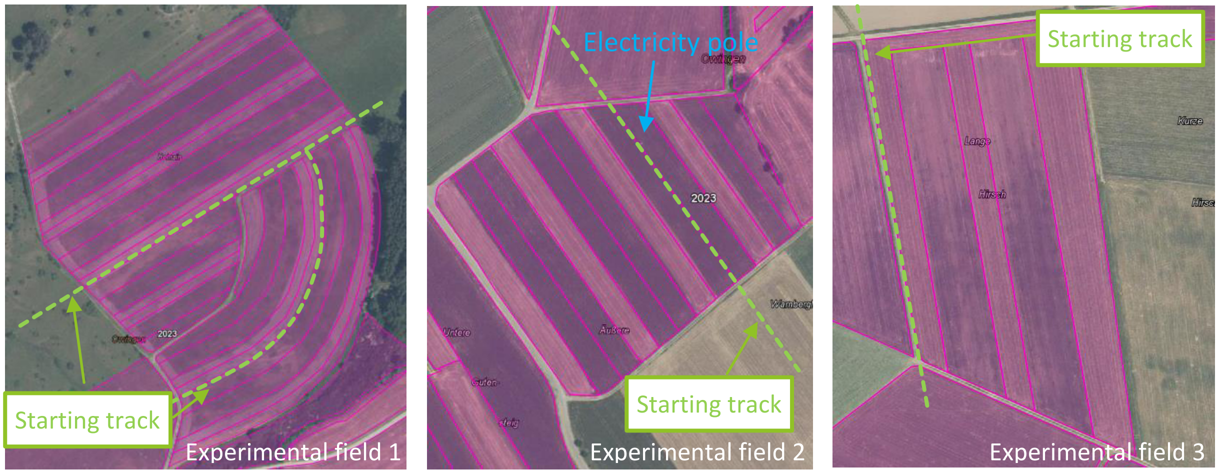


Figure 7: Guidance using primordial lines or primordial curves in experimental fields 1, 2 and 3

To ensure that the different implements on the tractor can be used optimally, separate tracks were generated from the original track for each working width and stored separately. The Weiherhof's agricultural machinery have a working width of 3 m, 6 m and 9 m and therefore fit ideally into the strip width of 18 m and 36 m. The individual track lines are numbered consecutively and are individually recognized by the tractor, so that it is possible to select the correct track line based on the track line number even under difficult visibility conditions. To ensure that there is a certain overlap between the tracks, the implements are configured in such a way that they are approx. 5 cm wider than the specification in the tractor. When sowing the arable crops, on the other hand, the seed drill of the Weiherhof is configured to an outer width of 5.75 m, so that a distance of 25 cm is maintained between the 6 m wide tracks, which is specially subsidized for measure E 13.1 "Lichtäcker (engl. light fields)" in the joint application [4]. This simple method allows the arable land to be programmed quickly. For the use of implements whose working widths do not fit optimally into the strip width, a different approach to tracking is necessary. For this purpose, each strip must be stored in the system as an independent geometry so that the tractor can orient itself directly to the boundary of this contour geometry with the respective implement. The area that has actually been worked is then stored in the system, so that the tractor can continue to drive parallel to the area that has already been worked. In principle, depending on the company's fleet, a company-specific strip width can also be selected.

2.4.2 Experimental field 1 with meadow strips

The forage strips on experimental field 1 differed in that after the sowing of meadow seed, a transfer of mowing material from species-rich permanent grassland also took place. From now on, these forage strips will be referred to as meadow strips, as they are intended to have the highest possible and regionally adapted plant diversity. However, the search for suitable seeds without white clover in organic quality proved difficult due to the limited supply. For example, regional seeds in organic quality were not available. The seeds used come from the two companies Freudenberger "Wieseneinsaat Trockenstandorte" and semopur "6.3 Kräutermischung". The sowing of the meadow seeds could not be carried out until May 21, 2023 due to the wet and cold spring. It should be emphasized here that one half of each meadow strip was sown at twice row spacing (25 cm) and half the seed thickness, so that other plant species can also establish themselves between the rows sown. Furthermore, a long-lasting flash drought occurred after sowing, which ensured that the seeds germinated only slowly and that many wild and weeds spread, see Figure 8.

Figure 8: Wild or field weeds and sown lines in meadow strips on experimental field 1

In order to compensate for this general risk of spring sowing and to establish other regional plant species in the meadow strip, species-rich permanent grassland was used as a donor area for a mowing transfer on 19 June. This method is already used in the “Archewiesenprojekt BW” for the preservation of species-rich permanent grassland and is adopted for the transfer of mowing material [6]. The donor areas were previously assessed by Mr. Jochen Kübler from the environmental office "365° freiraum + umwelt" and the general biodiversity can be classified with level C. For the actual mowing material transfer, the growth of the donor areas was mowed early in the morning on 19 June without mechanical processing and immediately afterwards assembled into swaths. In this way, the risk of falling plant seeds was reduced to a minimum in dense stands. The forage harvester was then able to pick up the mowed plant mass in one operation, chop it and load it one after the other into the two tractor combinations with manure spreader. The chopped biomass was then transferred to the meadow strips in experimental field 1 and finely distributed. The ratio of the areas was about 1:1.

Figure 9: Mowing transfer of species-rich permanent grassland in experimental field 1

The meadow strips showed a good development after the first rainfall in summer. However, in order to achieve an optimal stock, two cleaning cuts were necessary in the first year. Due to the still low root depth of the plants, a light tractor with a soil-protecting double-blade mower was used. This first cut then significantly improved the visibility of the individual rows. The plants from the mowing transfer were not yet visible at that time.

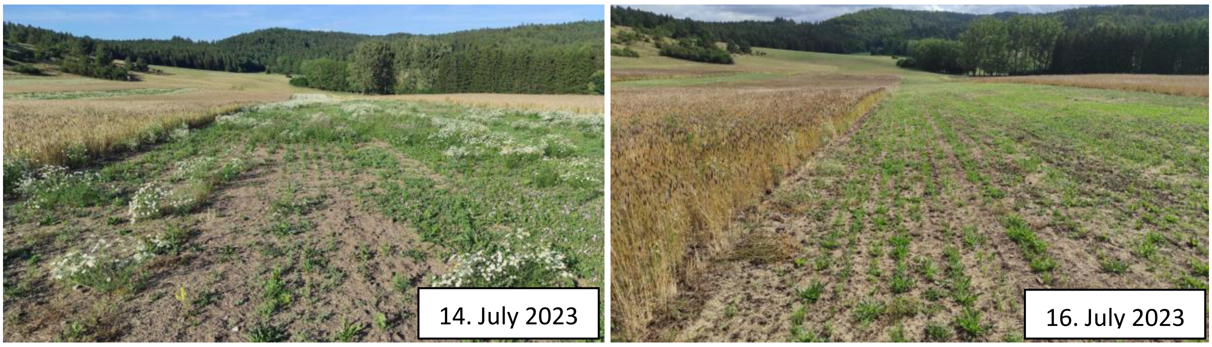


Figure 10: Meadow strips before and after the first cleaning cut with double knife bar mowers

The appearance of the meadow strips has changed greatly by the time of the second clean-up cut. There were now more grasses, legumes and herbs from the mowing transfer. Due to the denser vegetation, the subsoil became load-bearing and thus the growth could be mowed in autumn with a 9 m disc mower combination, see Figure 11. In addition to caraway and fennel from the seeds, there were still many pioneer plants such as chamomile and laurel. In both cleaning cuts, the mowed growth was left on the strips so that the organic matter contributes as much as possible to the humus build-up in arable farming. In the second year of the trial, a very good population developed on both variants, each of which came very close to a species-rich meadow. Between the single and double row spacing, no significant differences could be found either in the amount of growth or in the diversity of species.

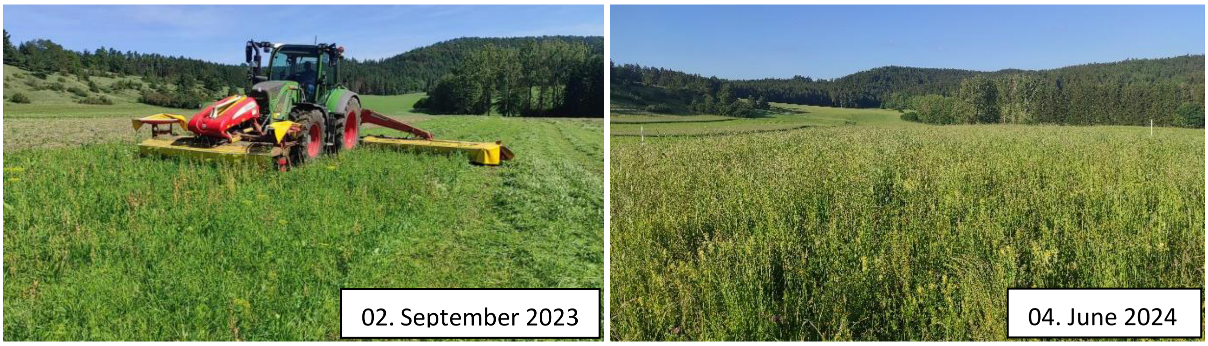


Figure 11: Meadow strips after the second clean-up cut and next summer

The meadow strips were mowed down only once in the second year of the trial and the growth was left lying around. The considerable amount of organic matter caused wild boars to start churning up the turf along the mulch cover. It can therefore be assumed that the increased amount of organic material contributes to increased soil activity and thus also attracts larger organisms, which in turn use this additional food supply.

2.4.3 Experimental field 2 with alfalfa grass strips

Two years before the start of the project, experimental field 2 was sown with alfalfa grass over the entire field and then tilled into strips at the start of the project in autumn 2021. The alfalfa was thus in its third year at the start of the project and was accordingly deeply rooted. Because only shallow soil cultivation was carried out for the ploughing, alfalfa repeatedly prevailed in the arable strip in the following years. Deep tillage with the cultivator, on the other hand, has the disadvantage that clods of soil are transported from the strip of arable land to the adjacent alfalfa grass strip. These clods of soil are then caught by the mower during the next mowing, which in turn greatly increases the wear and tear of this machine. In the second year of the trial, mechanical soil cultivation was optimized by using the "Acticut" cutting cultivator and adapting it to strip cultivation by 4Disc. The cutting discs of the cultivator enable minimal cultivation of the soil over the entire surface and the newly installed side boundaries kept the removed soil within the arable field strips.

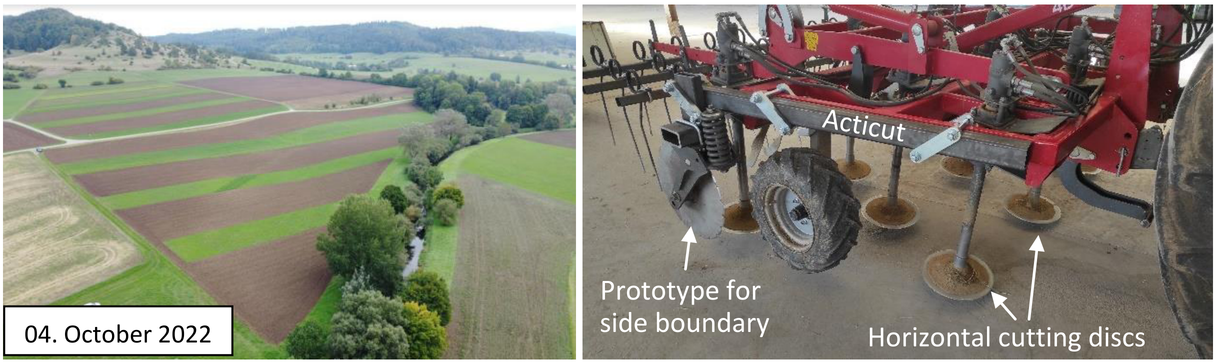


Figure 12: Alfalfa grass strips in experimental field 2 after partial tillage in strip form

2.4.4 Experimental field 3 with clover grass strips

In experimental field 3, the clover grass was sown in strip form before the start of the project in autumn 2020. The 18 m wide clover grass strips were laid out by six adjacent tracks with a 3 m wide seed drill. Until the next strip of clover grass, 12 tracks were then left free, so that the 36 m wide strip of arable land could later be sown with grain, see tractor monitor in Figure 13.

Figure 13: Sowing the strips of clover grass in Experimental field 3 in strip form

Experimental field 2 and 3 thus reflect a cost-effective way in which field forage strips can be established in arable land using only seeds. However, the number of plant species planted is limited to the respective seed.

2.4.5 Determination of plant species and biomass tag by Sebastian Löffler

As part of his bachelor's thesis, Sebastian Löffler examined the meadow strips on experimental field 1 in detail. On two separate days, all plant species occurring were recorded and compared with those of the donor areas from which the mown material originated. The results showed that a total of 59 different plant species have established themselves on the meadow strips. The majority of these species could not be traced back to the seeds sown, but came from the mowing material of the donor areas. Particularly noteworthy is the occurrence of a total of 10 characteristic species for FFH mowing meadows such as field widow's flower, meadow sage, meadow pippau, meadow goat's beard and daisy. A detailed list of all identified plant species can be found in the appendix.

Figure 14: Origin of plant species in meadow strips after one year

In order to quantify the increase in plant mass, the forage strips on the three test fields were sampled on three different dates from the beginning of May. Three representative sub-areas were selected on each field. According to the yield potential map, which is based on satellite data from the Copernicus programme, these sub-areas were as homogeneous as possible. The colors in the map indicate the expected yield, see Figure 15.

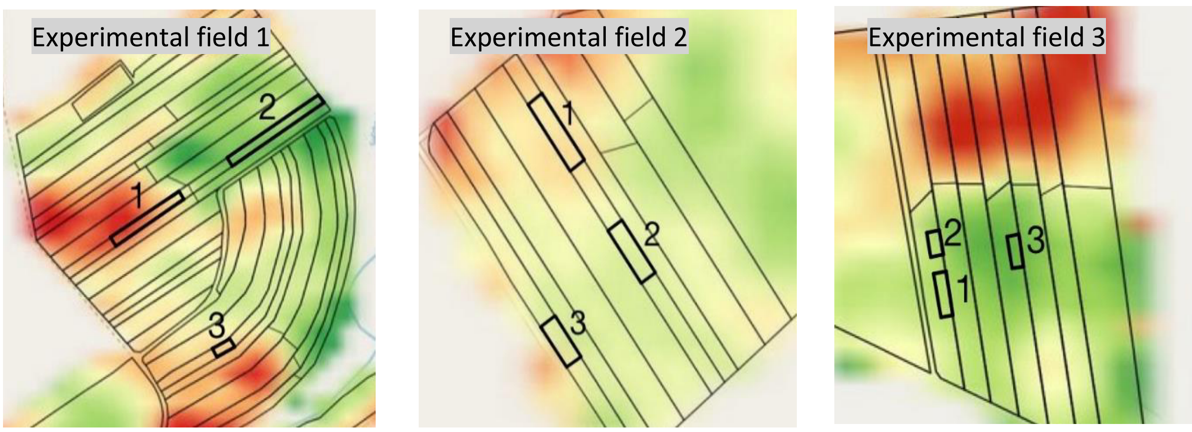


Figure 15: Yield potential maps of the experimental fields, green = high, red = low

In the different blocks, three repeat measurements were then examined, each with an area of 0.5 m², see black marking in Figure 16.

Figure 16: Test blocks in the test fields

The 81 sample areas were assessed in terms of their proportion of herbs and the proportion of unvegetated areas was determined. The clippings from each sample area were then collected in perforated plastic bags, dried and weighed. The carbon and nitrogen content of the dried material was also determined.

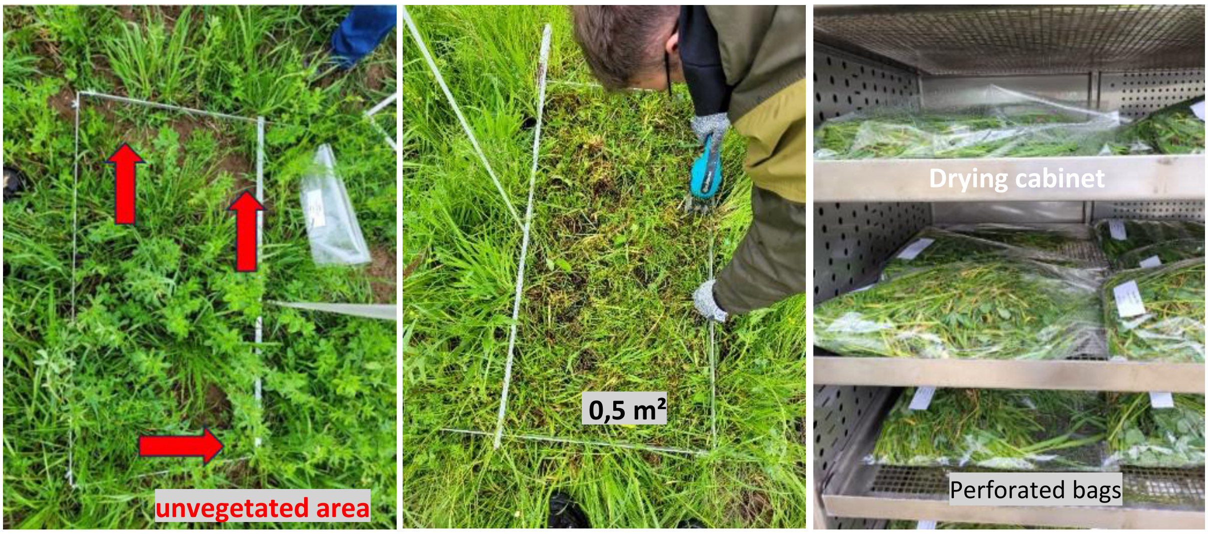


Figure 17: Sampling of test areas and sample preparation

The herb content in the meadow strips on Experimental field 1 was 18 %, while it was only 0-1 % in the alfalfa grass and clover grass strips of the other experimental fields. The proportion of unvegetated areas was comparable in the meadow and clover grass strips and ranged between 2-9 %. For four-year-old alfalfa grass strips, this proportion was already higher at 13%. Figure 18 shows the increase in dry matter per area over the study period. Until 24 May, the meadow strips had yields comparable to those of the alfalfa grass stands. Thereafter, a continuous increase in yield of the alfalfa grass strips continued and on 7 June was only slightly below the dry matter of the clover grass stand on the higher-yielding Experimental field 3. The chemical analysis on the right showed that the C/N ratio of the meadow strips corresponded to that of the clover grass. In contrast, the alfalfa-grass mixture had a consistently higher protein content and thus a lower C/N ratio.

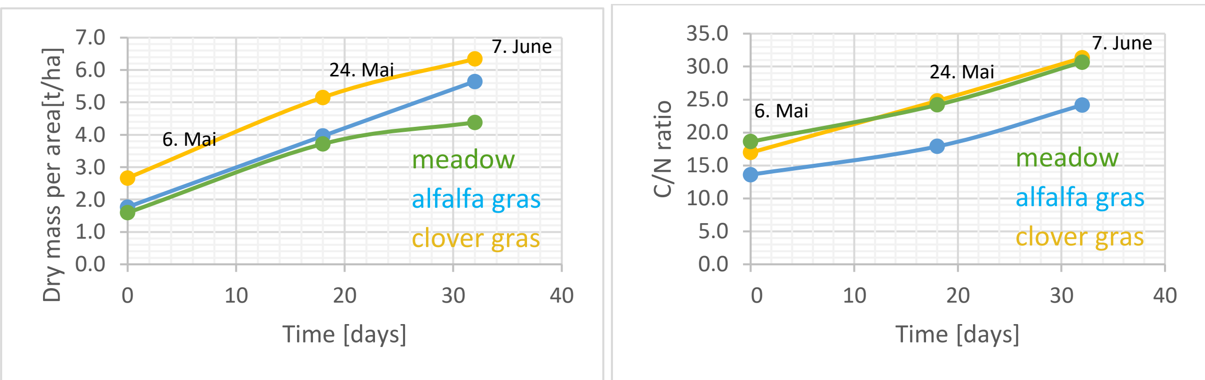


Figure 18: Increase in averaged dry matter per area and C/N ratio over time

Parallel to the investigation of plant species identification and their yields, the forage strips were also analysed with regard to their effects on insect fauna.

2.4.6 Insect counts by Beate Leidig

Of the planned eight insect counts, only six were carried out in the two years of the trial. Because of the long, cold spring of 2023, the development of vegetation and insect activity began very late. Therefore, no meaningful data could be collected in the first spring. Later in the project, insect counts were carried out on sunny and windless days by slowly passing through the previously measured transects. This did not involve a targeted search in the population, but rather recorded as many insects as possible that could be seen with the naked eye. The insects discovered were divided into the groups bees, grasshoppers, butterflies, moths, flies, spiders, beetles, hymenoptera, bugs, cicadas and others. The group "Other" consists of specimens that were able to hide too quickly when passing through before an exact identification was made. The individual groups of insects were in turn divided into several subcategories such as wild bees, bumblebees and honey bees. The number of insects smaller than 5 mm has been noted, but is not included in the total. In order to obtain comparable results between the investigated areas, all insect counts were carried out in 5 m wide transects. These transects were staked out across the strips of the respective experimental field with the help of plastic posts, whereby the length of the respective transect was already known by the respective strip width. On the other hand, a single 5 m x 50 m transect was defined on each reference area in permanent grassland. From the large amount of data, a simplified representation was finally generated by normalizing the number of all insects in the respective strips to 100 m². An overall mean value was then calculated from the mean values of all stripes of an experimental field. Figure 19 illustrates a direct comparison of the insect numbers in the three field forage strips examined over the trial years. In the first count, the alfalfa grass and clover grass strips had significantly higher insect numbers than the meadow strips. This is due to the fact that the legumes were in full bloom and thus offered an attractive food supply for insects, while the plant populations in the meadow strips were not yet fully established. The subsequent counts showed a decline in insect populations in the alfalfa grass and clover grass strips. The reason for this is the decreasing flowering supply, which declined sharply, especially from the third or fourth year onwards.

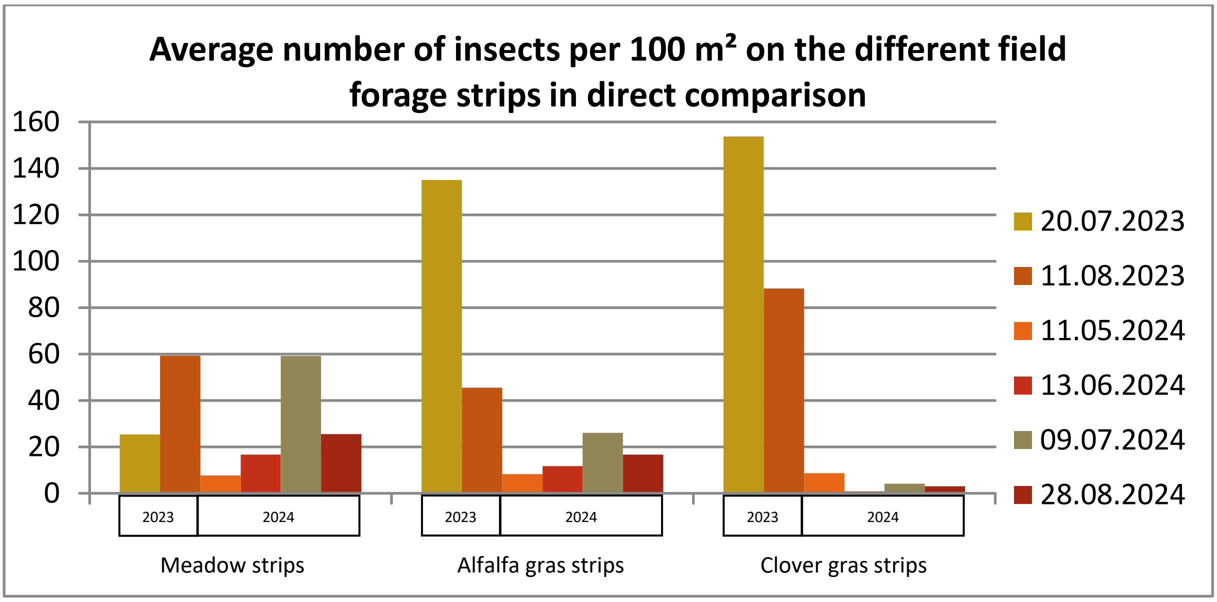
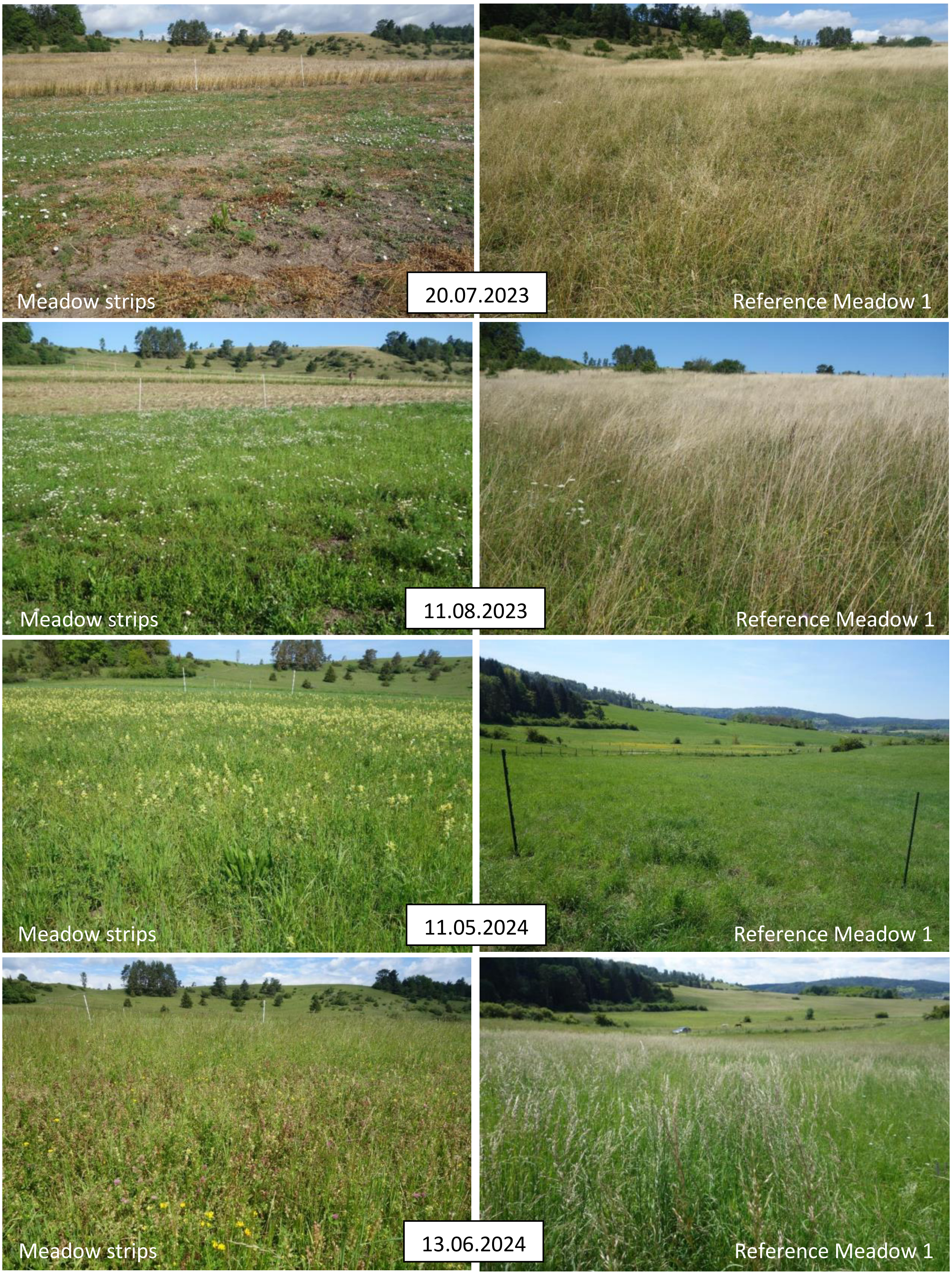


Figure 19: Average number of insects per 100 m² on the field forage strips in direct comparison

The temporal development of the individual forage strips is vividly illustrated in the following series of pictures and supplemented by a detailed list of insect numbers.

On Experimental field 1, the meadow strips showed a drastic development over the trial period. In the beginning, the sparse colonization with pioneer plants was still more like a fallow land, so that hardly any insects were to be found here. However, the trial area was able to develop into a species-rich meadow structure within one year due to the summer precipitation and the two clean-up cuts. The large number of different plants in turn also means that, as with the reference plot, a constant food supply was available over the rest of the experimental period.



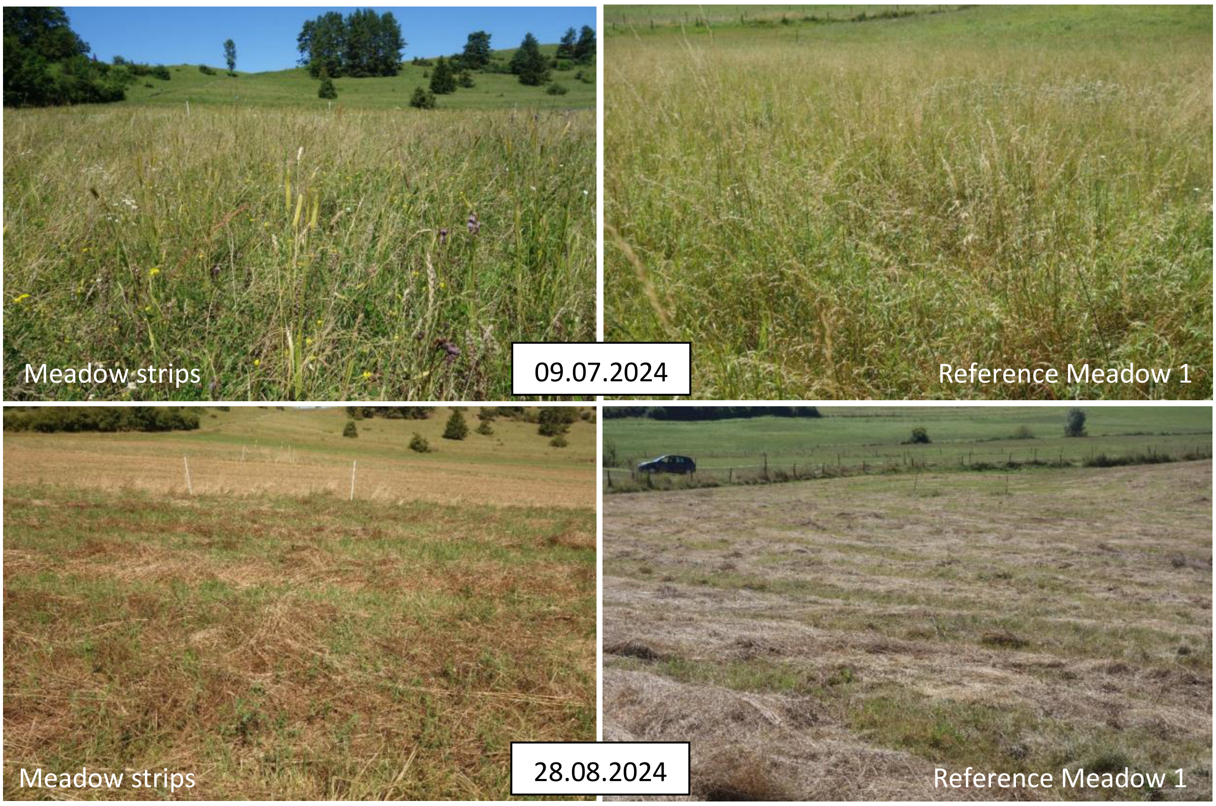


Figure 20: Comparison between meadow strip and reference area in all insect counts

The series of images clearly shows that the number of insects is closely linked to the food supply and the habitat quality of the areas. While the meadow strips had a lower insect diversity in the first year than the permanent grassland area 1, a higher number of insects could already be detected in the second year due to the abundant supply of flowers. The particularly high insect activity in 2023 is primarily due to a strong reproduction of locusts, which failed to materialize in 2024.

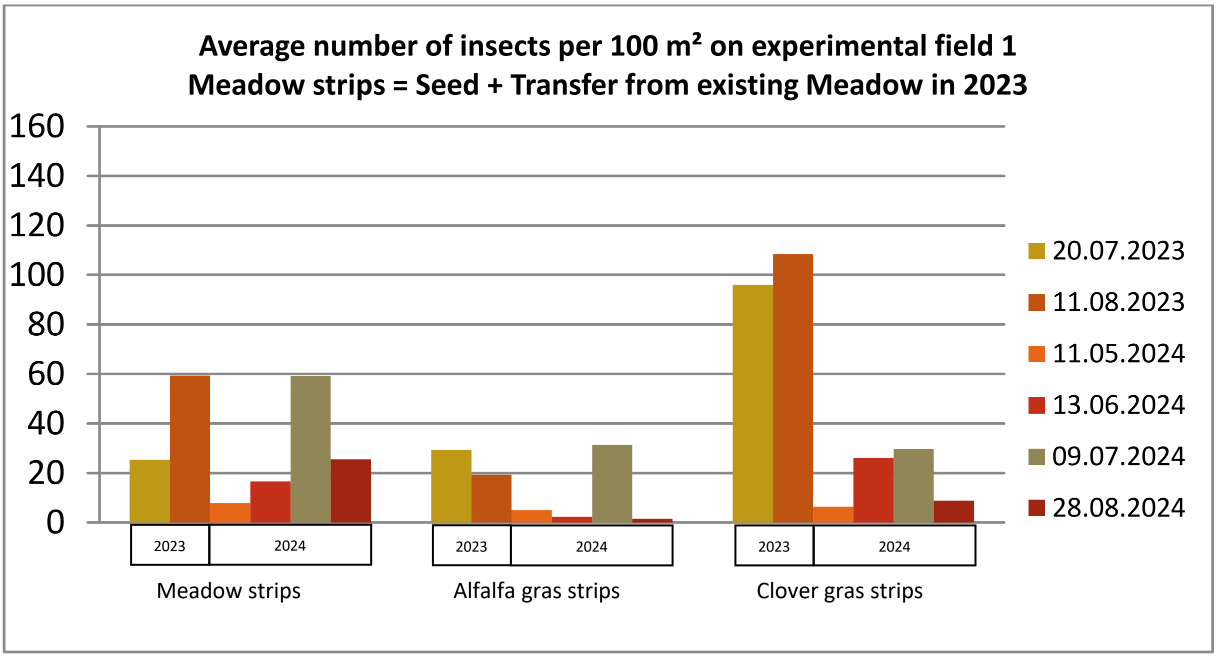


Figure 21: Mean number of insects per 100 m² on experimental field 1

The alfalfa grass in experimental field 2 was able to establish itself before the start of the project, so that in the first year of the trial there was already a deep-rooted stand in the field. This could then accommodate a very high number of insects in full bloom. It is remarkable, however, that in the second year of the trial, no more significant alfalfa flowers were formed in the alfalfa grass strips. The nearby reference area 2 has a large number of plants as a mapped FFH mowing meadow, whereby old grass strips were deliberately left standing.

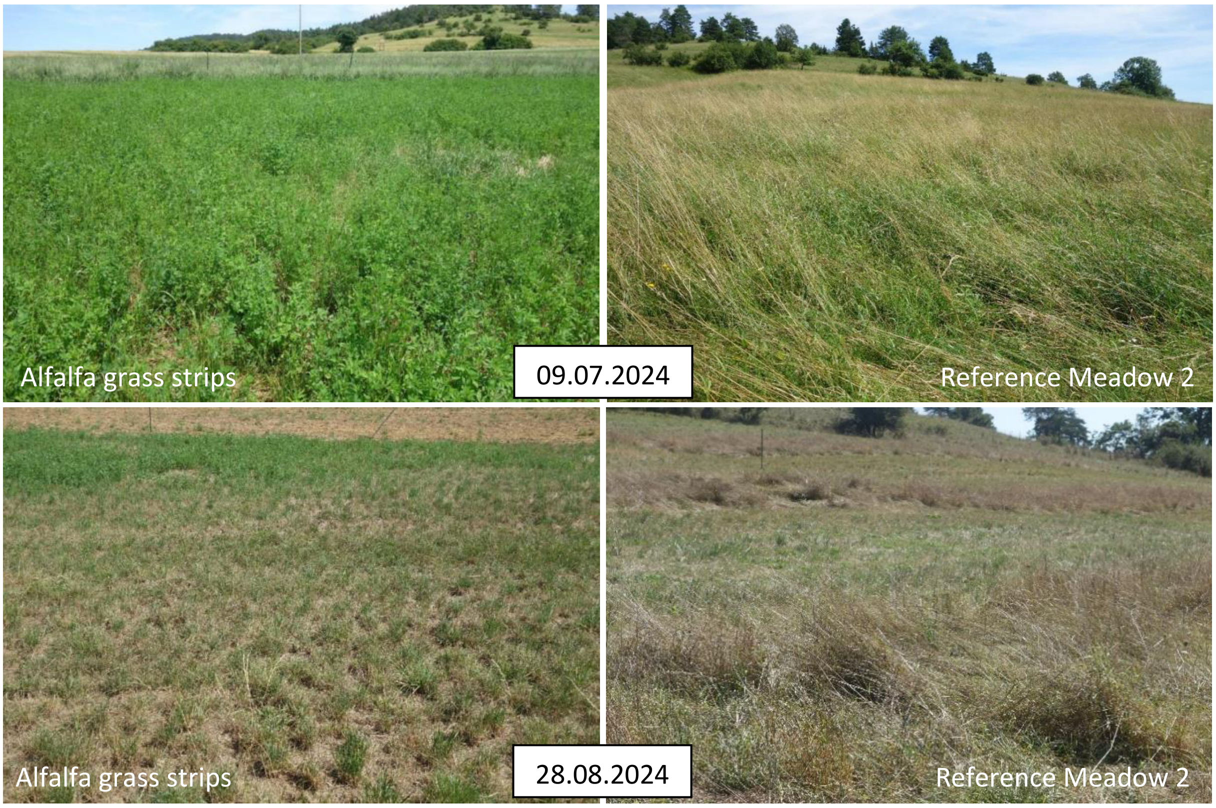


Figure 22: Comparison between alfalfa grass strips and reference area in all insect counts

The second series of images clearly shows that the number of insects is closely linked to the food supply and the habitat quality of the areas. In this case, alfalfa is the main food source responsible. However, as soon as this is no longer available, the offer will also cease to exist. The high number of insects on the arable strips in July 2024 is attributed to the oat-lentil mixture and the flowering alfalfa growth. Shallow tillage with disc harrow and cultivator meant that the alfalfa could only be completely removed by the end of the project.

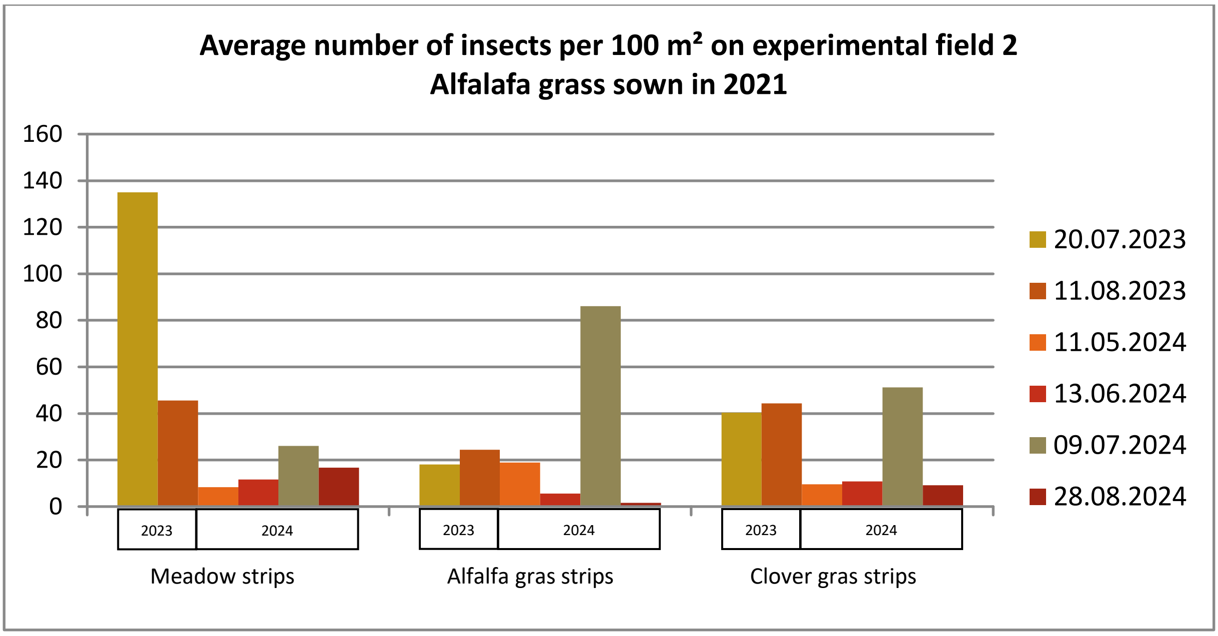


Figure 23: Mean number of insects per 100 m² on experimental field 2

At Experimental field 3, a very high incidence of insects can again be observed for the clover grass strips in the flowering population. However, it can also be seen here that in the second year there were hardly any clover flowers and the grasses dominated. In comparison, the reference surface shows a strongly changing appearance over the project period.

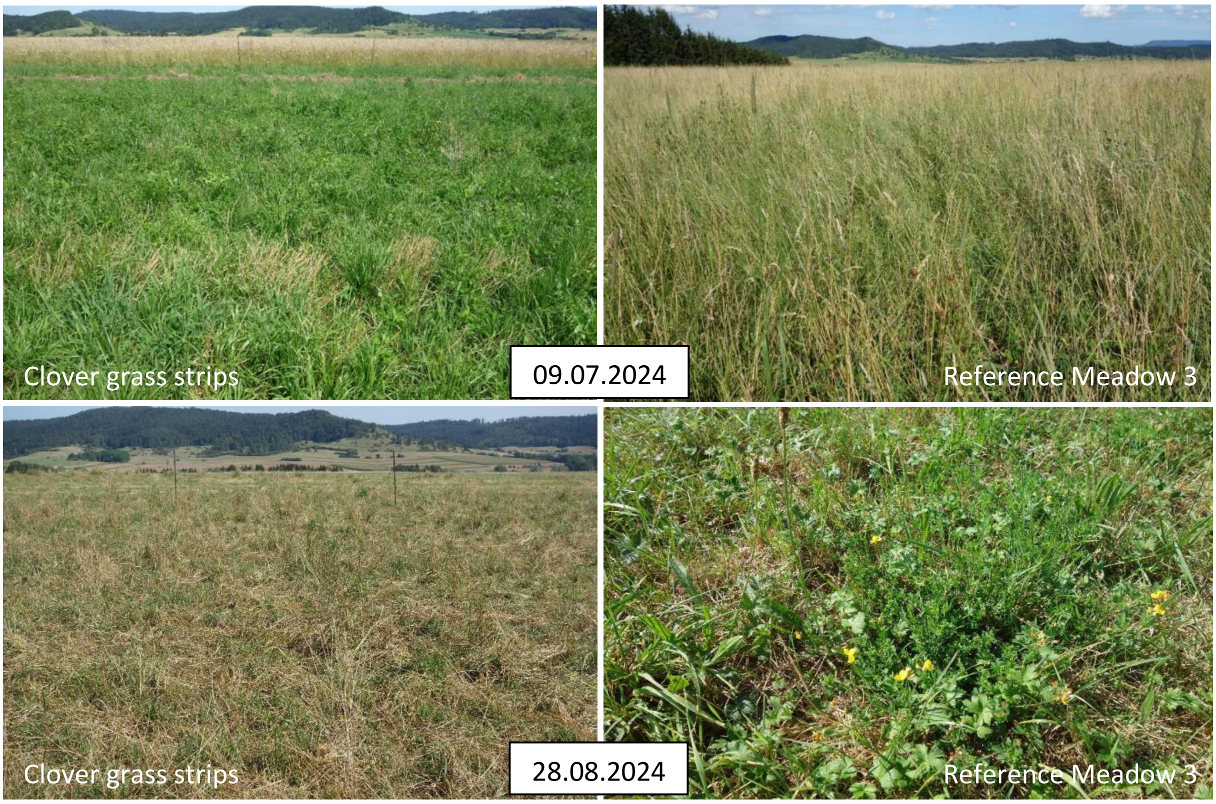


Figure 24: Comparison between clover grass strips and reference area in all insect counts

The last series of images shows most clearly that the number of insects is closely linked to the food supply and the habitat quality of the areas. As soon as the clover flowers are absent as a food source, there are hardly any insects left, see Figure 25. The high number of insects in the 2023 arable strip is due to the flowering undersowing caused by the transfer mulch. A detailed description of this method will follow in the next chapter.

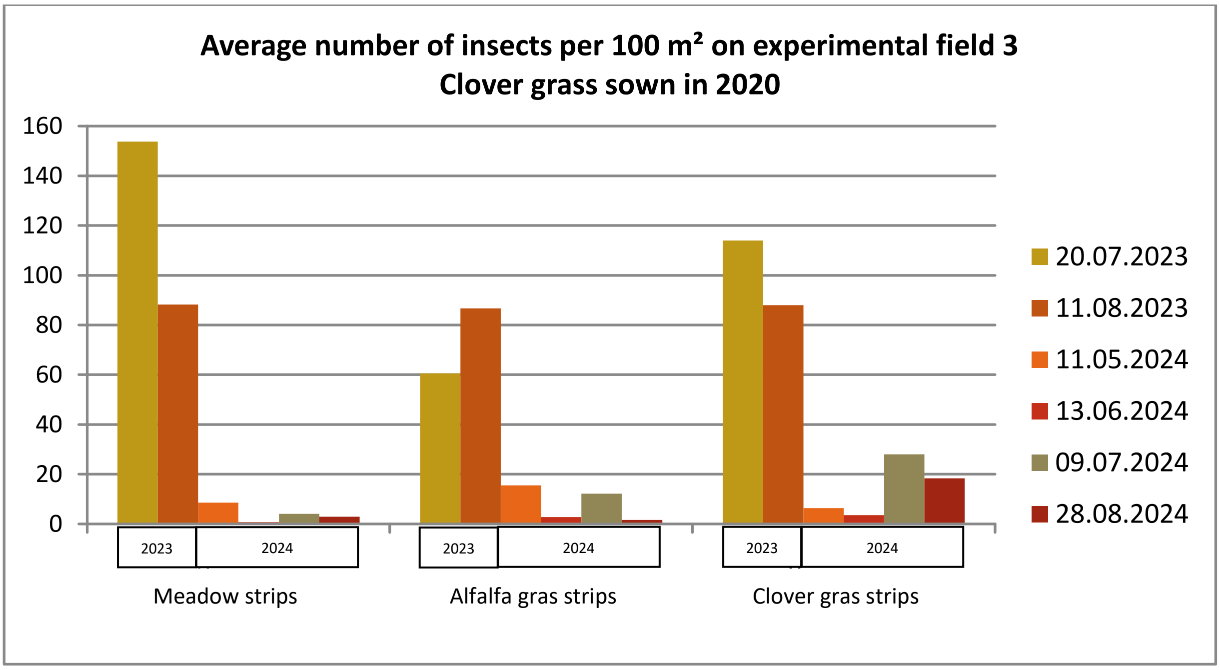


Figure 25: Mean number of insects per 100 m² on experimental field 3

2.4.7 Transfer mulch transfer

As before, the growth of the meadow strips can also be transported away as hay or silage. However, strip cultivation results in another possible use as transfer mulch. The aim is to transfer the biomass directly to the adjacent arable strips without transport costs, without heavy agricultural machinery driving over the arable strip. The green manure applied should then contribute to higher yields in arable cultivation and general humus formation. It is important to ensure that the throw distance of the transfer mulch is as high as possible and that the distribution is as even as possible. Three different variants were available for the application of the transfer mulch, which were tested in terms of area performance, throwing distance and distribution, see Figure 26. It should be emphasized that all three variants should be carried out when there is no wind, as the individual finely chopped plant components have hardly any mass and are very easily deflected by the wind due to the high surface area. The forage harvester was deliberately chosen oversized, so that its performance was not the limiting factor.

Figure 26: Comparison between application methods for transfer mulch transfer

The simplest variant was a forage harvester with an adapted discharge pipe. For the wide distribution of the shredded material, Johannes Härter built two different models for the ejection distributor. Model 1 deflects the emerging biomass jet downwards in a fan-like manner using diagonally arranged plates, thereby achieving an even distribution to the left and right. Model 2, on the other hand, scatters the mass to the side at different angles, resulting in different distances. Both models have the disadvantage that the exit speed of the chopped biomass is reduced, which in turn limits the travel speed of the forage harvester. Driving at too high a speed would increase the risk of clogging the wide distributor. Despite this limitation, the distribution of the shredded material over a width of 6 m was satisfactory. The high drop height of the discharge tower ensured that the transfer mulch was evenly distributed over the area before it reached the ground. As a result, the material could even be gently applied to growing grain crops. However, care should be taken with arable crops with low stability, as the additional weight of the mulch can lead to twisting. A high-water content in the mulch material increases this risk considerably, especially if a lot of organic matter is applied selectively.

An actively driven accelerator would help to further distribute the escaping biomass. For this purpose, a tractor with an attached throwing fan was used, which in turn also serves as an intermediate storage for the biomass. This is particularly advantageous if there is no adjacent field strip next to the field forage strip. The large propeller allowed a strong air flow to be generated by the throwing fan, which transported the chopped biomass up to 18 m. However, since the mass throughput of 2 km/h is very low, this method was not pursued after two uses.

The best variant has proven to be the side manure spreader. This can spread the chopped biomass most quickly by means of an actively driven milling drum and also shows a very good distribution. The 1.4 m long milling drum rotates at 700 rpm and transports the shredded material to the side at different throwing angles. The large screw conveyor inside ensures a constant flow of material to the rotor and the filling volume is also the highest at 15 m³. The throwing distance decreases from a maximum of 15 m to up to 12 m at higher driving speeds.

Table 1: Variants for spreading the transfer mulch with forage harvester

	Transfer mulch application with forage harvester and …		
Variant	Wide distributors	Throwing blower	Side discharge spreader
Filling volume	none	7 m³	15 m³
Working speed	5 km/h	2 km/h	6 - 9 km/h
Throwing distance	6 m	18 m	15 - 12 m
Area performance at 9m swath width	4,5 ha/h	1,8 ha/h	5,4 - 8,1 ha/h

Higher work speeds can directly increase the area output, which ultimately leads to lower costs per hectare. Furthermore, the transfer mulch transfer in strip cultivation is independent of transport costs and always manages with a single side manure spreader. In contrast, the Cut&Carry system requires at least two standard manure spreaders to alternately transport and distribute the chopped plant mass from the donor to the recipient field. As the distance between the encoder and recipient fields increases, more standard manure spreaders are required in the Cut&Carry system to maintain the chopping chain, which in turn increases the cost of spreading. The full load of standard manure spreaders continues to lead to increased soil pressure, which leads to greater soil compaction and thus to reduced yields in the following years. In strip cultivation, the simultaneous filling and spreading of the chopped plant mass ensures that the side manure spreader is usually only partially filled, thus significantly reducing the soil pressure on the substrate. Furthermore, the side manure spreader is only moved over the already deeply rooted ground and the adjacent arable plants are not driven over. These advantages also apply to the application of farm manure, which is often limited in time due to unsustainable soils in spring.

Due to the limited throwing distance of the side manure spreader, the 36 m wide strips of arable land could not be completely supplied with transfer mulch from the adjacent meadow strips. The resulting unfertilised median strips served as untreated control areas in order to better compare the effects of fertilisation on soil conditions over the two-year project period.

2.4.8 Effects on the soil and landscape

The applied transfer mulch, as a protective layer, improved the conditions for the subsequent crop by regulating soil moisture, promoting soil life and thus contributing to higher soil fertility. At the same time, the transfer mulch provided valuable nutrients that contribute to the stronger growth of the subsequent crop. If no forage harvester is available, the mowed plant mass from the forage strips can also be transferred to the field strips with a loader wagon. Through the subsequent shallow soil cultivation with a disc harrow, the organic matter was evenly incorporated into the soil. This led to an improved soil structure and promotes the formation of stable crumbs, which in turn can store water and nutrients better. The induced area rotting also promotes soil life and accelerates the decomposition of plant residues. For example, a legume-free cover crop can grow into a dense stand due to the additional nutrient supply from the transfer mulch or, as in the case of the zero plot without transfer mulch, remain patchy, see Figure 27.

Figure 27: Effect of different transfer mulch quantities on subsequent legume-free cover crops

In order to be able to make a statement about the change in soil condition, a soil sample was taken at the beginning and at the end of the project by the service provider "Soil Samples from Farms". For each soil sample, at least 15 punctures were made to a depth of approx. 20 cm, whereby the position coordinates and the driving route on the strips were recorded in the map material. Subsequently, all soil samples were analyzed by the Lehle soil laboratory for humus, pH value and the nutrients phosphorus, potassium and magnesium. For the humus analysis, the carbonate content in the soil was previously eliminated by adding acid. Subsequently, a weighed soil sample was burned in the oxygen stream at 1350 °C and the CO2 released was analyzed with an infrared spectrometer. The measured value then corresponds to the TOC value (Total Organic Carbon) and can be converted into humus percent by a factor of 1.72.

The meadow strips on Experimental field 1 show a humus build-up of 0-1.2 % in two years, whereby the adjacent arable strips did not change their mean humus content. The arable crops were fertilized with horse and sheep manure with a total amount of 10 t/ha per year. Within these two years, no organic matter was removed from the meadow strips, where the grain yield of an average of 3 t/ha is to be considered in the field strip. In the case of test fields 2 and 3, organic matter was transferred in the form of transfer mulch from the alfalfa grass and clover grass strips to the adjacent arable strips. This measure ensured that the humus content in the alfalfa grass or clover grass strip was reduced and credited to the arable strip. The high humus build-up on experimental field 3 varies from 0.4 to 1.0 %, as the remaining amount of straw was also transported away from arable farming in different proportions.

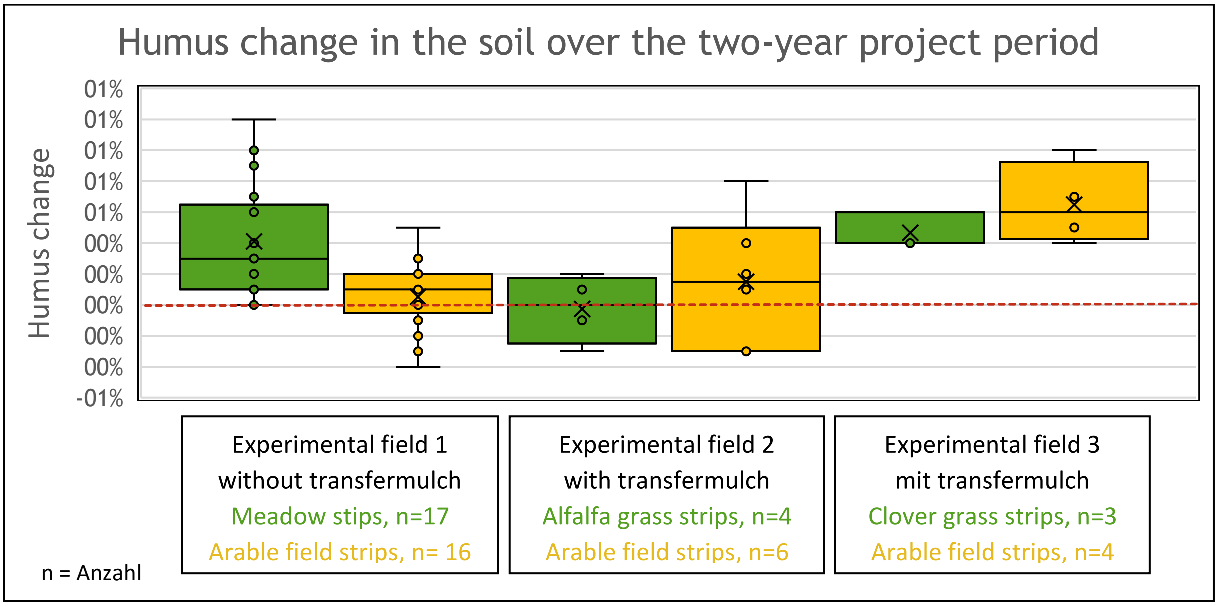


Figure 28: Humus change in the soil during the two-year project period

The supply of large quantities of organic matter, as is done by the application of transfer mulch, promotes humus formation in the soil. However, this process is subject to strong fluctuations, which are influenced by different weather conditions and soil conditions from year to year. In addition to carbon, which is essential for humus formation, the transfer mulch also introduces other important plant nutrients such as phosphorus, potassium and magnesium into the soil. The amounts of nutrients transferred are then in turn dependent on the amount of transfer mulch, which will usually be higher in wet years.

Due to the deliberately late transfer of the transfer mulch, the plants in the field forage strips were able to grow to flowering and thus create a valuable habitat for insects and other animals. However, the late application also means that the nutrients from the transfer mulch are only available after the ears have been pushed and can therefore not be efficiently transferred to the growing arable crop, see Figure 29. It is also not possible to mechanically incorporate the plant mass from the transfer mulch, as the growth of the arable crops was already too advanced. It is therefore not possible to estimate exactly how many nutrients will remain or be lost in the soil until the next crop.

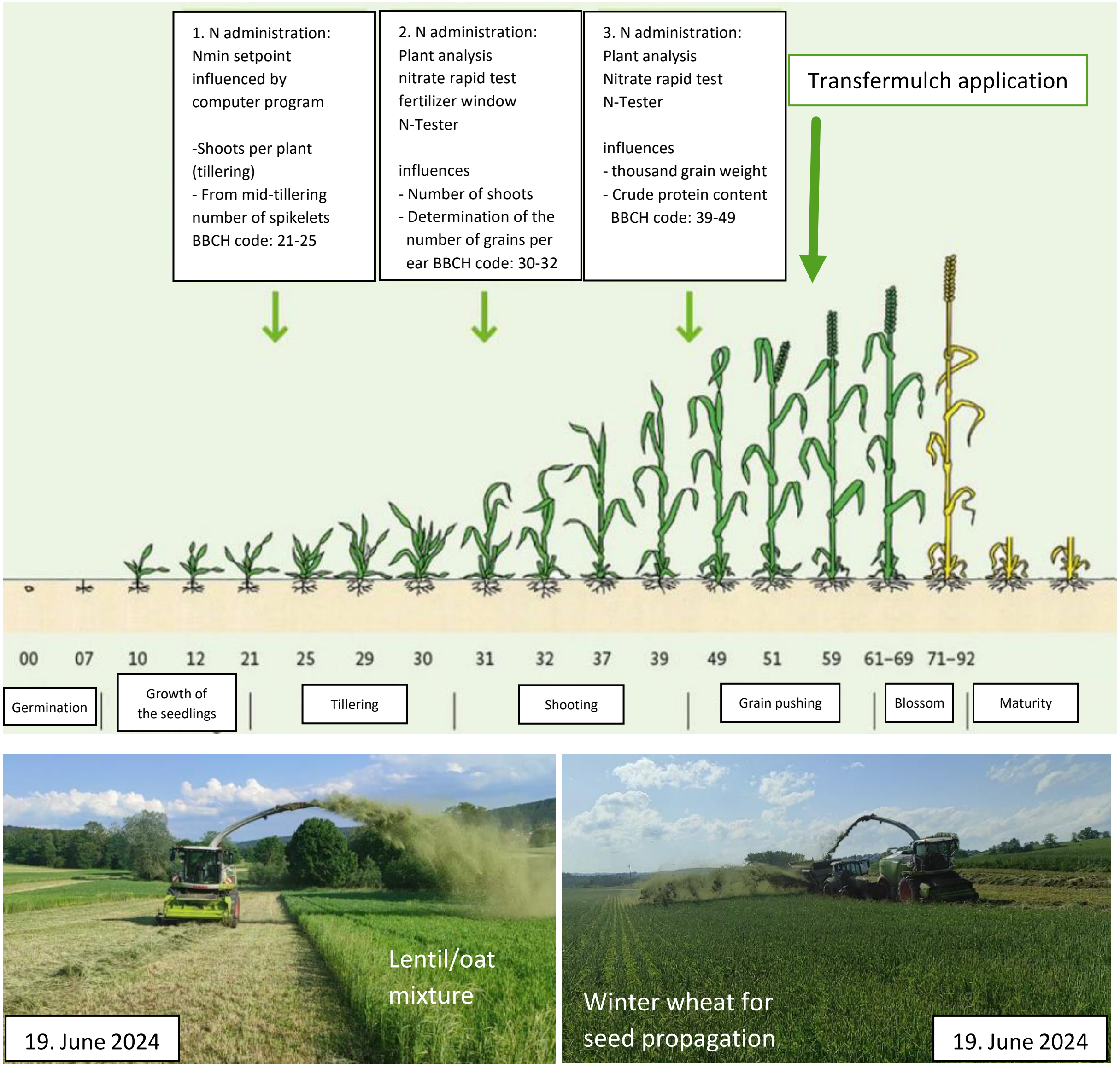


Figure 29: Transfer mulch transfer compared to efficient N application (translation) [7]

An early date for the transfer mulch would increase the fertiliser efficiency for the arable crops, but at the same time endanger the livelihood of many species before a sufficient food supply can develop in the forage strips. The ideal would be to choose a mowing date for the field forage strips that ensures that there is an appropriate food supply when the field strips are mechanically processed or harvested. Alternatively, it is also possible to mow the forage strips at different times.

The mulch layer and organic fertilization are intended to build up stable soil crumbs in the long term, which have increased resistance to erosion. However, even these soils are not completely protected from leaching. The risk of erosion is additionally increased, especially in the case of long-lasting heavy rainfall events, slopes and intensive tillage. The recurring forage strips can serve as an effective protective measure here by collecting the soil components in the runoff water and thus reducing soil erosion. Figure 30 illustrates this effect using the example of Experimental field 2, where heavy rain on thawing snow led to significant amounts of water. The washed away soil was collected on the alfalfa grass strips, as the young winter cereal stock was not yet able to form a barrier to the run-off water.

Figure 30: Washed away soil at experimental field 2

The forage strips take up about a third of the experimental plots in order to keep the water in the landscape longer and thus reduce superficial washing. Especially in the event of flooding, this retention function can help river levels rise more slowly and ultimately reduce damage to settlements, such as that which occurred in the neighboring municipality of Bisingen on 2 May 20224. At the same time, the forage strips are intended to serve as possible fire protection strips even in extreme drought by reducing the spread of wildfires, see Major fire on arable land in Mücheln on July 15, 02023.

Figure 31: Flooding in the neighboring municipality of Bisingen [8] and wildfire in Mücheln [9]

The transfer of transfer mulch is restricted by the fertilizer Ordinance due to its classification as organic fertilization. In particular, the bans on autumn fertilization for many winter crops contradict the positive effects of mulch application on the soil and plant growth. In order to overcome these legal requirements, an alternative method has been developed that combines the late cutting of forage strips with the construction of more stable soil aggregates.

2.4.9 Crop cultivation on square bales as a way to increase soil fertility

Instead of being applied immediately, the cut plant mass from the forage strips can also be pressed into square bales and applied to the arable land as fertilizer at a later date. However, pressing and intermediate storage lead to an increase in production costs. To compensate for these additional costs, the square bales are converted into raised beds and used for the production of high-quality food, see Figure 32. By arranging the square bales in rows and using arable soil or compost as the top substrate, the principle of bio-intensive vegetable cultivation (market gardening) can also be implemented. The aim is to achieve a high yield density on a small area and multiple use of the beds per year. The young plants grow in the soil or compost and form roots into the square bale over time. The complete irrigation of the square bale rows is to be simplified by a relocated drip hose system. Both irrigation water and precipitation lead to a continuous leaching of easily soluble substances from the square bale. To prevent the nutrients contained in the leachate from accumulating in the soil below the square bales, the square bales are placed on water-impermeable substrates. This allows the leachate to be collected and drained into a separate container. These collected nutrients can then be returned to the irrigation cycle for nutrient-poor square bales, such as hay from nature conservation areas, to serve as a source of nutrients for the growth of new plants.

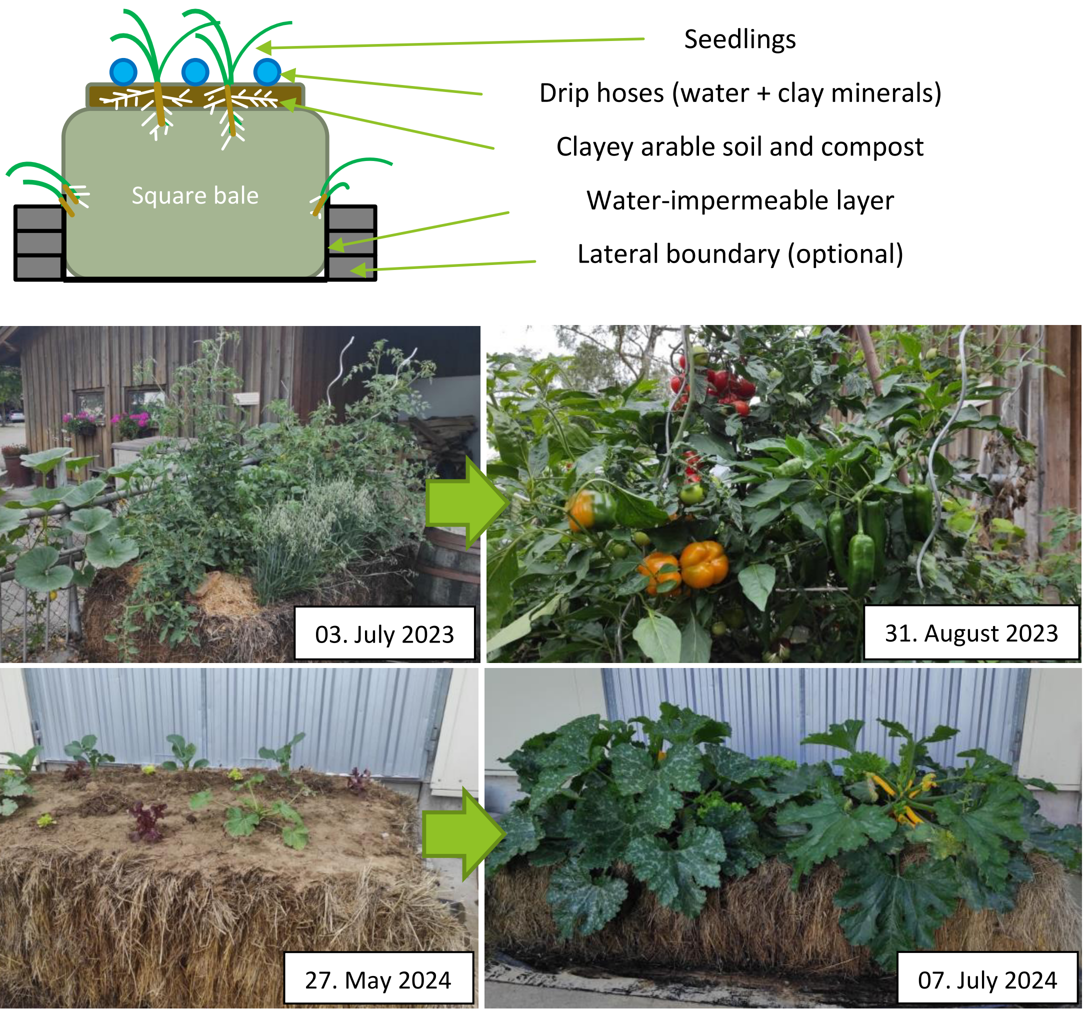


Figure 32: Sketch and examples of crop cultivation on square bales

Crop cultivation on square bales is possible with both dry hay and freshly pressed plant mass. The production of silage bales is usually more cost-effective, as no elaborate drying phase is necessary. In this case, it is even possible to dispense with the wrapping film, which usually encloses the silage bales airtight and enables the fermentation process. However, the frequent turning during the drying of the hay also leads to more plant seeds remaining on the meadows and thus the seed potential for the preservation of plant diversity is retained in the long term. In order to take advantage of this advantage in silage production, the first mowing can be delayed well into the summer. This gives the plants more time to form seeds, which then fall off on their own before the plants are mowed. This so-called haylage can make a valuable contribution by combining the advantages of hay and silage.

A common feature of the irrigated square bales made of hay, fresh silage or fresh haylage is the strong spread of grey tintlings after a few weeks, see Figure 33. The mushrooms go through a typical life cycle: In the morning, the fruiting bodies appear, which dissolve again after just a few hours, releasing the characteristic black ink, consisting mainly of fungal spores.

Figure 33: Fruiting bodies of tintlings in square bales

By avoiding mechanical disturbances, the fungal mycelium in the square bale remains intact. At the same time, the high core temperature of over 60 °C ensures a continuous transformation of the plant material over several weeks and prevents the emergence of harmful organisms. After a few weeks, no new fungal bodies are formed and after a total of one year of residence, more dung worms, woodlice and centipedes can be found in the top layer of the square bale next spring, see Figure 34.

Figure 34: Dung worms, woodlice and centipedes in square bales

Over time, plant matter inside the cuboid bale transforms into a brownish-black substance, which is equated with humic substances or humus due to its appearance and characteristic smell. The metabolic processes of the microorganisms play a central role in this and Figure 35 shows a schematic model that illustrates the presumed humus biosynthesis. The aim is not to break down the carbohydrates obtained through photosynthesis back into carbon dioxide and water, but to convert them into more stable carbon compounds through the catalytic influence of enzymes, acid and clay particles. For example, reactive double bonds can be formed in the molecular structures of the starting material by means of dehydration and dehydration reactions, which in turn polymerize into high-molecular end products through chain growth reactions. Alternatively, the transition states of these eliminations can continue to react under substitution reactions, binding nutrients from other cell components such as proteins, DNA, phospholipids, carbohydrates and vitamins. As a further reaction pathway, amination describes how new bonds are formed between nitrogen and carbon atoms. This allows ammonium ions, for example, to be chemically bound, which in turn serve as centers for the cross-linking of large molecular structures. These chemical reaction pathways thus form the basis for the formation of compost currently suspected in the project, whose Latin word origin "compositum" already indicates the joining of different substances.

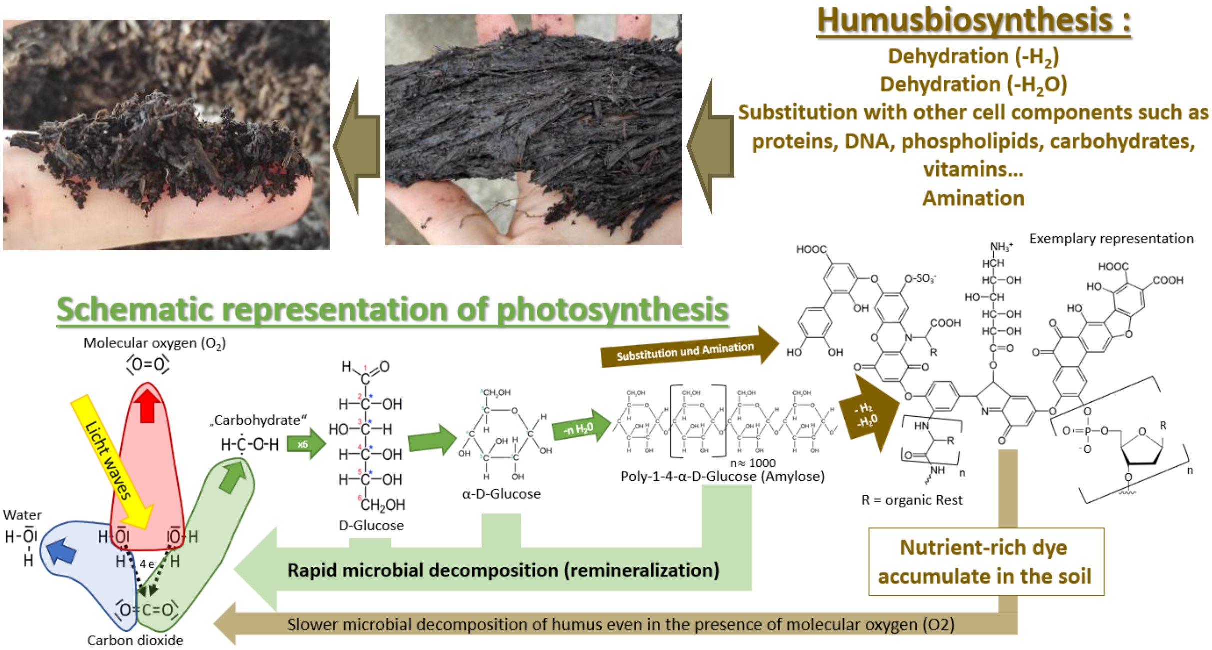


Figure 35: Schematic representation of photosynthesis and humus biosynthesis

The end products of these chemical reactions are stable, nutrient-rich compounds that accumulate in square bales in a similar way to a dye. The high molecular weight structures and the higher proportion of aromatic systems reduce the risk of leaching. At the same time, their certain water solubility allows for natural distribution into deeper soil layers without the need for mechanical incorporation. The aim is for these dissolved humic substances to accumulate between the clay, silt and sand components and contribute to a better stability of the soil aggregates. The reduction of the intermolecular forces between the mineral components is also said to result in a variety of advantages: easier tillage, improved root penetration, higher microbial activity, a higher proportion of water available to plants and a reduced tendency to crack formation during drought.

The first hay bale trial has shown that the compost obtained from it is an easy-to-produce alternative to peat-containing potting soils. In addition, the compost does not require any chemical-synthetic or animal fertilizers and offers an opportunity for vegan plant cultivation, see pepper plant in Figure 36 on the left. On the right side, further experiments were carried out with pellets. The large barrels were chosen for their airtight plastic sidewalls to create a low-oxygen environment for the experiments. At the beginning of the trial, two-thirds of the barrels were filled with straw pellets and layers of alfalfa, meadow or corn pellets were applied on top. Clay-rich soil was then dissolved in water and poured over the pellets to distribute the clay minerals evenly inside the pellets. Finally, the pellets were covered with a thin layer of arable soil and each planted with a pepper seedling, see Figure 36.

Figure 36: Crop cultivation (sweet peppers) on different substrates as a demonstration object

Although all plants grew well in the different substrates, there were clear differences in the waterlogged leachate. The leachate from the compost was almost odorless and mainly contained brown-black humic substances. In contrast, the leachate from the barrels had a characteristic silage smell. While the organic matter in the compost was already converted into more stable compounds in the previous year, anaerobic conditions dominated in the barrels, which favored the growth of lactic acid bacteria in the fresh biomass and were responsible for the typical silage odors. Over time, the areas inside the three barrels turned dark, so it is assumed that humic substances also form here. A final assessment can only be made next spring after the end of the project, so further investigations are necessary here.

Crop cultivation on square bales was published during the project period in a more detailed article in "Reports on Agriculture", see appendix. All further developments on this topic will be bundled under the newly created brand name Heulandzack® and thus complement the Wandernde Wiese® arable farming system, as it offers an alternative recycling option for the field forage strips.

2.5 Exploitation and exploitation of the results

The results show that the creation of meadow strips in arable farming is a promising way to implement environmental services and thus improve soil fertility. Furthermore, various sensible utilization options for the growth could be described, including direct transfer as transfer mulch or use as a substrate for raised beds.

In order for the social achievements from strip cultivation and extensive cultivation to be rewarded, a simple inspection by a control authority is necessary. This data can be extracted, for example, from the satellite images of the Copernicus program [10], see Figure 37. In this map material, the stripes are still easy to see despite the low resolution and the mowing dates can also be estimated based on the color change. The evaluation can be calculated using an algorithm and thus the risk of unjustified payment claims can be classified as low.

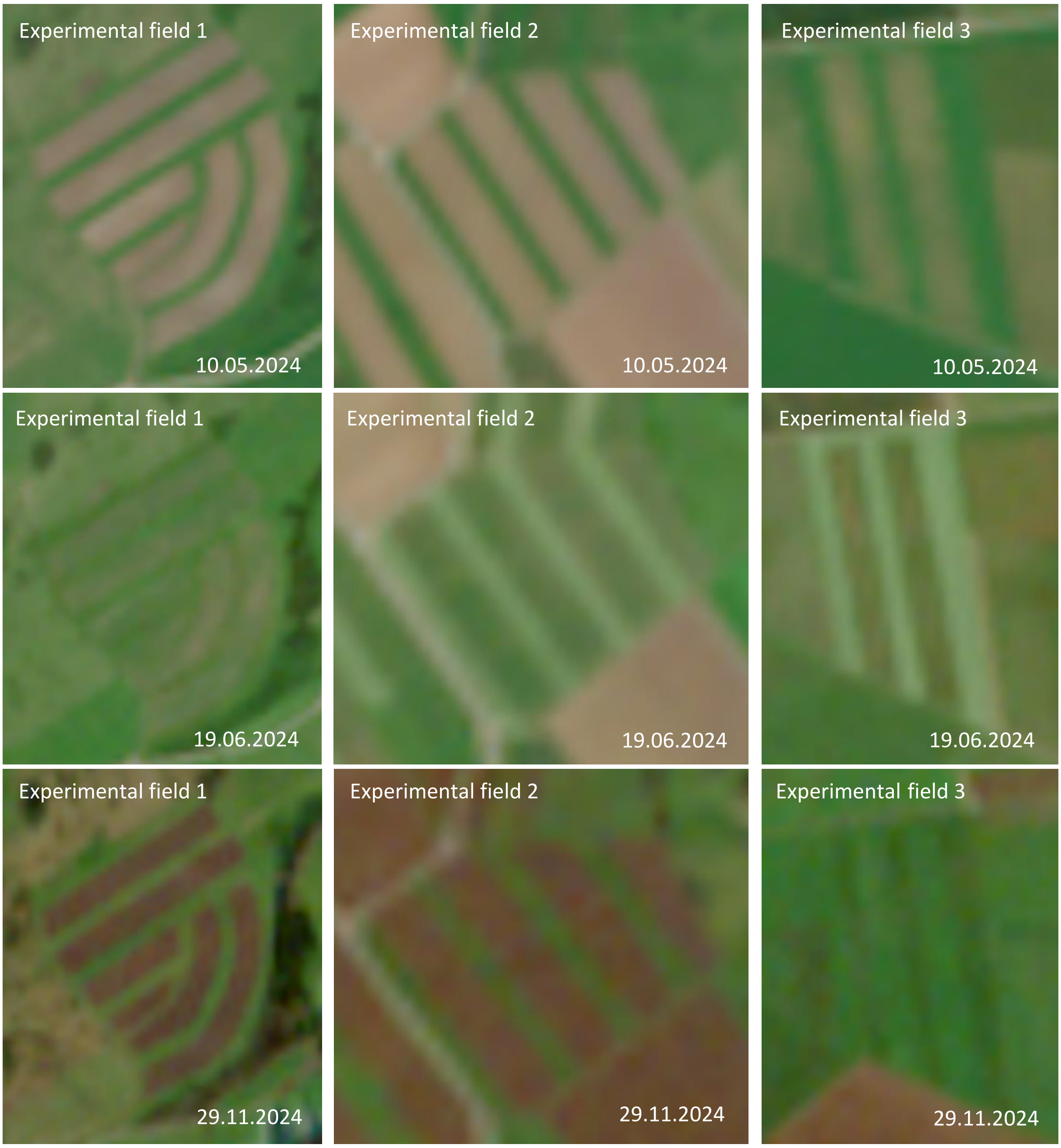


Figure 37: Satellite images of test fields 1, 2 and 3 at different times

So far, the meadow strips have been listed as individual fields in the joint application, which causes a considerable bureaucratic effort. To simplify documentation, a funding program was to be set up specifically for the Wandernde Wiese® arable farming system. This program would make it possible to maintain the existing geometries of larger arable land and to place the creation of the meadow strips in the responsibility of the applicants. Only the percentage of the meadow area would have to be determined in advance and a higher proportion of meadow strips should be associated with a correspondingly higher funding rate. The arable strips are then cultivated annually with a single crop type and are considered as a uniform area for the determination of fertilizer requirements in accordance with the fertilizer regulation. In addition, the number of permitted mowing runs per year should be defined. A staggered cultivation of arable and meadow areas is of crucial importance here. For example, staggered mowing of the meadow strips helps to ensure that flowering plants are always available. Furthermore, not all meadow strips should be ploughed up at the same time and replanted in an adjacent position, otherwise there will be hardly any retreat areas for the creatures in the field. Previous experience with meadow strips at headlands has shown that they serve both for erosion control and can be used as driving paths between the meadow strips during mowing. However, it must be determined during which period the meadow strips may be used for the turning maneuver when tilling the arable strips in order to exclude excessive damage by the tractor tires.

2.6 Economic and scientific compatibility

The soil investigations showed a humus build-up in arable farming. However, it is assumed that this consists largely of nutrient humus and can therefore be quickly broken down again by soil organisms. This degradation depends on several factors such as tillage, crop rotation, weather... A comprehensive analysis was not possible during the two-year project period. In order for the organic matter to be stored in the soil in the long term, the conversion to more stable permanent humus compounds is necessary. To this end, the efficiency, emissions and costs of the respective measure should be determined. Due to the short project duration and the relatively low budget, the experiments were planned and carried out only on the Weiherhof. Exact tests were also not possible on these experimental fields, because the arable land is very inhomogeneous. The influence of different soil types would be far too high, so that no comparative data could be obtained for exact tests at this site. In addition, after a few years, the meadow strips continue to migrate across the field, which in turn makes long-term trials less applicable to this arable farming system. Thus, the tests were deliberately planned, carried out and evaluated as demonstration tests. Through year-round plant growth, the meadow strips serve as efficient CO_2 trappers, while their deep root system contributes to the creation of water reservoirs, which are essential for dealing with increasing heavy rainfall events or droughts. This not only binds the carbon from the atmosphere, but also keeps the rainwater in the landscape. These findings are to serve as the basis for a new funding measure for other farms in the joint application to integrate nature conservation measures into the business cycle. The aim is to build up soil fertility from these social services and ultimately to produce food.

2.7 Communication and dissemination concept

An attempt was made to publish the results as up-to-date as possible and in different ways so that a broad interest group is addressed. The following list shows that it is possible to provide information about goals and plans at the beginning of the project, even if the final results are not available until later

- Radio report on SWR4 Tübingen (3.5 minutes) 18.10.2022
- Presentation at Bioland Winter Conference Baden-Württemberg in Bad Boll 30.01-01.02.2023
- Bioland Field Day (Jonathan Kern), workshop with Urs Mauk (ReLaViso) and demonstration of the trial areas at the Weiherhof in Haigerloch-Owingen (Zollernalbkreis) 13.08.2023
- Article in local magazine Schwarzwälder Bote and Hohenzollerische Zeitung 18.08.2023
- Visit of 13 international students as part of the I2 Connect project 13.09.2023 [11]
- Article at Foundation for Ecology and Agriculture (SÖL) and later at Schwäbischer Bauer 17.03.2023
- Youtube video on the channels FIBLOnline and I2connect, Thomas Alföldi 30.01.2024 [12]
- Newspaper article Trade journal Schweizer Bauer via Youtube video 14.02.2024
- Article published in "Reports on Agriculture" by the Federal Ministry of Agriculture (BLE): Wandering Meadow® Part II – Crop Production on Hay Bales as a Way to Increase Soil Fertility (22 pages) 26.03.2024 [13]
- Presentation of the EIP Wanderende Wiese project at the closing event of ARGE Streifenanbau (Morgentau BioGemüse, Austria) by Sebastian Löffler 19.06.2024
- DLG Field Days at the EIP-AGRI booth and Pop-Up Talk 11.07.2024-13.07.2024 [14]
- Poster presentations at the 5th Bioeconomy Congress 2024 in Fellbach 18.09.2024-19.09.2024
- Thesis: Sebastian Löffler (University of Hohenheim) Deadline: 25.11.2024
- Admission as a teaching module for prospective farmers on the topic of innovations by the Federal Information Centre for Agriculture (BZL) at the Federal Office for Agriculture and Food (BLE) 10.12.2024 [15]

Figure 38: Publication of the results via e.g. Youtube video and field day with Urs Mauk (ReLaVisio)

The arable farming system will continue on the Weiherhof after the end of the project, so that interested persons still have the opportunity to see the implementation. The final results of the Wanderende Wiese project will also be incorporated into a possible follow-up project called Heulandzack® and will be disseminated there. Since further funding has not yet been secured, crop cultivation on square bales will be limited to a smaller scale of 10-20 bales in the coming year. This is intended to gain further knowledge and test new ideas in advance.

3 Outlook

The implementation of the Wandernde Wiese® arable farming system is very easy for conventional, regenerative and organic farms, provided that larger fields are available. It is also possible for several farmers to join forces and thus cultivate strips across the boundaries of the parcel. However, it is absolutely necessary here that the ownership and lease relationships are also available over a longer period of time.

For the Weiherhof, the Wandernde Wiese® arable farming system is to be optimized in such a way that the relative proportion of arable and meadow strips is reduced from 2:1 to 1:2. As a result, the arable strips are reduced to 18 m strip width and the meadow strips have a total strip width of 36 m. It is advantageous that the meadow strips are in two different stages and that the entire field is never fallow when ploughing up or moving on. The findings from the Wandernde Wiese® arable farming system can also be transferred to the cultivation of large areas of permanent grassland. In spring, for example, 18 m wide strips can be mowed alternately and 18 m wide strips can be left standing. The second half is then mowed only after the first half has grown back, so that the creatures on the permanent grassland always find a retreat area in the immediate vicinity. With a higher number of cuts per year, a correspondingly finer division of the area into strips is necessary.

For the high proportion of meadow strips in the field and their extensive cultivation, it is imperative to ensure targeted utilization in advance. In addition to being used as transfer mulch, crop cultivation on square bales has proven to be a promising cultivation method. In order to simplify the work processes, crop cultivation on square bales is to take place on a large asphalt surface in the future, which will allow the seepage sediments to be collected. The square bales are then to be completely coated with compost from the previous year so that the highest possible yield of humic substances is achieved in the square bale. However, further measurements are needed for a final assessment of the impact on soil and the environment. In particular, the actual emissions and leachate must be quantified more precisely. Only when this data is available can a decision be made as to whether it is possible to place the square bales directly on the ground. Such an approach would significantly reduce production costs, but would also have to be combined with a rotation system and classic arable farming.

Future studies will also examine whether crop cultivation on square bales can be transferred to the composting of municipal organic waste and the treatment of municipal wastewater. Here, too, the aim is to keep the nutrients in the irrigation cycle for as long as possible until they have been completely absorbed by the plants or bound in the form of stable humic substances. Instead of food, for example, insect-friendly plants with a high supply of flowers are to be grown on these square bales. By returning the bound nutrients to the agricultural land, the aim is to create a material cycle that is as closed as possible.

Thus, farms play an even more decisive role in the management of natural resources. Large farms can actively contribute to the promotion of biodiversity and climate protection through targeted landscaping with meadow strips, while smaller farms can enable regional and ecologically valuable food production through biointensive crop cultivation on square bales even with low capital expenditure.

4 References

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5 Appendix

Due to the high number of pages, the following reports have been saved as separate files on the website www.wanderndewiese.de in the download area:

Oliver Schmid, (2022), Wandernde Wiese® Teil I – Ideen und Ziele

Oliver Schmid, (2024) Wandernde Wiese® Teil II - Pflanzenbau auf Heuballen als Weg zur Steigerung der Bodenfruchtbarkeit

Beate Leidig, (2023), Insektenzählung im Rahmen des EIP-Projektes „Wandernde Wiese“

Beate Leidig, (2024), Insektenzählung im Rahmen des EIP-Projektes „Wandernde Wiese“

Species found on the meadows of experimental field 1 by Sebastian Löffler as part of his thesis „Wandernde Wiese: Einfluss des Mahdzeitpunktes auf das C/N-Verhältnis und den Biomasseertrag“	**Also found in donor meadows**	**Component in the seed mixtures used**
Acker Kratzdistel (*Cirsium arvense*)		
Acker Winde (*Convolvulus arvensis*)	X	
Acker-Fuchsschwanz (*Alopecurus myosuroides*)		
Acker-Vergissmeinnicht (*Myosotis arvensis*)	X	
Acker-Witwenblume (*Knautia arvensis*)	X	
Deutsches Weidelgras (*Lolium perenne*)	X	
Echter Steinklee (*Melilotus officinalis*)		
Emmer (*Tricticum dicoccon*)		
Feld-Klee (*Trifolium campestre*)	X	X
Festolium (*Festuca spec. x Lolium spec*)		X
Fettwiesen-Magerite (*Leucanthemum ircutianum*)	X	
Filzige Klette (*Arctium tomentosum*)		
Futtercichorie (*Cichorium intybus*)		X
Gemeine Quecke (*Agropyron repens*)		
Gemeine Rispe (*Poa trivialis*)	X	
Gemeine Schafgarbe (*Achilliea millefolium*)	X	X
Geruchlose Kamille (*Tripleurospermum inodorum*)		
Gewöhnlicher Hornklee (*Lotus corniculatus*)	X	X
Gewöhnliches Hirtentäschel (*Capsella bursa-pastoris*)		
Gewöhnliches Hornkraut (*Cerastium holosteoides*)	X	
Gewöhnliches Ruchgras (*Anthoxanthum odoratum*)		
Glatthafer (*Arrhenatherum elatius*)	X	X
Gras-Sternmiere (*Stellaria graminea*)	X	
Hopfenklee (*Medicago lupulina*)	X	X
Klatsch-Mohn (*Papaver rhoeas*)		
Kleiner Storchenschnabel (*Geranium pusillum*)		
Kleiner Wiesenknopf (*Sanguisorba minor*)		X
Knäuel Hornkraut (*Cerastium glomeratum*)		
Knaulgras (*Dactylis glomerata*)	X	X
Knolliger Hahnenfuß (*Ranunculus bulbosus*)	X	

Kompass-Lattich (*Latuca serriola*)		
Krauser ampfer (*Rumex crispus*)		
Kriechendes Fingerkraut (*Potentilla reptans*)	X	
Löwenzahn (*Taraxacum* s. Ruderalia)	X	
Luzerne (*Medicago sativa*)	X	X
Purpurote Taubnessel (*Lamium purpureum*)		
Raue Gänsedistel (*Sonchus asper*)		
Rauhaarige Wicke (*Vicia hirsuta*)		
Rohrschwingel (*Festuca arundinacea*)		X
Rot Klee (*Trifolium pratense*)	X	
Saat-Esparsette (*Onobrychis viciifolia*)	X	
Saatwicke (*Vicia sativa*)		
Sauerampfer (*Rumex acetosa*)	X	
Schlitzblättriger Storchenschnabel (*Geranium Dissectum*)	X	
Spitzwegerich (*Plantago lanceolata*)	X	X
Weiche Trespe (*Bromus hordeaceus*)		
Weißes Labkraut (*Galium album*)	X	
Weiß-Klee (*Trifolium repens*)	X	
Weizen (*Tricticum*)		
Wiesen-Bocksbart (*Tragopogon pratensis* subsp. *Orientalis*)	X	
Wiesenfuchsschwanz (*Alopecurus pratensis*)		
Wiesen-Kerbel (*Anthriscus sylvestris*)		
Wiesen-Kümmel (*Carum carvi*)		X
Wiesen-Pippau (*Crepis biennis*)	X	
Wiesenrispen Gras (*Poa pratensis*)	X	X
Wiesen-Salbei (*Salvia pratensis*)	X	
Wolliges Honiggras (*Holcus lanatus*)		
Zaun-Wicke (*Vicia sepium*)	X	
Zottiger Klappertopf (*Rhinanthus alectorolophus*)	X	