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Enhancing multifunctional benefits of cover crops - vegetable intercropping

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Enhancing multifunctional benefits of cover crops – vegetable intercropping

Final report

University of Kassel

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Table of Contents pp.

Index of Tables pp

Index of Figures pp

Abbreviations

HE	Head of cauliflower
ST	Stem of leek
RES	Residues (leaves)
LM	Living mulch
WE	Weeds
CC	Cover crop
NC	No cover crop
FH	Final harvast
IH	Intermediate harvest
HW	Hand weeding
CH	*Chambord F1*
BE	*Belot F1*
WB	*White ball*
HA	*Hannibal*
AX	*Axima*
CA	*Catcher F1*
LLH	Landesbetrieb Landwirtschaft Hessen (Hessian Governmental Agricultural Office)
fm	Fresh matter
DAP	Days after planting
DWD	Deutscher Wetterdienst

1 Abstract

The multifunctionality of living mulch systems was the underlying research question for field trials with cauliflower (*Brassica oleracea L. convar. Botrytis*) and leek (*Allium porrum L.*). Field trials were conducted at the Hessian Research Estate Frankenhausen over 3 years, parallel demonstration plots were established over 2 years on commercial pilot farms for entomological investigations in a big scale mode, plots of 1000 m^2. In all trials white clover (*Trifolium repens L.*) was used as a single species living mulch. In the years 2012 and 2013 the experimental design consisted of a 2-factorial approach for the test of 3 cultivars and the effect of additive and substitutive system for the establisment of living. The cultivars of cauliflower were *Chambord F1, Belot F1,* and *White ball*, of leek *Herbstriesen Hannibal, Axima,* and *Catcher F1*. For the substitutive system of living mulch each third row was replaced by clover with the potential of common weeding in the areas covered by vegetables. The establishment of clover took place between 4 weeks after planting or later. In 2014 a one year trial was added for the investigation of different sowing dates of living mulch, 2 and 4 weeks after planting, towards the performance of cauliflower and leek, cultivated with one cultivar. The two year pilot farm activities were located at two organic field vegetable farms in Northrhine-Westfalia, each site in one year.

Crop yields were mainly influenced by the fact that the Substitutive system had a plant density which was 2/3 of the figures in control and Additive system. Therefore all figures found were significantly lower. Opposite to these findings the data referred to single crops showed an advantage for the Substitutive system. With regard to the second system tested the addition of clover into the vegetable system did not cause reductions of yields in any case. This was obvious on the levels of nutrient yields of the crops.

The samples of pit fall traps were measured over a time-span between August and midth of September in 2013 and midth of August till end of September in 2014. The estimates were done on a family level. The main groups were found at each site, in each crop as dominant: *Carabidae >> Staphilinidae > Arachnidae.* The abundance was significantly different on the species level according to Kruskal Wallis evaluations, statistical distinctions on the system could not be found due to small diffenrences and partly inconsistent results.

2 Introduction

Per se it is derisable to increase biodiversity (Willey 1990, Hole et al. 2005, Bo & Hara 1999) in organic growing systems in order to stabilize a system by providing leaf cover for the soil and protecting the soil surface against erosion events (Brainard et al. 2012), by increasing the number of different species in a defined, quite often depleted environment (Meyling et al. 2013), by offering habitat facilities for soil insects and other micro-faunistic elements that can be interpreted as green net within a stand of growing main crops (den Belder et al. 2000). Due to the fact of using similar sources i.e. water, nutrients, radiation interactions can occur which under unfavourable conditions can lead to severe reductions of yield quantities and qualities (Bottenberg et al. 1997, Chase & Mbuya 2008, Hartwig & Ammon 2002). Therefore the use of cover crops, in specific as components in a scheme of plant companion system is not of common use in practice, so far. Uncertainties on the one hand about the success of the economically important main crops, on the other hand subsidy systems which do favour the exclusion of mixed croppings might make understandable the critical considerations of the farming community.

Nonetheless there is a need for the optimisation of cropping systems, especially of those providing higher degrees of self-regulation and a more efficient use of existing resources (Kremen & Miles 2012, Kołota & Adamczewska-Sowińska 2013). Simple questions i.e. which partners, which species, which cultivars suit best in this kind of enriched growing systems (Masiunas 1998, Theriault et al. 2009) which cover crops do not compete main crops too much, but show enough suppressiveness against developing weeds should be picked up (den Hollander et al. 2007, Müller-Schärer 1996, Baumann et al. 2002) and transferred into scientific practice as done in the completed project InterVeg, supported by the funds of the Core Organic II Era-Net programme (Burgio 2014, Canali et al. 2014, Ciaccia et al. 2014, Kristensen et al. 2014, Tittarelli et al. 2014).

3 Methods & Materials

3.1 Trials 2012 & 2013 (Additive vs. Substitutive)

3.1.1 Cauliflower

The design of parcels had to be different between the treatments ***Control*** and ***Additive*** on the on the hand, and ***Substitutive*** on the other hand. Within the latter one each third row was replaced by the cover crop in order to keep the traditional, not undersown system for those rows of the vegetable crop. Within the additive design undersowing took place in each intermediate space between the rows of main crops.

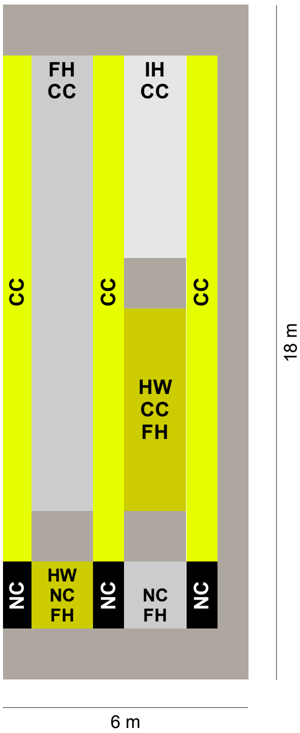


Figure 1:
Parcel-design 2012
of Substitutive

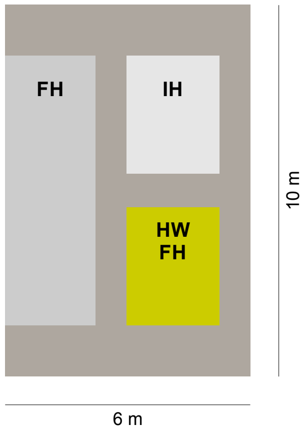
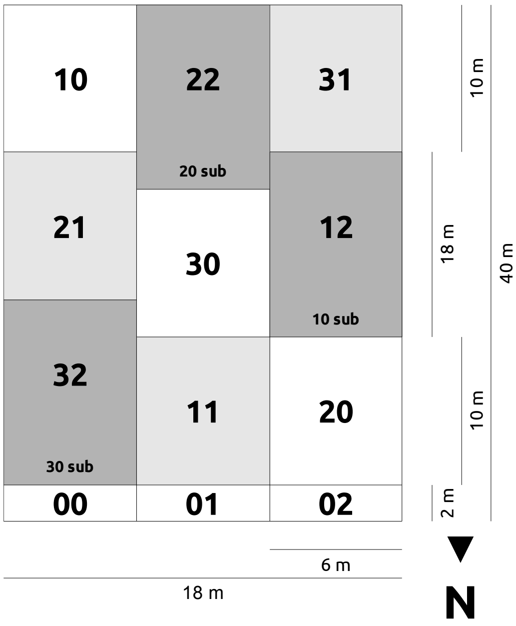
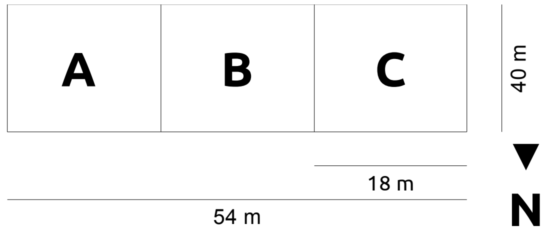


Figure 2: Parcel-design 2012 of Control and Additive

CC = cover crop, NC = no cover crop
FH = Final harvest, IH = Intermediate harvest
HW = Hand weeding





(top)
Figure 3: ***Distribution of blocks 2012***

(left)
Figure 4: ***Distribution of treatments in block A 2012***

Table 1: ***Cauliflower 2012 & 2013- Explanations of treatments***

	Factor A **Cultivars**		Factor B **Undersowing**
1#	*Chambord F1*	#0	Without undersowing ***(Control)***
2#	*White Ball*	#1	Undersowing ***(additive)*** normal planting design + clover
3#	*Belot F1*	#2	Undersowing ***(substitutive)*** replacing each 3rd row by clover

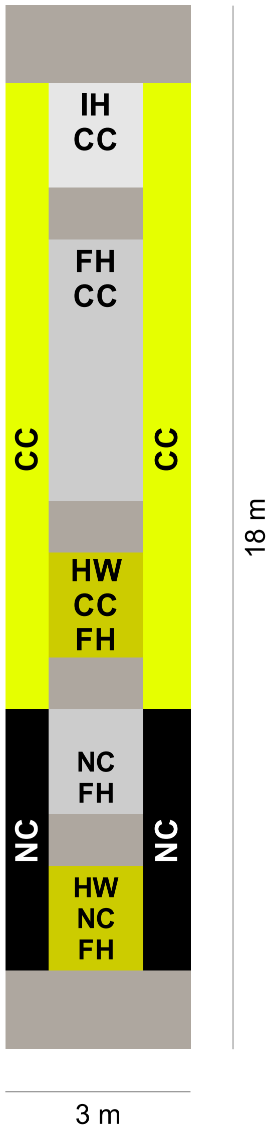
10 = Chambord F1, without undersowing

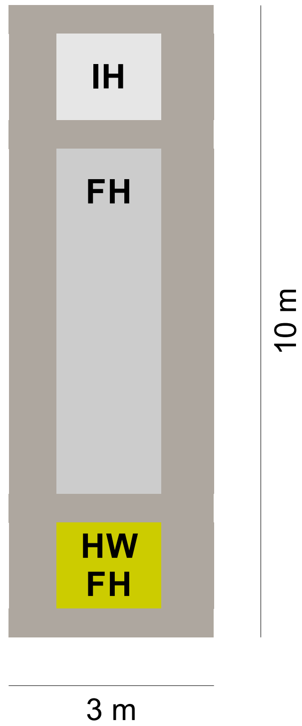
The trials of the years 2012 and 2013 were located at different fields of the Hessian State Estaste Frankenhausen (51°4'N, 9°4'E), 2012: Lindenbreite, 2013: Holzbeck II. Due to different plot sizes the design had to be adapted to the existing conditions, 2012 all blocks were arranged horizontally, 2013 vertically. The design of parcels and their distribution within the blocks are shown in figures 1 to 4 and figures 5 to 8. The scheme for planting was 45 cm distance in a row and 75 cm between rows.

In each year the trials were placed after a leguminous forage crop. In response to Nmin data in spring the plots were applied by appropriate amounts of a plant-based fertilizer, Phytoperls®, in order to reach 200 kg N ha^{-1} (see table 2).

Table 2: ***Basic data 1 of the trials in 2012 & 2013***

	2012	**2013**
Precrop	Alfalfa (2^{nd} year)	Grass clover
Soil management	Plough (2011 Nov)	Plough (2012 Nov)
Seedbed preparation	Rotary harrow (2012 Apr)	Rotary harrow (2013 Apr)
Cover crop	Ray gras *(Hellen)*	
Sowing date	2012 Apr 12	
Fertilisation type	Phytoperls® (to reach 200 kg N ha^{-1})	
Fertilsation date	Two weeks before planting	

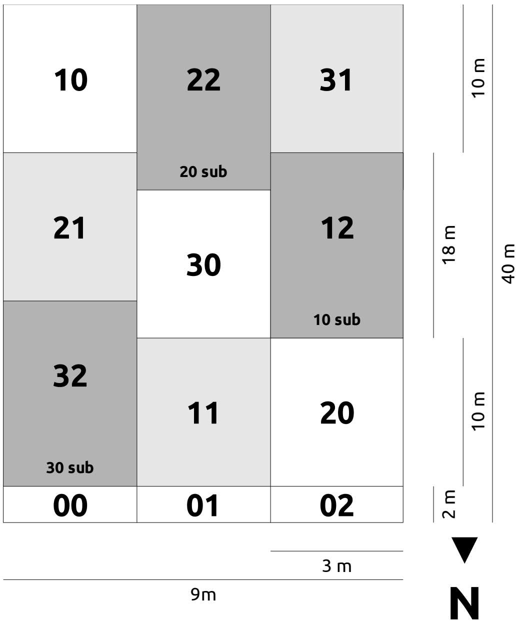


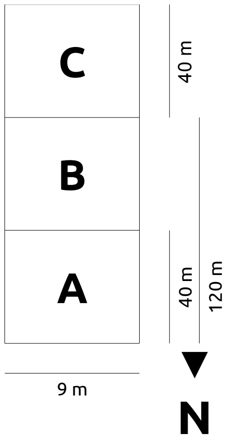


(top)
Figure 5: ***Parcel-design 2013 of Control and Additive***

(left)
Figure 6: ***Parcel-design 2013 of Substitutive***

CC = cover crop, NC = no cover crop
FH = Final harvest, IH = Intermediate harvest
HW = Hand weeding





(left)
Figure 7:
Distribution of blocks 2013

(left)
Figure 8:
Distribution of treatments in block A 2013

Table 3:
Basic data 2 of the trials
(A) in 2012

Date	Action	DAP	Crop	Cultivar
2012-06-28	Planting			
2012-07-26	Sowing	28	White clover	*Huia (8 kg ha^{-1})*
2012-09-03	Harvest	67	Cauliflower	*Chambord F1*
2012-09-10	Harvest	74	Cauliflower	*White ball*
2012-11-19	Harvest	144	Cauliflower	*Belot F1*

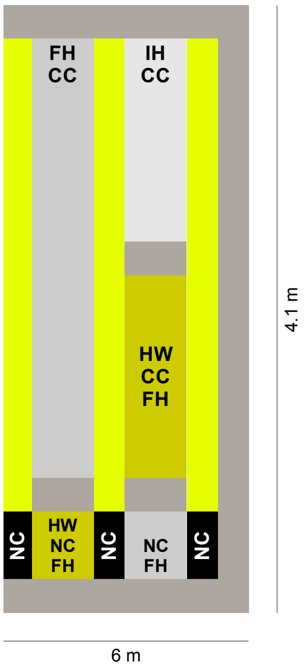
(B) in 2013

Date	Action	DAP	Crop	Cultivar
2013-06-27	Planting			
2013-08-07	Sowing	41	White clover	*Huia (8 kg ha^{-1})*
2013-09-02	Harvest	67	Caulifower	*Chambord F1*
2013-09-04	Harvest	69	Cauliflower	*White ball*
2013-11-25	Harvest	151	Cauliflower	*Belot F1*

The chosen cultivars were two hybrids, *Chambord F1* and *Belot F1,* and one open-pollinated cultivar, *White ball (see tables 1 and 3). Chambord F1* was harvested 67 days after planting in both years, *White ball* after 69 & 74 DAP in 2012 and 2013. *Belot F1* could have been cultivated longer than 150 DAP, but it was stopped at 144 DAP in 2012 and 151 DAP in 2013.

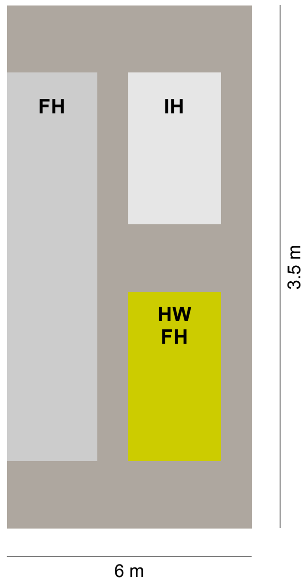
3.1.2 Leek

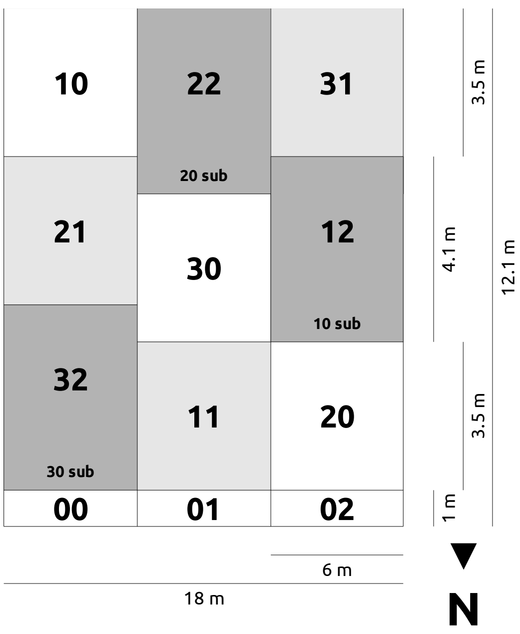
The design of parcels followed the same scheme described for the other crop tested, cauliflower. Due to other figures for planting (11 cm in rows, 75 cm between rows) the size of parcels was different. Due to the different systems, ***Control*** and ***Additive*** on the on the hand, and ***Substitutive*** on the other hand, the size of parcels . Within the latter one each third row was replaced by the cover crop in order to keep the traditional, not undersown system for those rows of the vegetable crop. Within the additive design undersowing took place in each intermediate space between the rows of main crops.

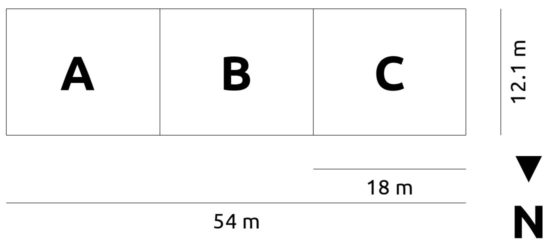


(left)
Figure 9:
Parcel-design of Substitutive in 2012

(right)
Figure 10:
Parcel-design of Control and Additive in 2012







(top)
Figure 11:
Distribution of blocks in leek trial 2012

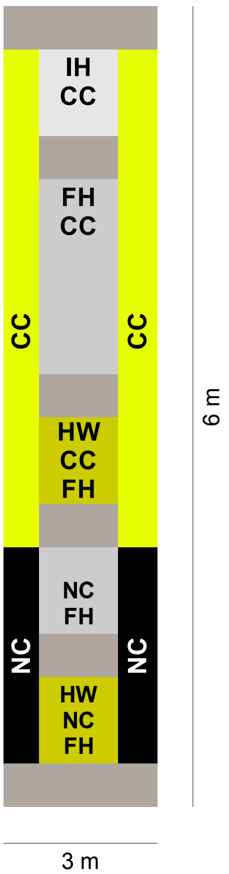
(left)
Figure 12:
Distribution of treatments in block A in leek trial 2012

Table 4: Leek 2012 & 2013- Explanations of treatments

	Factor A **Cultivars**		Factor B **Undersowing**
1	*Catcher F1*	0	Without undersowing ***(Control)***
2	*Herbstriesen Hannibal*	1	Undersowing ***(Additive)*** normal planting design + clover
3	*Axima*	2	Undersowing ***(Substitutive)*** replacing each 3rd row by clover

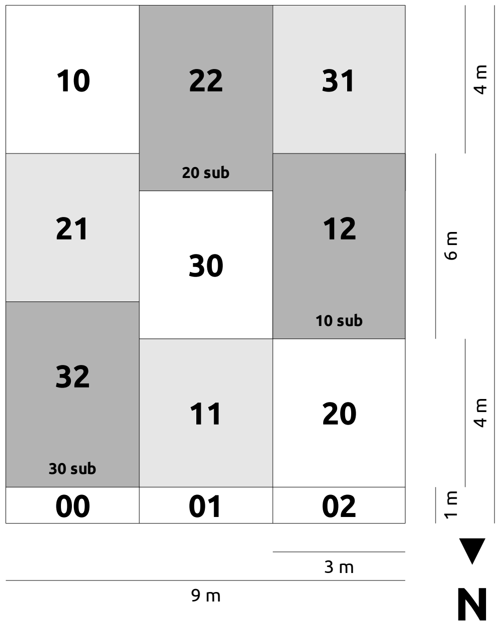
10 = Catcher F1, without undersowing

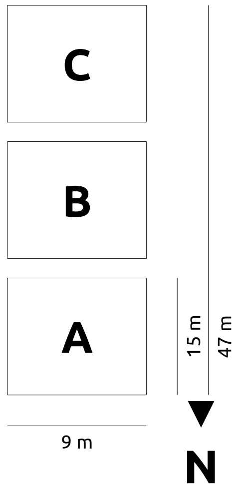
The trials of the years 2012 and 2013 were located at different fields of the Hessian State Estaste Frankenhausen, 2012: Lindenbreite, 2013: Holzbeck II. Due to different plot sizes the design had to adapted to the existing conditions. The design of parcels are shown in figures 9 to 10 and 13 to 14, the distribution of blocks (see figures 11 to 12 nd 15 to 16) were arranged horizontally in 2012, and vertically in 2013.



(left)
Figure 13:
Parcel-design of Substitutive in 2013

(right)
Figure 14:
Parcel-design of Control and Additive in 2013





(left)
***Figure 15:* Distribution of blocks in 2013**

(left)
***Figure 16:* Distribution of treatments in block A in 2013**

***Table 5:* Basic data 2 of the leek trials (A) in 2012**

Date	Action	DAP	Plant	Cultivar
2012-06-28	Planting			
2012-07-26	Sowing	28	White clover	*Huia (8 kg* ha^{-1}*)*
2012-10-29	Harvest	123	Leek	*Hannibal*
2012-11-05	Harvest	130	Leek	*Axima*
2012-11-12	Harvest	137	Leek	*Catcher F1*

(B) in 2013

Date	Action	DAP	Plant	Cultivar
2013-06-27	Planting			
2013-08-07	Sowing	41	White clover	*Huia (8 kg* ha^{-1}*)*
2013-09-26	Harvest	91	Leek	*Hannibal*
2013-10-09	Harvest	113	Leek	*Catcher F1*
2013-10-16	Harvest	120	Leek	*Axima*

The cultivars tested were two open pollinating ones, *Herbstriesen Hannibal* and *Axima*, and one hybrid *Catcher F1*. In both years Hannibal was harvested as first crops, 123 and 91 days after planting (DAP), *Axima* was harvested one week before *Catcher F1* in 2012 (130 DAP) and one week later in 2013 (120 DAP). Accordingly the figures of Catcher F1 were 137 DAP in 2012 and 113 DAP in 2013. The N supply of the leek crops were managed as described for cauliflower. Leek and cauliflower were grown without any artifical irrigation.

3.2 Weather measurements (2012 & 2013)

In general the temperature during the growing season in 2013 was slightly higher than in 2012 (see figures 17 & 18). With regard to water supply 2012 155 mm were fallen before the date of planting, from Jan 01 to Jun 27. In 2013 the similar figure reached 254 mm. These differences were compensated by opposite moisture conditions during the growing period, in 2012 145 mm were measured as rainfall for the two early maturing cultivars, 240 mm for the late maturing one. In 2013 67 mm for Chambord F1 and White ball, 238 mm for Belot F1. After harvest potential leaching conditions were characterised by 280 to 180 mm in response to harvest in 2012/13 and 258 to 87 mm in 2013/14. The temperature between December and March were distinctly lower in 2012/13 than one year later where only some dayly minimum values reached minus celsius degrees, the season before had average temperatures below zero between January and March.

3.3 Trials 2014 (Sowing date: early versus late)

According to agreements in 2013 a third year could be added for plot trial. Differing from the initial question whether additive or substitutive approaches would provide better chances for the introduction of living mulch systems in organic field vegetable production the underlying question was the date of establishing of the cover crop into a growing stand of a main crop. The additive approach for the establishment of the cover crop was chosen for the trials in 2014. The trials were located at the field Schmalenbeck, except differing plots sizes the design was similar for both crops, cauliflower ('*Chambord F1*')and leek ('*Hannibal*'). The number of replicates was four. The analysis of variance was calculated as Latin Rectangle.

The experimental design is presented in figure 19, explanations of the treatments in table 6.

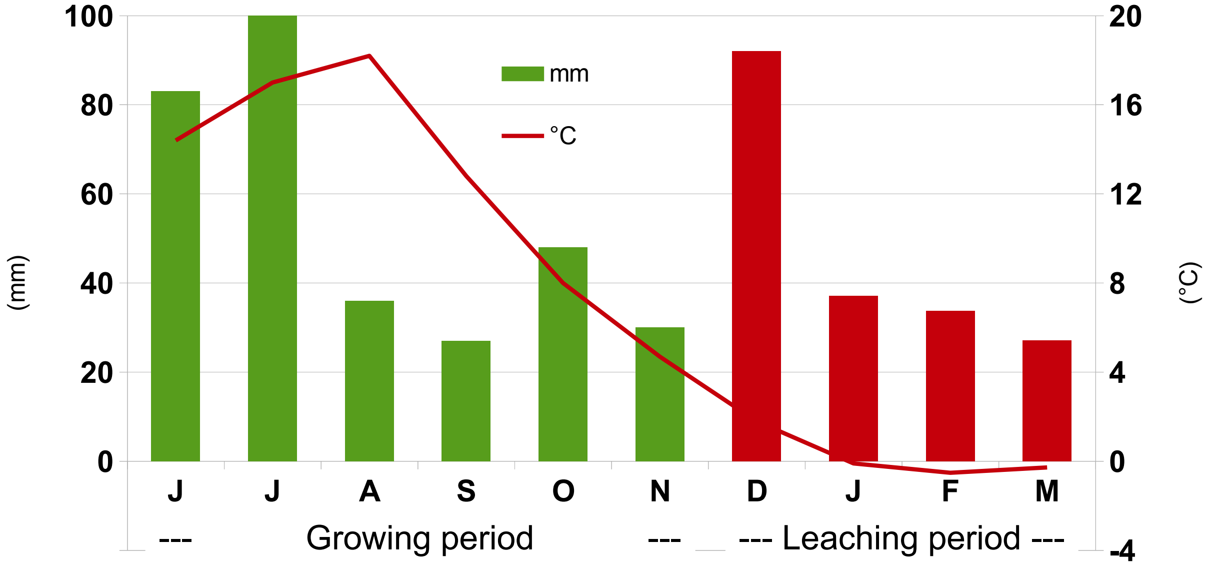


Figure 17: Climatic conditions from June 2012 to March 2013 (LLH KS-Harleshausen)

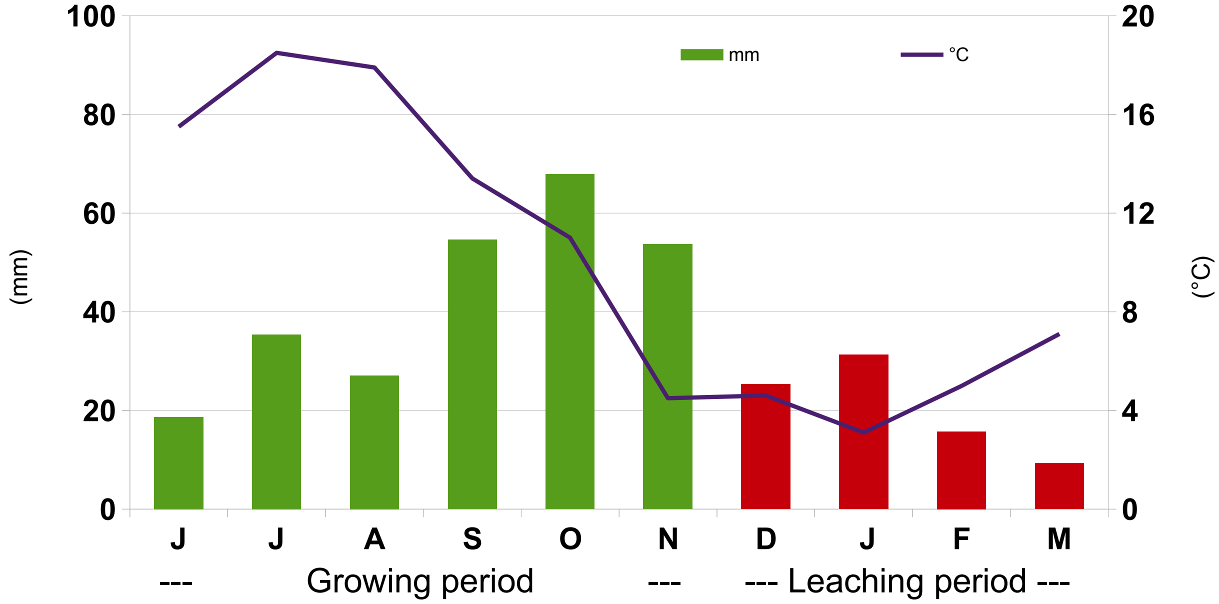


Figure 18: Climatic conditions from June 2013 to March 2014 (LLH KS-Harleshausen)

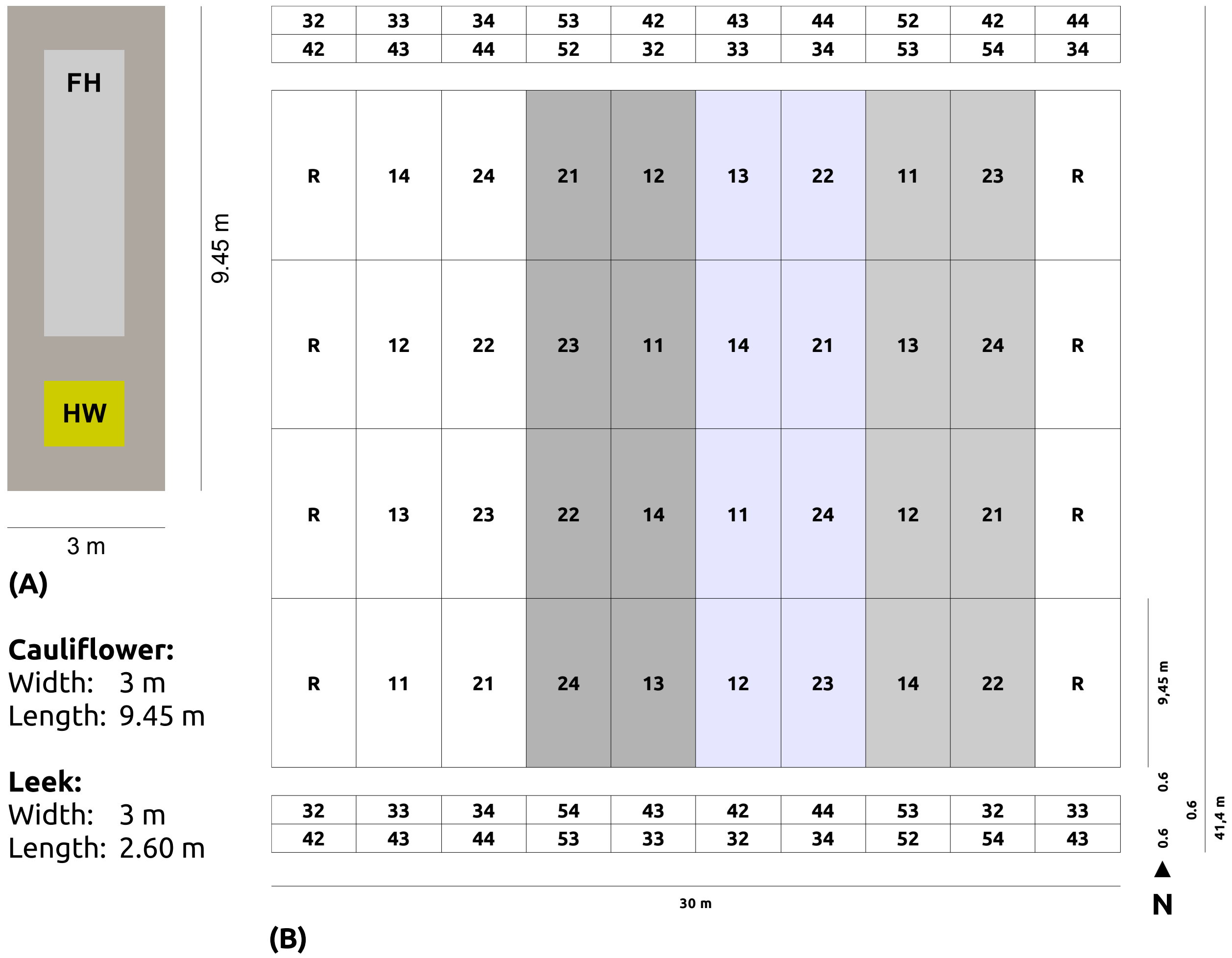


Figure 19: Design parcels (A) and distribution of treatments (B) in 2014

Tabelle 6: Explanation for the treatments

No	Treatments	No	Treatments
11	Control	32	Clover, drilled sowing 2 weeks
12	Drilled sowing 2 weeks	33	Clover, drilled sowing 4 weeks
13	Drilled sowing 4 weeks	34	
14		42	Clover, broad sowing 2 weeks
21	Control	43	Clover, broad sowing 4 weeks
22	Broad sowing 2 weeks	44	
23	Broad sowing 4 weeks	52	Control, fallow
24		53	Control, fallow
		54	

Table 7: ***Basic data 1 of the trial in 2014***

Precrop:	Grass alfalfa (2nd year)
Soil management:	Plough (Feb 10)
Seedbed preparation:	Rotary harrow, (several times between March & June)
Fertilisation:	Phytoperls® (to reach 200 kg N ha^{-1}) (two weeks before planting)

Date	Action	DAP	Crop	Cultivar
2014-06-17	Planting			
2014-07-01	Sowing	14	White clover	*Huia (8 kg ha^{-1})*
2014-07-15	Sowing	28	White clover	*Huia (8 kg ha^{-1})*
2014-08-27	Harvest	71	Caulifower	*Chambord F1*

Table 8: ***Basic data 2 of the trial in 2014***

The procedures of the second trial were very similar to those of the first one (see table 7). A forage legume was chosen as precrop. Nonetheless of the amount of available N for the N demanding field vegetable was adjusted by appropriate application of Phytoperls® for a level of 200 kg N ha^{-1}. The cover crop, white clover (*Huia*), was established 2 and 4 weeks after planting as drilled or broadly sown seeds (see table 8).

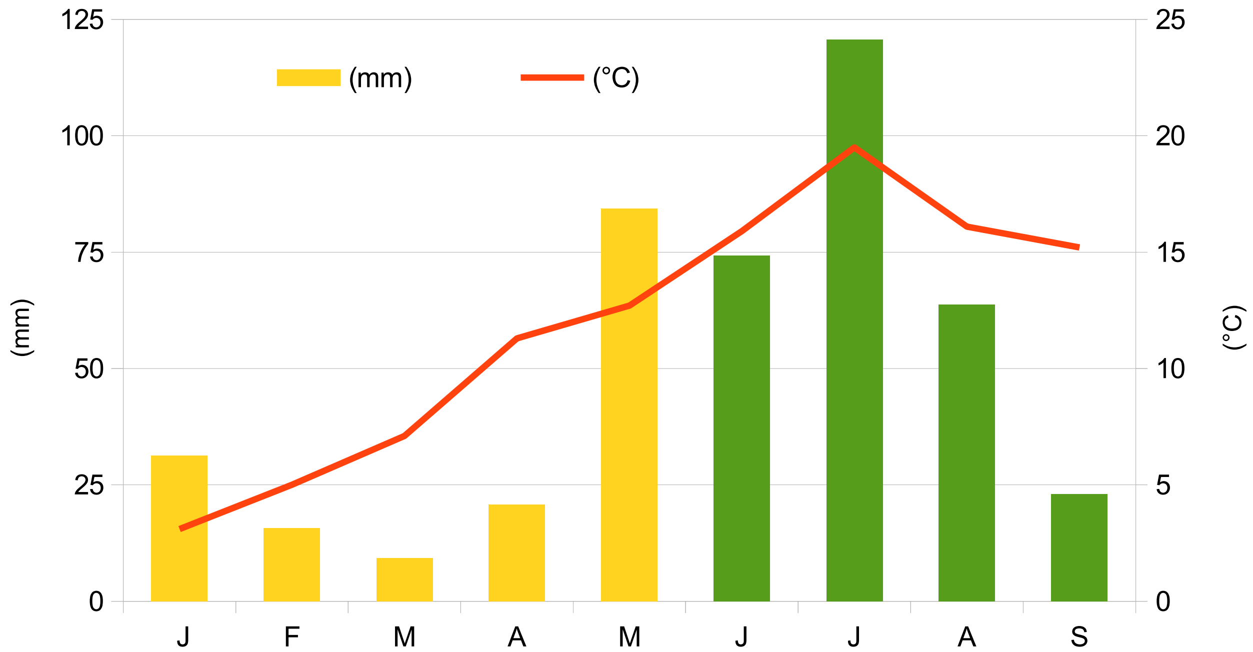


Figure 20: ***Climatic conditions from Jan to Sep 2014 (LLH Frankenhausen)***
Precipation before cultivation (Jan to May): 161 mm
Precipation during cultivation (Jun to Sep): 282 mm
Mean Temperature from Jun to Sep: 16.7°C

The climatic conditions in year 2014 provided a fairly warm winter, but cool spring (see figure 20). The water supply from January to May was limited by 161 mm. The growing season between June and September was slightly cool, in specific in August with an average temperature of less than 17°C, accompanied by wet season in June and July.

3.4 Parameters for assessment

Parameters for assessment were fresh matter yield, nutrient content and uptake per area, visual monitoring of pest and diseases were done in 2012 with regard to selected species. 10 plants were harvested from inner rows of a plot. Fresh matter, dry matter and dry matter content were measured for main crop, divided into ***main organ***, head for cauliflower, stem for leek, and ***residues***, ***living mulch*** and ***weeds***, harvested on special mini plots of the parcels. The dry matter content was measured after a gradual heating at 60°C and 105°C. Total N content was determined by an automated N analyser, P spectrophotometrically (VDLUFA 1991), K by using the AAS technology.

3.5 Entomological measurements on pilot farms

These trials were carried out on two different organic farms, both located in the Eastern part of Northrhine-Westfalia, both characterized as arable farms with a clear specialisation of field vegetable production. In 2013 Frank Arendes, Böhlenhof GbR, (www.frank-arendes.de;) in 34434 Borgentreich-Großeneder (51° 33' N, 9° 9' E) offered parcels on one of his fields. In 2014 Hartmut Böhner, Kilianihof (http://www.bio-mit-gesicht.de/20265.html) in 33165 Lichtenau (50° 54' N, 12° 59' O) offered two fields with the crops requested. The trials were placed into the same vegetables, leek and cauliflower, of the experimental site in Frankenhausen. Essential difference to the small scaled plots were (a) the bigger area for two treatments (LM- = without undersowing versus LM+ = undersown by white clover ('*Huia*'), (b) partly different cultivars compared to the scientific approaches with respect to the marketing needs of the commercial farms. The essential informations of both trials are listed in table 9.

Table 9: Essential data of pilot farm activities

	Farm ARENDES	Farm BÖHNER
Land parcels		
Cauliflower	*Schappen Scheune*	*Taubenheide*
Leek	*Schappen Scheune*	*Hoppenberg*
Cultivars		
Cauliflower	*Tarifa F1*	*Balbao F1*
Leek	*Hannibal*	*Megaton F1*
Planting		
Cauliflower	*2013-06-10*	*2013-07-03*
Leek	*2013-06-19*	*2014-06-04*

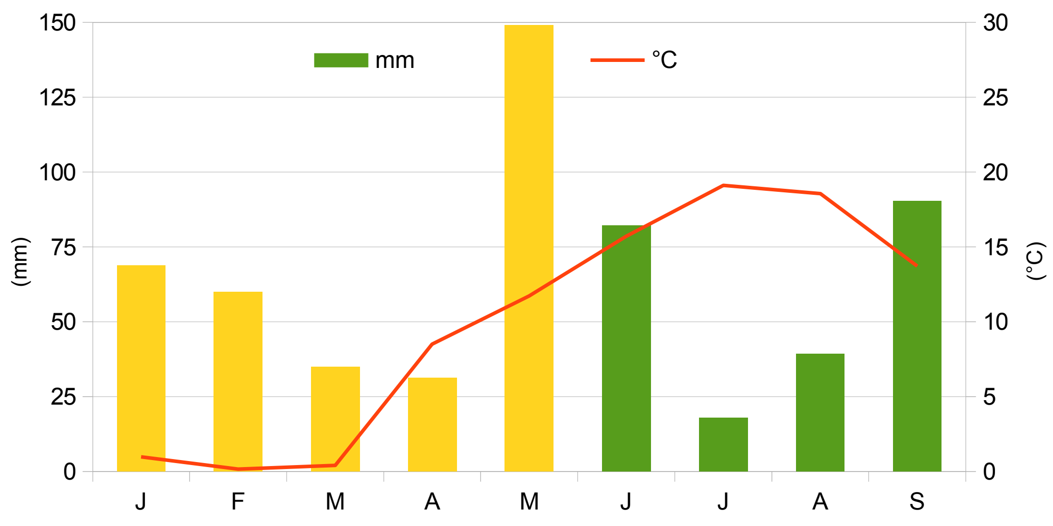


Figure 21: Climatic data at site 1 (2013)
Next station to Großeneder
Precipation before cultivation (Jan to May): 344 mm
Precipation during cultivation (Jun to Sep): 233 mm
Mean Temperature from Jun to Sep: 16.8°C

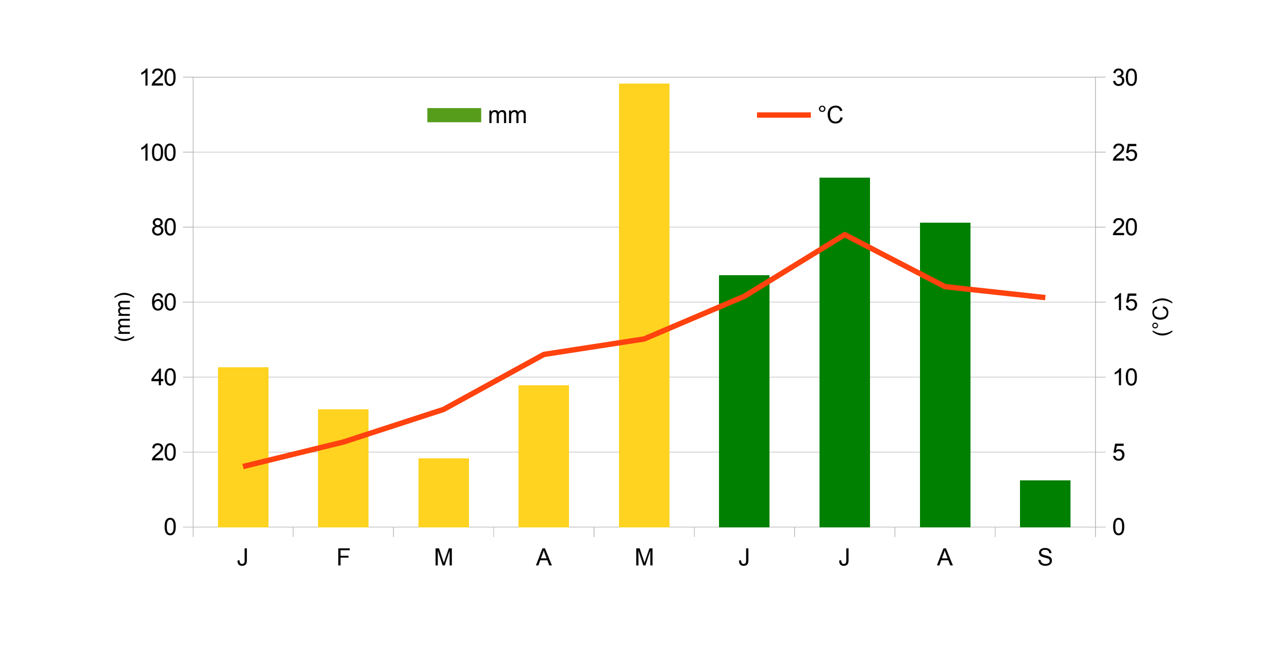


Figure 22: Climate data at site 2 (DWD 2014, Station Bad Lippspringe)
Next station to Lichtenau/Westfalen
Precipation before cultivation (Jan to May): 174 mm
Precipation during cultivation (Jun to Sep): 254 mm
Mean Temperature from Jun to Sep: 16.6°C

Both sites are very airy. Due to that fact wind mills are formative for both landscapes. The winter period in season 2012/13 had lower temperatures compared to the year after at site 2 (see figure 21 & 22). Rainfall till the end of May provided over 300 mm in 2013, but less then 200 mm in 2014. During the cultivation period between June and September the volume of precipation was fairly similar (2013: ~230 mm, 2014: ~250 mm), but the distribution was very different. The temperature during the same period was less promotative for the germination and growth of undersown clover in 2014.

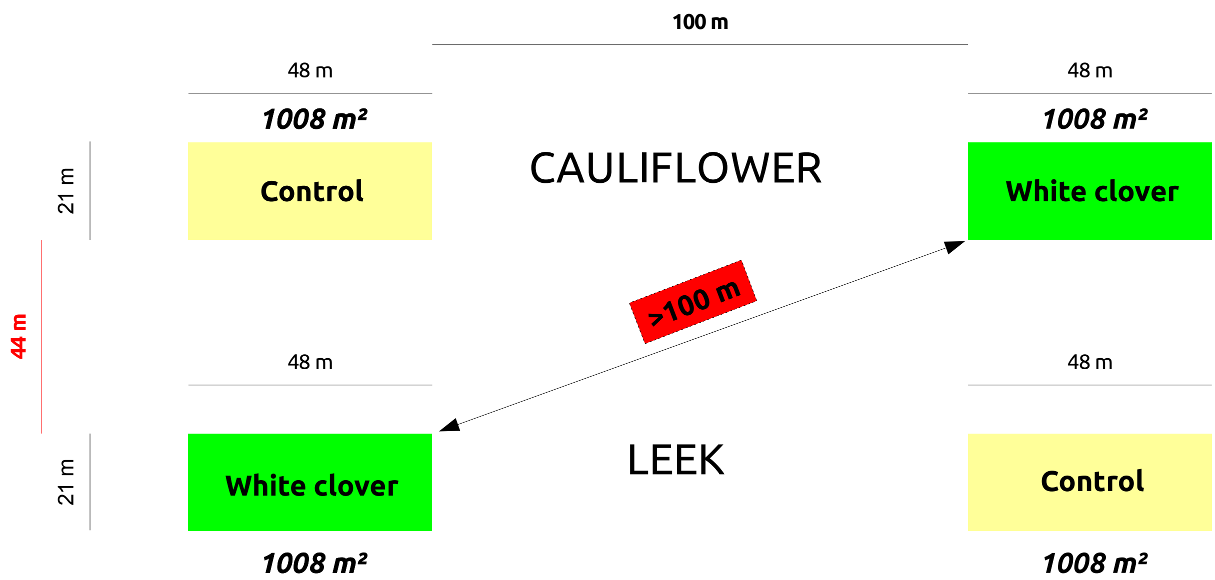


Figure 23: Experimental design at site 1 of both crops in one field

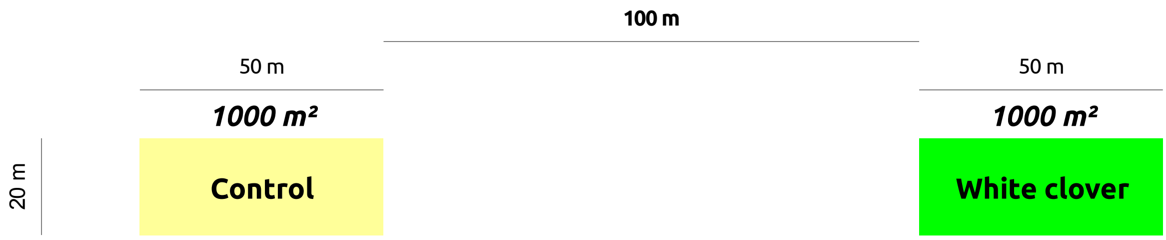


Figure 24: Design of pilot farm experiment at site 2 (two plots at two fields)

Each plot consisted of 1000 m^2, both treatments had a distance of at least 100 m in order to exclude migrations between the two plots. The same was true in 2013 when both crops were cultivated on the same field. Pit falls were established as four pseudo-replicates in each treatment, in a sub-unit of 20 x 12.5 m^2.

4 Results & Discussion

4.1 Cauliflower (Additive vs. Substitutive)

Due to the unevenness of maturity between the three cultivars the late maturing Belot F1 was excluded from the current presentation of data.

The biomass yield of the four components, head, residues, living mulch and weeds, clearly showed the low influence of Living mulch and Weeds on the development of caulifower biomass (see table 10), on the system's level >95 % at Control and Additive, 88 % at Substitutive. With concern to cultivar influences *White ball* had a significantly lower level of head biomass, but a significantly higher level of residue biomass compared to *Chambord F1*. Living mulch biomass was found to be higher in Substitutive compared to Additive, higher under *White ball* compared to *Chambord F1*. Biomass of living mulch and weeds corresponded to less than 4 % for Control and Additive, to 13 % for the Substitutive system. Its share on the cultivar level was slightly higher under *White ball* compared to *Chambord F1* (WB: 7 % versus CH: 5 %).

	CON	ADD	SUB	CH	WB
HE	28.3a	28.1a	21.3b	27.6g	24.2h
RES	34.6a	32.8a	20.3b	21.4h	37.1g
LM		0.8b	2.9a	1.2h	2.5g
WE	0.8	1.3	3.1	1.6	1.8

Table 10: Biomass yield (fm Mg ha^{-1})

Table 11 provides data referred to yield of heads per running meter. This perspective excludes the influence of different crop densities per area and enables a clearer vue of the potential of various living mulch systems. In addition these data are also presented on the level of individual years. Hereby it becomes very obvious that the early maturing cultivars *Chambords F1* and *White ball* were grown under less optimal conditons in 2013 compared to 2012 (see figures 17 & 18, with regard to the diverging water levels before and during cultivation), documented by significant lower yield levels in 2013. With concern to the influence of the Living mulch systems Substitutive was more promotative to the development of single plants, in 2012 more obvious than in 2013, for the lower yielding cultivar *Chambord F1* more than for *White ball*. The results of the Additive design were always similar to the Control.

Table 11: Biomass yield (kg m^{-1})

	CH	WB	MEANyear
2012	5.36 a	5.60 a	5.48 X
2013	3.44 b	5.21 a	4.32 Y
MEANcult	4.40 Q	5.40 P	

	CON	ADD	SUB	MEANyear
2012	5.08 b	5.23 b	6.13 a	5.48 X
2013	4.37 cd	3.91 d	4.70 bc	4.32 Y
MEANsyst	4.72 I	4.57 I	5.41 H	

	CH	WB	MEANsyst
CON	4.15 c	5.30 ab	4.72 I
ADD	4.15 c	4.99 b	4.57 I
SUB	4.90 b	5.93 a	5.41 H
MEANcult	4.40 Q	5.40 P	

The N yield was very much influenced by the yield level of the various organs (see table 12). It ranged between 76 and 101 kg N ha^{-1} for the heads of Substitutive and Additive, respectively, the lower value of Substitutive also significantly different to Control and Additive. Similar figures were measured by 71 and 121 kg N ha^{-1} for the residues of Substitutive and Control, significantly different, as well. *White ball* was found as significantly more N absorbing than *Chambord F1*. Living mulch of Substitutive resulted in significantly higher N uptake compared to Additive, the same was found comparing the situation between *White ball* and *Chambord F1*. N uptake by weeds was promoted in the Substitutive system, under crops of *Chambord F1* more than of *White ball*.

Table 12: N yield (kg ha^{-1})

	CON	ADD	SUB	CH	WB
HE	93.1 a	101.0 a	75.5 b	84.8 h	94.6 g
RES	121.0 a	111.0 a	71.4 b	75.4 h	127.0 g
LM		4.8 b	18.3 a	8.3 g	14.9 g
WE	4.6	8.4	21.6	18.1	7.5

Influences of the uptake of P and K were very similar to those of N, even though on different levels (see tables 13 & 14). On the system's level Control and Additive were found as similar, Substitutive as significantly lower to Control and Substitutive. The same is true for Living mulch comparing Substitutive and Additive. On the cultivar's level heads of *Chambord F1* absorbed higher amounts of P and K, although with significances. The proportion of absorbed P and K for Living mulch and Weeds were slightly higher for *Chambord F1* than for *White ball*. The entire absorption of P and K of the above-ground biomass of cauliflower was higher for *White ball* than *Chambord F1* (WB: 27 versus CH: 20 kg P ha^{-1}; WB: 149 versus CH:125 kg K ha^{-1}).

	CON	ADD	SUB	CH	WB
HE	12.5a	13.3a	9.9b	12.1g	11.7g
RES	14.5a	13.5a	7.9b	8.4h	15.5g
LM		0.5b	1.6a	0.5h	1.5g
WE	1.0	1.1	2.5	2.1	1.1

Table 13:
P yield (kg ha^{-1})

Table 14:
K yield (kg ha^{-1})

	CON	ADD	SUB	CH	WB
HE	84.9a	88.8a	65.9b	81.1g	78.6g
RES	72.6a	60.0b	39.1c	43.7h	70.7g
LM		3.9b	14.8a	5.7g	13.1g
WE	5.0	9.3	20.6	17.8	7.9

The contents of P and K in the soil, analysed in two soil layers, 0-30 cm and 30-60 cm, all in all, resulted in similar levels in both perspectives, systems and cultivars (see tables 15 to 18). Differences between Control, Additive and Substitutive can be interpreted as inconsistent with regard to the result of cultivars and the effects on the layers tested.

System	CH	BE	WB	MEANsyst
CON	65 a	66 a	60 ab	64 H
ADD	60 ab	52 b	69 a	60 H
SUB	70 a	64 ab	64 ab	66 H
MEANcult	65 P	61 P	64 P	

Table 15:
Available P (mg kg^{-1})
(0-30 cm)

System	CH	BE	WB	MEANsyst
CON	33 ab	25 b	32 ab	30 H
ADD	31 ab	38 a	33 ab	34 H
SUB	32 ab	34 ab	33 ab	33 H
MEANcult	32 P	32 P	33 P	

Table 16:
Available P (mg kg^{-1})
(30-60 cm)

System	CH	BE	WB	MEANsyst
CON	72 a	73 a	68 a	71 H
ADD	72 a	66 a	69 a	69 H
SUB	73 a	64 a	68 a	68 H
MEANcult	72 P	68 P	68 P	

Table 17:
Available K (mg kg^{-1})
(0-30 cm)

System	CH	BE	WB	MEANsyst
CON	47 a	50 a	46 a	47 H
ADD	55 a	55 a	44 a	52 H
SUB	51 a	51 a	46 a	49 H
MEANcult	51 P	52 P	45 P	

Table 18: Available K (mg kg⁻¹) (30-60 cm)

The analyses of mobile N sources in the soil layers provided moderate levels of Nmin, for the pre-winter date between 40 and 44 kg Nmin ha^{-1} on the cultivar level, between 38 and 47 kg Nmin ha^{-1} for Additive and Substitutive, respectively as sum of both layers analysed (see tables 19 to 23). Within the layers 1 and 2 data were not significant to each other, neither on the system nor on the cultivar level. Only at layer 3 (60-90 cm) the values for *Belot F1* were the lowest compared to the other cultivars, partly significantly different to them (see table 23), a cultivar with a massive development of residues.

System	CH	BE	WB	MEANsyst
CON	32 a	21 a	17 a	23 H
ADD	19 a	16 a	19 a	18 H
SUB	20 a	26 a	30 a	25 H
MEANcult	23 P	21 P	22 P	

Table 19: Nmin (kg ha^{-1}) (0-30 cm) December

System	CH	BE	WB	MEANsyst
CON	22 ab	16 b	17 b	18 H
ADD	22 ab	19 ab	18 b	20 H
SUB	20 ab	22 ab	26 a	22 H
MEANcult	21 P	19 P	20 P	

Table 20: Nmin (kg ha^{-1}) (30-60 cm) December

System	CH	BE	WB	MEANsyst
CON	13 b	19 ab	15 ab	16 H
ADD	15 ab	21 a	16 ab	17 H
SUB	15 ab	16 ab	15 ab	15 H
MEANcult	14 P	19 P	16 P	

Table 21: Nmin (kg ha^{-1}) (0-30 cm) March

System	CH	BE	WB	MEANsyst
CON	15 a	11 a	13 a	13 H
ADD	12 a	12 a	13 a	13 H
SUB	12 a	13 a	12 a	12 H
MEANcult	13 P	12 P	13 P	

Table 22: Nmin (kg ha^{-1}) (30-60 cm) March

System	CH	BE	WB	MEANsyst
CON	20 ab	7 d	20 ab	16 I
ADD	16 bc	9 cd	13 bcd	13 I
SUB	27 a	16 bcd	20 ab	21 H
MEANcult	21 P	11 Q	18 P	

Table 23: Nmin (kg ha⁻¹) (60-90 cm) March

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4.2 Leek (Additive vs. Substitutive)

The leek trials provided quite similar tendencies as found for the cauliflower. Due to the lower plant densities of the Substitutive system the results of Substitutive biomass for stem and residues were significantly lower than for Additive and Control (see table 24). Among the cultivars tested *Axima* reached the lowest levels for stem and residue biomass, partly significant to the other cultivars. Within Substitutive the biomass of Living mulch and Weeds was found as signifinatly higher than the to other systems, its share reached 21 % compared to 7 and 3 % of Additive and Control. Among the cultivars the proportions of biomass of crops and non-crop plants ranged between 86 and 91 % to 14 and 9 %.

	CON	ADD	SUB	HA	AX	CA
ST	33.5 a	33.8 a	23.9 b	32.5 g	29.1 h	29.6 h
RES	22.0 a	20.6 a	15.4 b	20.7 g	15.5 h	21.8 g
LM		2.2 b	4.8 a	3.2 g	3.9 g	3.4 g
WE	1.8 b	1.6 b	5.5 a	2.1 h	2.1 h	4.7 g

Table 24: Biomass yield (fm Mg ha⁻¹)

Parallel to the cauliflower data table 25 provides an insight view into the stand of the crop. Referred to the single rows the biomass yield of the Substitutive system reflects the effect of neighbouring living mulch more pronounced: in 2012 on the same level of the data of Control, in 2013 significantly higher than those. The less optimal growing conditions can also be found in the results of that parameter. In two of three cultivars the Substitutive system revealed significantly higher biomass data compared to Control. Results of the Additive treatment were stastistcally similar to the Control. Which means Living mulch did not cause growth reductions on the single crop level.

The N uptake of leek showed substantial differences between Control, Additive and Substitutive (see table 26). This is true for both components, stem and residues (CON: 176, ADD: 166, SUB: 120 kg N ha⁻¹). In case of the latter one that corresponded a share of 71 % of absorbed N per area. The significant high N levels for Living mulch and Weeds of the same system resulted in 29 % of N absorbed by non-crop plants. Among the three cultivars very similar data were found for the different components, only residues of *Catcher F1* took up N on a significantly higher level than the same organs of the two other cultivars.

Year	HA	AX	CA	MEANyear
2012	4.98 a	4.07 cd	4.46 b	4.50 X
2013	3.98 d	3.54 e	4.30 bc	3.94 Y
MEANcult	4.48 P	3.80 Q	4.38 P	

Year	CON	ADD	SUB	MEANyear
2012	4.51 ab	4.39 ab	4.62 a	4.50 X
2013	3.82 c	3.78 c	4.22 b	3.94 Y
MEANsyst	4.16 I	4.08 I	4.42 H	

System	HA	AX	CA	MEANsyst
CON	4.50 ab	3.73 d	4.26 bc	4.16 I
ADD	4.48 ab	3.56 d	4.20 bc	4.08 I
SUB	4.47 ab	4.12 c	4.68 a	4.42 H
MEANcult	4.48 P	3.80 Q	4.38 P	

Table 25: Biomass yield (kg m⁻¹)

	CON	ADD	SUB	HA	AX	CA
ST	99.5 a	95.9 a	71.4 b	86.5 g	92.0 g	88.3 g
RES	76.7 a	69.0 a	49.0 b	62.0 h	58.0 h	74.7 g
LM		12.4 b	28.3 a	20.4 g	22.2 g	18.4 g
WE	9.0 b	8.3 b	21.9 a	11.2 g	10.1 g	17.9 g

Table 26: N yield (kg ha⁻¹)

The data of P and K absorption (see table 27 & 28) were quite similar in tendency to the ones of the cauliflower trial. The treatment Substitutive caused always a significantly lower level of both nutrients. At the same time Living mulch and Weeds took off significant higher amounts of P and K in the same system. In consequence the share of absorbed P and K by the non-crop plants even reached shares of 25 and 39 %, respectively. The parallel levels for Control and Additive were calculated as 7 and 14 % for P, and 8 and 17 % for K. With concern to the cultivars the results of P uptake were found as rather similar for the different components, opposite to the effect on the K uptake, in specific to the cultivar Catcher F1. The share of nutrient uptake by the non-crop plants layed between 20 and 23 % for P, and 21 and 28 % for K.

Table 27: P yield (kg ha⁻¹)

	CON	ADD	SUB	HA	AX	CA
ST	11.2 a	11.1 a	8.0 b	10.2 gh	10.5 g	9.5 h
RES	7.0 a	6.2 b	4.2 c	5.7 h	5.0 h	6.8 g
LM		1.3 b	2.9 a	2.1 g	2.4 g	1.8 g
WE	1.4 b	1.5 b	3.6 a	1.8 g	1.7 g	3.0 g

	CON	ADD	SUB	HA	AX	CA
ST	59.7 a	59.7 a	41.6 b	53.1 h	62.1 g	45.8 i
RES	44.6 a	39.4 a	28.1 b	37.8 gh	31.2 h	43.1 g
LM		9.6 b	21.7 a	16.4 g	15.3 g	15.1 g
WE	9.2 b	10.7 b	23.4 a	13.3 g	10.1 g	19.8 g

Table 28:
K yield (kg ha⁻¹)

The soil analyses of available P and K content in the soil after harvest resulted in very similar data (see table 29 & 30). Only the Additive system linked to the cultivation of *Catcher F1* revealed significantly higher levels compared to Control and Substitutive. The homogenities on the system and cultivar level were quite obvious. Similar facts can be found for the K content of the soil.

System	HA	AX	CA	MEANsyst
CON	52 ab	51 ab	48 b	50 H
ADD	54 ab	53 ab	60 a	56 H
SUB	57 ab	51 ab	47 b	52 H
MEANcult	54 P	52 P	52 P	

Table 29:
Available P (mg kg⁻¹)
(0-30 cm)

System	HA	AX	CA	MEANsyst
CON	61 a	65 a	62 a	63 H
ADD	59 a	65 a	55 a	60 H
SUB	64 a	62 a	58 a	61 H
MEANcult	61 P	64 P	59 P	

Table 30:
Available K (mg kg⁻¹)
(0-30 cm)

The values of mobile N sources in the soil were found as similarly moderate as for the cauliflower trial, ranging between 33 and 51 kg Nmin ha⁻¹ for two layers, the value of Substitutive linked to cultivar *Hannibal* significantly different to the values of Control and Additive (see table 31 & 32). Within the other cultivars no treatments was different to each other.

System	HA	AX	CA	MEANsyst
CON	16 bc	12 bc	12 bc	14 I
ADD	16 bc	11 c	21 b	16 I
SUB	40 a	13 bc	15 bc	23 H
MEANcult	24 P	12 Q	16 Q	

Table 31:
Nmin (kg ha⁻¹) (0-30 cm)
December

System	HA	AX	CA	MEANsyst
CON	16 b	21 b	20 b	19 H
ADD	16 b	14 b	26 ab	19 H
SUB	38 a	17 b	21 b	26 H
MEANcult	23 P	18 P	22 P	

Table 32:
Nmin (kg ha⁻¹) (30-60 cm)
December

The data of the post-winter date did not provide severe downward movements of nitrate and ammonium during the winter period (see table 33 to 35). System effects should not be over-estimated due to opposite effects in different layers, i.e. *Hannibal*: 1=lowest, 2=lowest, 3=highest, *Axima*: 1=highest, 2=highest, 3=lowest. The sum of three layers resulted in *Hannibal*=63, *Axima*=69, *Catcher F1*=55 kg Nmin ha^{-1}, in Control=67, Additive=62, Substitutive=64 kg Nmin ha^{-1}.

System	HA	AX	CA	MEANsyst
CON	22 bcd	37 a	19 bcd	26 H
ADD	14 d	27 bc	24 bcd	22 H
SUB	23 bcd	27 ab	17 cd	22 H
MEANcult	20 Q	31 P	20 Q	

Table 33:
Nmin (kg ha^{-1}) (0-30 cm)
March

System	HA	AX	CA	MEANsyst
CON	16 abc	20 a	18 abc	18 H
ADD	14 c	18 abc	19 ab	17 H
SUB	19 abc	17 abc	15 bc	17 H
MEANcult	16 P	18 P	17 P	

Table 34:
Nmin (kg ha^{-1}) (30-60 cm)
March

System	HA	AX	CA	MEANsyst
CON	23 b	22 b	25 b	23 H
ADD	23 b	22 b	25 b	23 H
SUB	36 a	16 b	23 b	25 H
MEANcult	27 P	20 Q	24 PQ	

Table 35:
Nmin (kg ha^{-1}) (60-90 cm)
March

4.3 Cauliflower (Sowing date: early vs. late sowing)

The results of the second trials can be interpreted in a very similar manner. In tendency the living mulch, sown out two and four weeks after planting, caused slight reductions within the parameters under assessment. The effects of early sowing were more pronounced than the the ones of later sowing and can be interpreted as higher competetion by the early established living mulch. The data are mostly homogeneous without clear stastistical distinction. This is true for all parameters presented: biomass per plant (see table 36 to 37), biomass yield per area (see table 38 to 39), Uptake of nutrients (see table 40 to 41 for N, table 42 to 43 for P, and table 44 to 45 for K). In case of yield of N and P absorbed by the heads the means of date for the 2 weeks treatment were found statistically lower than the untreated control, in both cases with values of less than 14 % of the control.

Table 36: Biomass yield (fm g plant^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	1944 a	1807 a	1876 H
2 weeks	1622 a	1531 a	1576 H
4 weeks	1950 a	1692 a	1821 H
Mean$_{(Type)}$	1839 P	1677 P	

Table 37: Head yield (fm g plant^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	1129 a	983 a	1056 H
2 weeks	923 a	955 a	939 H
4 weeks	1021 a	1003 a	1012 H
Mean$_{(Type)}$	1024 P	980 P	

Table 38: Biomass yield (t ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	57.6 a	53.5 a	55.5 H
2 weeks	48.0 a	45.3 a	46.7 H
4 weeks	57.7 a	50.1 a	53.9 H
Mean$_{(Type)}$	54.4 P	49.6 P	

Table 39: Head yield (t ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	33.4 a	29.1 a	31.3 H
2 weeks	27.3 a	28.3 a	27.8 H
4 weeks	30.2 a	29.7 a	30.0 H
Mean$_{(Type)}$	30.3 P	29.0 P	

Table 40: Biomass N yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	253.1 a	238.6 a	245.8 H
2 weeks	192.5 a	184.3 a	188.4 H
4 weeks	240.9 a	205.2 a	223.0 H
Mean$_{(Type)}$	228.8 P	209.3 P	

Table 41: Head N yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	91.6 a	81.6 a	86.6 H
2 weeks	72.7 a	75.8 a	74.2 I
4 weeks	82.0 a	80.3 a	81.1 HI
Mean$_{(Type)}$	82.1 P	79.2 P	

Table 42: Biomass P yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	27.1 a	24.9 a	26.0 H
2 weeks	21.4 a	20.4 a	20.9 H
4 weeks	26.7 a	21.9 a	24.3 H
Mean$_{(Type)}$	25.1 P	22.4 P	

Table 43: Head P yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	12.1 a	10.5 a	11.3 H
2 weeks	9.3 a	10.0 a	9.6 I
4 weeks	10.4 a	10.1 a	10.3 HI
Mean$_{(Type)}$	10.6 P	10.2 P	

Table 44: Biomass K yield (kg ha⁻¹)

	Drill	Broad	Mean (Date)
Control	107.4 a	96.8 a	102.1 H
2 weeks	85.9 a	85.5 a	85.7 H
4 weeks	107.8 a	91.3 a	99.6 H
Mean (Type)	100.4 P	91.2 P	

Table 45: Head K yield (kg ha⁻¹)

	Drill	Broad	Mean (Date)
Control	68.4 a	61.6 a	65.0 H
2 weeks	56.1 a	58.7 a	57.4 H
4 weeks	63.5 a	61.9 a	62.7 H
Mean (Type)	62.7 P	60.7 P	

4.4 Leek (Sowing date: early vs. late sowing)

The data of the leek trial confirm the results of the cauliflower trial. Although the differences between control and the two living mulch treatments were found as more pronounced, reductions by 15 to 20 % of the current control value, deviations within the data set prohibited any statistical distinction in the system comparison. The mode of sowing indicated a clear advantage of the drilling method or a weakness of the broad sowing if seeds are not regularly mixed into the top soil. For all parameter assessed the values of broad sowing were 10 to 16 % less than the values of the drilled reference. Parameter assesed are listed for biomass per plant (see table 46 to 47), biomass yield per area (see table 48 to 49), Uptake of nutrients (see table 50 to 51 for N, table 52 to 53 for P, and table 54 to 55 for K).

Table 46: Biomass yield (fm g plant⁻¹)

	Drill	Broad	Mean (Date)
Control	243 a	230 a	236 H
2 weeks	231 a	142 a	186 H
4 weeks	212 a	205 a	209 H
Mean (Type)	229 P	192 P	

Table 47: Stem yield (fm g plant⁻¹)

	Drill	Broad	Mean (Date)
Control	147 a	134 a	140 H
2 weeks	133 a	87 a	110 H
4 weeks	126 a	117 a	121 H
Mean (Type)	135 P	113 P	

Table 48: Biomass yield (t ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	29.4 a	27.9 a	28.6 H
2 weeks	28.0 a	17.2 a	22.6 H
4 weeks	25.7 a	24.9 a	25.3 H
Mean$_{(Type)}$	27.7 P	23.3 P	

Table 49: Stem yield (t ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	17.8 a	16.2 a	17.0 H
2 weeks	16.1 a	10.6 a	13.3 H
4 weeks	15.2 a	14.2 a	14.7 H
Mean$_{(Type)}$	16.4 P	13.7 P	

Table 50: Biomass N yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	95.4 a	93.9 a	94.6 H
2 weeks	93.2 a	67.9 a	80.6 H
4 weeks	83.7 a	82.0 a	82.9 H
Mean$_{(Type)}$	90.8 P	81.3 P	

Table 51: Stem N yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	46.7 a	41.2 ab	44.0 H
2 weeks	42.2 ab	31.3 b	36.8 H
4 weeks	39.9 ab	36.7 ab	38.3 H
Mean$_{(Type)}$	42.9 P	36.4 Q	

Table 52: Biomass P yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	12.0 ab	12.4 a	12.2 H
2 weeks	11.8 ab	7.6 b	9.7 H
4 weeks	11.2 ab	11.0 ab	11.1 H
Mean$_{(Type)}$	11.7 P	10.3 P	

Table 53: Stem P yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	5.9 a	5.7 ab	5.8 H
2 weeks	5.6 ab	4.1 b	4.9 H
4 weeks	5.5 ab	5.1 ab	5.3 H
Mean$_{(Type)}$	5.7 P	4.9 Q	

Table 54: Biomass K yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	46.3 a	49.8 a	48.1 H
2 weeks	45.6 a	31.6 a	38.6 H
4 weeks	40.5 a	38.7 a	39.6 H
Mean$_{(Type)}$	44.1 P	40.0 P	

Table 55: Stem K yield (kg ha^{-1})

	Drill	Broad	Mean$_{(Date)}$
Control	23.6 a	23.1 a	23.4 H
2 weeks	21.5 a	16.0 a	18.8 H
4 weeks	19.8 a	18.6 a	19.2 H
Mean$_{(Type)}$	21.6 P	19.2 P	

4.5 Pilot farm activities

The content of pit falls were measured on the family level. Most of the species belonged to three families: C*arabidae, Arachnidae and Staphilinidae*. The content of pit falls which were filled for one to two weeks by 50 % propylenglycole, were collected four to five times in both years, in 2013 between Jul 30 and Sep 17, in 2014 between Aug 16 and Sep 25. The number of individuals was calculated as activity per week.

Table 56: Leek 2013 - N individuals pitfall^{-1} (Activity per week)

Date	***Carabidae***		% Surplus	***Arachnidae***		% Surplus	***Staphilinidae***		% Surplus
	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)
2013-07-30	57.3	57	-1%	3.8	4.5	18%	5.8	6.3	9%
2013-08-06	167.5	179.5	7%	15.3	18	18%	19.0	24.5	29%
2013-08-20	13.8	20.0	45%	3.4	5	47%	1.3	3.1	138%
2013-09-03	6.8	10.3	51%	4.4	3.4	-23%	0.3	0.3	0%
2013-09-17	1.8	4.3	139%	1	1.3	30%	0.0	0.3	
Mean			**48%**			**18%**			**44%**

	p value	KW			p value	KW
System	0.417		→	Car	0.375	
Family	0.000			Ara	0.104	
Date	0.000			Sta	0.278	

KW = Kruskal Wallis test

Table 57: Leek 2014 - N individuals pitfall^{-1} (Activity per week)

Date	***Carabidae***		% Surplus	***Arachnidae***		% Surplus	***Staphilinidae***		% Surplus
	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)
2014-08-16	13.5	16.8	24%	9.3	15.8	70%	1.3	1.0	-23%
2014-08-23	5.5	10.8	96%	7.8	11.5	47%	0.3	0.8	167%
2014-09-01	15.8	16.5	4%	7.0	7.3	4%	0.0	0.8	
2014-09-13	15.3	27.0	76%	9.5	6.8	-28%	0.0	0.0	
2014-09-25	14.0	18.5	32%	9.0	12.0	33%	0.5	0.3	-40%
Mean			**47%**			**25%**			**35%**

	p value	KW			p value	KW
System	0.303		→	Car	0.162	
Family	0.000			Ara	0.378	
Date	0.622			Sta	0.451	

KW = Kruskal Wallis test

Results of leek trials (see table 56 & 57)

Whereas *Carabidae* and *Staphilinidae* were less abundant in 2014, possibly a reaction to the cool weather conditions, *Arachnidae* achieved higher counts within both crops. This might be either a higher robustness against climate conditions or a reaction towards the lower number of carabids. The different levels of the three families are statistically highly significant in each year. The sequence of their abundance were found as *Carabidae > Arachnidae > Staphilinidae*. Although a system effect is continuously visible in all families the differences were too small for any clear significance.

Results of cauliflower trials (see table 58 & 59)

Most of the observations above-mentioned are also true for the cauliflower crop. Only the system effect between undersown and not undersown area were not that constant and regular in one direction, +LM > -LM. Within the *Staphilinidae* and the *Carabidae* the +LM plots were counted by smaller values than their references, within the group of *Arachnidae* the effects changed between both years, in 2013 +LM enhancing, in 2014 +LM diminishing.

Table 58: Cauliflower 2013 - N individuals pitfall⁻¹ (Activity per week)

Date	*Carabidae*		% Surplus	*Arachnidae*		% Surplus	*Staphilinidae*		% Surplus
	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)
2013-07-30	15.0	12.5	-17%	3.0	3.3	10%	4.8	1.5	-69%
2013-08-06	54.0	47.0	-13%	17.8	18.0	1%	12.0	8.3	-31%
2013-08-20	5.8	4.0	-31%	1.8	1.9	6%	1.4	0.6	-57%
2013-09-03	0.8	10.0	1150%	1.3	8.5	554%	0.1	0.1	0%
Mean			**272%**			**143%**			**-39%**
Mean (J-A)			***-20%***			***6%***			***-52%***

	p value	KW			p value	KW
System	0.417		→	Car	0.375	
Family	0.000			Ara	0.104	
Date	0.000			Sta	0.278	

KW = Kruskal Wallis test

Table 59: Cauliflower 2014 - N individuals pitfall⁻¹ (Activity per week)

Date	*Carabidae*		% Surplus	*Arachnidae*		% Surplus	*Staphilinidae*		% Surplus
	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)	LM-	LM+	(LM+ / LM-)
2014-08-16	17.0	3.5	-79%	26.8	12.0	-55%	7.0	2.5	-64%
2014-08-23	2.3	1.3	-43%	10.3	10.3	0%	0.5	0.3	-40%
2014-09-01	7.8	9.8	26%	12.5	11.3	-10%	0.3	1.3	333%
2014-09-13	7.3	7.3	0%	7.8	8.0	3%	0.5	0.5	0%
2014-09-25	12.0	8.0	-33%	7.5	6.0	-20%	0.5	1.0	100%
Mean			**-26%**			**-16%**			**66%**

	p value	KW			p value	KW
System	0.257		→	Car	0.266	
Family	0.000			Ara	0.302	
Date	0.038			Sta	0.804	

KW = Kruskal Wallis test

Table 60: ***Leek 2013 (Site 1: harvest: 2013 Sep 29)***

Treatment	Stem	Stem	Clover	Weed
	g $plant^{-1}$	t ha^{-1}	t ha^{-1}	t ha^{-1}
- LM	377	44.97		5.66
+ LM	421	51.03	1.45	

Table 61: ***Leek 2014 (Site 2: harvest: 2014 Oct 06)***

Treatment	Stem	Stem	Clover	Weed
	g $plant^{-1}$	t ha^{-1}	t ha^{-1}	t ha^{-1}
- LM	120	15.44		5.83
+ LM	119	14.42	1.24	9.80

At site 1 the living mulch system caused a higher stem yield (+12 %) compared to the not undersown area (see table 60). The performance of leek at the other site can be interpreted as similar, even though the weed biomass was found as doubled compared to the area without undersown clover (see table 61).

The performance of cauliflower crops were effected at both sites by slight reductions in yield (site 1: -9 %, site 2: -7 %) (see tables 62 & 63). The weed pressure at site 2 was found increased fivefold. Due to different cultivars which were grown at the two farms a direct comparison of the yield level is not recommendable.

Table 62: ***Cauliflower 2013 (Site 1: harvest: 2013 Aug 29)***

Treatment	Head	Head
	g $plant^{-1}$	t ha^{-1}
- LM	834	24.71
+ LM	756	22.41

Table 63: ***Cauliflower 2014 (Site 2: harvest: 2014 Sep 25)***

Treatment	Head	Head	Clover	Weed
	g $plant^{-1}$	t ha^{-1}	t ha^{-1}	t ha^{-1}
- LM	923	27.35		1.59
+ LM	858	25.41	1.51	9.27

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