LIFE Project Number

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Deliverable "Report on implementation of the action plans in the demo farms"

Sub-action B2.2 "Implementation of the soil management solutions"

LIFE+ PROJECT Soil4Wine

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Abstract

During the first project year SMART (Specific, Measurable, Achievable, Realistic an Time bounded) Action Plans to mitigate soil threats were defined for each demo farm, were described in details in Deliverable B2.1 and are briefly presented in Table 1. Starting from Fall 2017 soil management actions foreseen by the SMART Action Plans were carried out in the demo farms and the present Deliverable describes in details when, where and how these actions were performed, as well as problems encountered during the implementation itself.

Table 1: brief description of the SMART Action Plans defined in sub-action B2.1 for each Demo Farm

Demo Farm	SMART Action Plan
SP1	Permanent artificial grassing with a mixture of *Festuca, Lolium* and *Poa* seeds (Grass B, Annex 1 of Deliverable B2.1) to reduce erosion in the inter-row, especially in the upper part of the vineyard, and to increase soil organic matter content.
SP2	Temporary grassing with Leguminouse and Brassica cover crops (Green Manure B, Annex 1 of Deliverable B2.1) seed mixture to limit tillage and reduce compaction and hard pan. Water logging at vineyard bottom and erosion on the top would be also reduced. Soil organic matter should be increased.
SP3	Temporary grassing with Leguminouse and Brassica cover crops (Green Manure A and B, Annex 1 of Deliverable B2.1) seed mixture to reduce water logging and soil compaction.
SP4	Permanent artificial grassing with species belonging to *Poaceae* and *Fabaceae* families (Grass A, Annex 1 of Deliverable B2.1) to reduce water logging in the bottom part of the vineyard, compaction and hard pan and increase soil organic matter.
VT1	Temporary grassing with Leguminouse and Brassica cover crops (Green Manure A, Annex 1 of Deliverable B2.1) seed mixture to reduce erosion, increase soil organic matter and increase ecosystem biodiversity. To reach this last objective *Phacelia tanacetifolia* will be sowed in a buffer area near the vineyard.
VT2	Temporary grassing with Leguminouse and Brassica cover crops (Green Manure A, Annex 1 of Deliverable B2.1) seed mixture to reduce erosion, increase soil organic matter and increase ecosystem biodiversity
TBC1	Permanent artificial grassing with species belonging to *Poaceae* and *Fabaceae* families (Grass A, Annex 1 of Deliverable B2.1) to reduce erosion, effects of drought and low organic matter on vine vigor. The biomass cut will be moved under the row to control weeds.
TBC2	Permanent grassing with Leguminouse species (Grass C, Aneex 1 Deliverable B2.1) to increase soil organic matter, promote vine vigor and water movement in soil.
RES1	Preliminary superficial water control followed by underground drainage within the vineyard and permanent grassing of headlines (different species, pure or in mixture, see Deliverable B2.1) to control water logging and soil compaction.
RES2	Preliminary superficial water control followed by underground drainage joined with the restoration of damaged inter-row due to severe erosion processes
RES DEMO	Permanent and temporary grassing with different seed mixtures (sowed in Demo Farms and additional ones) to compare seed mixtures features and behavior in same environmental conditions and verify the suitability of several permanent grass solutions (microtermal and macrotermal species) to track movement.

Agricultural machinery used in the implementation of demonstrative actions

To perform the actions described in Table 1 specific agricultural machinery where rent from a subcontractor, in particular for sowing a combined machine, composed by a power harrow, a seeding bar and a rear roller (*Figure 1*), specifically designed for inter-row sowing was used. When soil was hard and compact, a subsoiler was used to till the inter-row before sowing.

Figure 1: sowing machine used in Soil4Wine demonstrative vineyards

Cutting of green manure was performed with a mower (*Figure 2 a and b*). After drying, biomass was incorporated in the ground with a rotary tiller (*Figure 2 c*) to 10 cm depth.

Figure 2: a,b) mower c) soil incorporation with rotary tiller

Implementation of action plans in demonstrative vineyards (Oct17-Oct18)

DEMO FARM SP1_Az. Vitivinicola Barbuti Giuseppe

Activities		Notes
Sowing	23rd April 2018	Spring 2018 was considerably rainy and soil was not in proper moisture condition for sowing (*Figure 3.)* Unfortunately, after sowing, temperature was very low (*Figure 4*) making not the best conditions for seed germination. Sowing dose was 90 kg/ha
Cut		Two cuts were performed, in May (18/05/18) and June (07/06/18), less than the planned in Action Plan because during summer grass didn't grow enough to be cut again.

Figure 3: Demo Farm SP1 - demonstrative vineyard before (left) and after (right) sowing

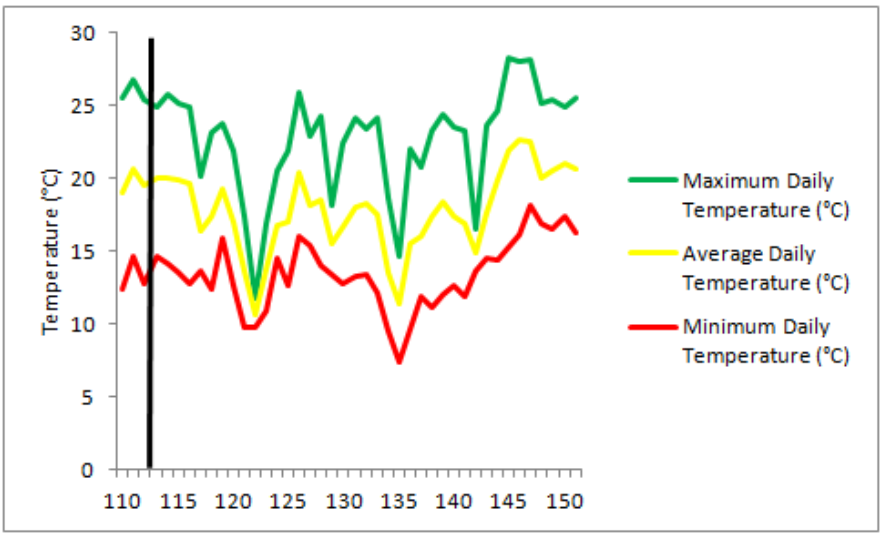

Figure 4: Temperature in Demo Farm SP1 demonstrative vineyard from 20/04/18 to 31/05/18. Sowing was on DOY 113 (black line)

UCSC and HORTA visited the Demo Farm SP1 demonstrative vineyard 4 times after sowing (7/06/18, 28/06/18, 14/08/18, 18/09/18) (*Figure 5*) to evaluate the growth of the grass: beside the seeded species,

spontaneous species were identified, in particular in the lower part of the vineyard that was characterized by higher soil humidity and lower slope. No erosion rills and track grooves were identified.
Unfortunately, grass growth was very limited in the upper part of the demonstrative vineyard, it was therefore decided to perform a new sowing (by hand) in October 2018 in the upper part to enhance grass covering and reduce erosion during rainy seasons.

Figure 5: Demo Farm SP1 Demonstrative vineyard at different monitoring dates in 2018.

DEMO FARM SP2_Az. Podere Le Lame

Activities		Notes
Sowing	3rd November 2017	**Green Manure B** was sowed in demonstrative vineyard to reduce erosion, enhance soil organic matter content and vine vigor. (*Figure 6*). As a consequence soil compaction and hard pan should be also reduced. Sowing dose was 90 kg/ha
Cut	18th May 2018	*Figure 11*
Soil incorporation	19th June 2018	After cut biomass should have been left on soil for few days to dry before soil incorporation. Unfortunately, as indicate in *Figure 8*, a rainy period started just after biomass cut and incorporation into the soil (*Figure 12)* could only be performed in the middle of June.

Figure 6: Demo Farm SP2 demonstrative vineyard during sowing

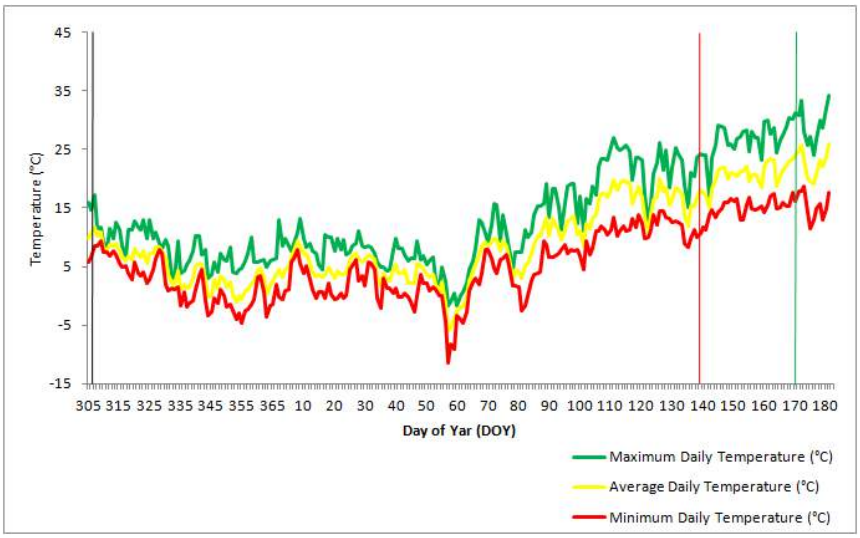

Figure 7: temperature in Demo Farm SP2 demonstrative vineyard from 01/11/17 to 30/06/18. Sowing was on DOY 308 (black line), cut was on day 138 (red line) and incorporation was on day 170 (green line)

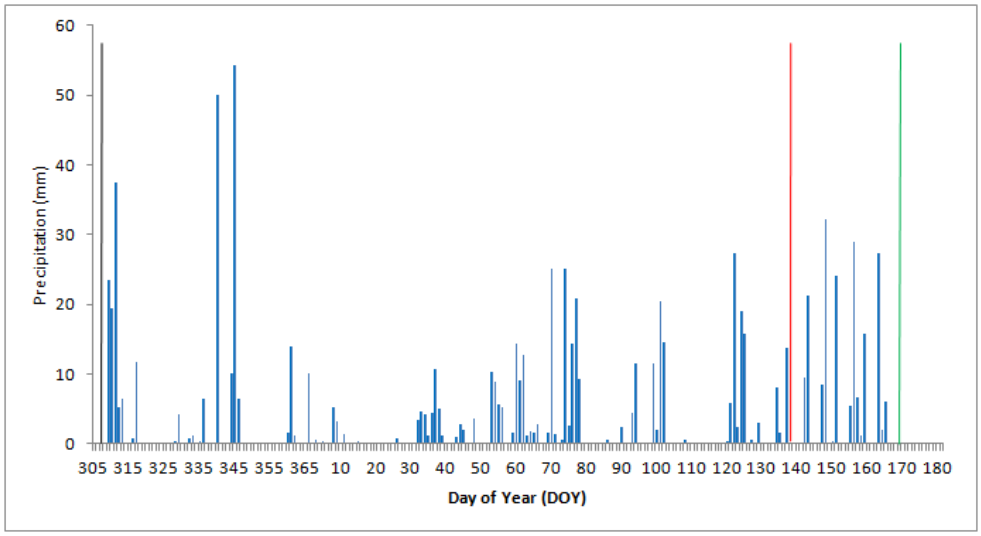

Figure 8: precipitation in Demo Farm SP2 demonstrative vineyard from 01/11/17 to 30/06/18. Sowing was on DOY 308 (black line), cut was on day 138 (red line) and incorporation was on day 170 (green line)

UCSC and HORTA visited Demo Farm SP2 demonstrative vineyard 4 times after sowing (20/02/18, 20/03/18, 12/04/18, 08/05/18) (*Figure 9*).

Since first monitoring visit the growth of seeded species was evident, especially of *Pisum sativum, Brassica nigra and* horse radish (*Figure 10)*. Nonetheless, those species, unfortunately suffered low temperature in February and, in March, clear leaves yellowing was noted (*Figure 10b*).

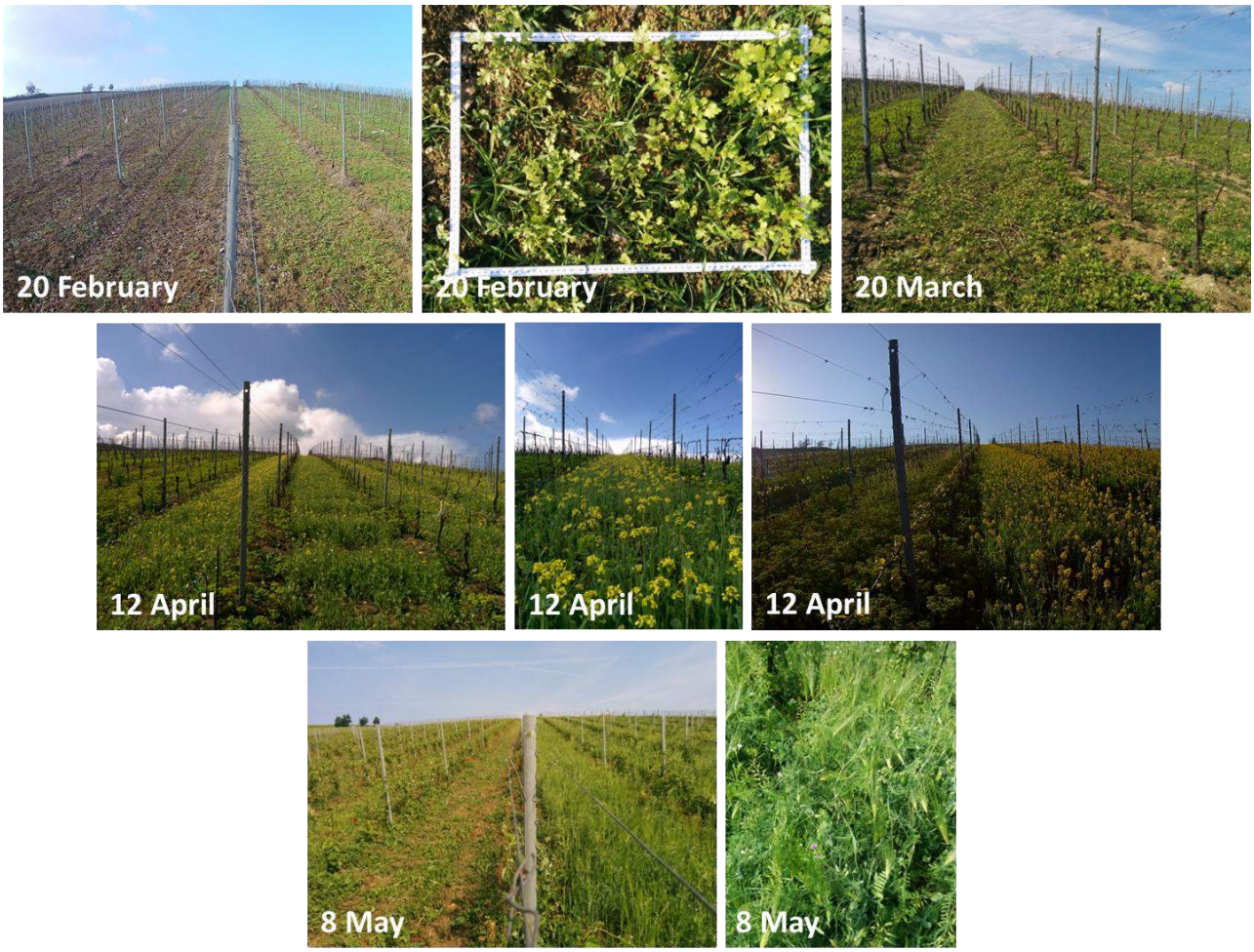

Figure 9: Demo Farm SP2 demonstrative vineyard at different monitoring date in 2018.

Figure 10: green manure species details: a:Pisum sativum 20/02/18; b:Sinapsis nigra and Hordeum vulgare 21/03/18; c: flower of Sinapsis nigra 12/04/18; d: Vicia spp, Pisum sativum and Sinapsis nigra 12/04/18

Cut was performed on 18th May 2018: for certain species (in particular *Legumes* and *Brassica)* it was slightly late because they already presented mature seeds. This should have been avoided because nutrients could be dislocated in seed and not stay in plant tissues that, after incorporation into the soil, are easily degraded and provide nutrients to the vines, but heavy rains in the first part of May (*Figure 8*) did not enable the passage of the tractor in vineyard.

During cutting (*Figure 11*) UCSC collected biomass in three sampling points along the inter-row to quantify average biomass production. Fresh biomass was weighted in vineyard and put in oven at 105° for few days until weight was stable.

Fresh biomass production was 1253.46 g/mq and dry biomass was 330.61 g/mq corresponding to 26.41%.
At soil incorporation date some species growth again and new biomass was incorporate in soil with dried one (*Figure 12*).

Figure 11: cut of green manure in Demo Farm SP2

Figure 12: soil incorporation of fresh and dried biomass in Demo Farm SP2

DEMO FARM SP3_Az.Vitivinicola Visconti Massimo

Activities		Notes
Sowing	3rd November 2017	A mixture of **Green Manure A** (50%) and **Green Manure B** (50%) was sowed to reduce water logging and, consequently, soil compaction and hard pan. Sowing dose was 90 kg/ha (*Figure 13*)
Cut	16th May 2018	Cut could be performed only at mid May because of heavy rains and high humidity in the soil (*Figure 15 and 16)*. Considering that water logging was identified as main soil threat in this demonstrative vineyard, green manure biomass was cut and left on soil, rather than incorporated into the soil, to enhance seeded plant roots functions as drains.

Figure 13: Demo Farm SP3 demonstrative vineyard during sowing

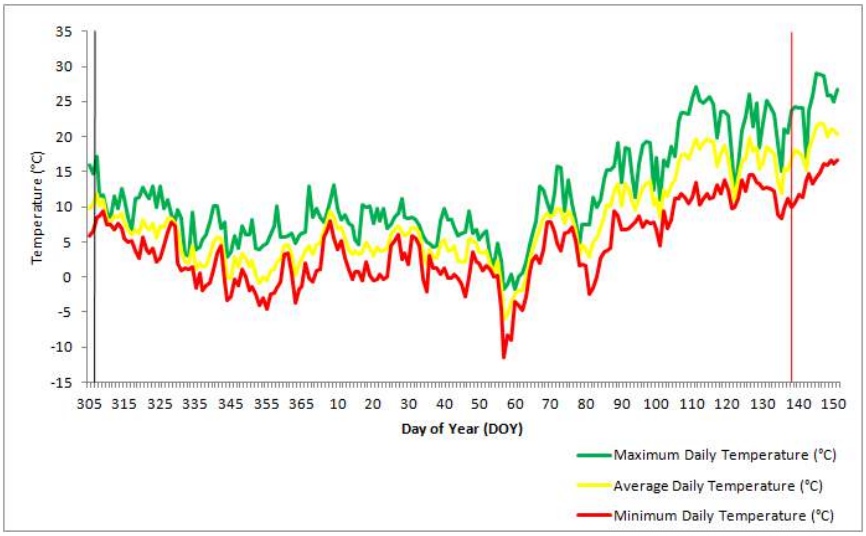

Figure 14: temperature in Demo Farm SP3 demonstrative vineyard from 01/11/17 to 31/05/18. Sowing was on DOY 308 (black line), cut on day 136 (red line)

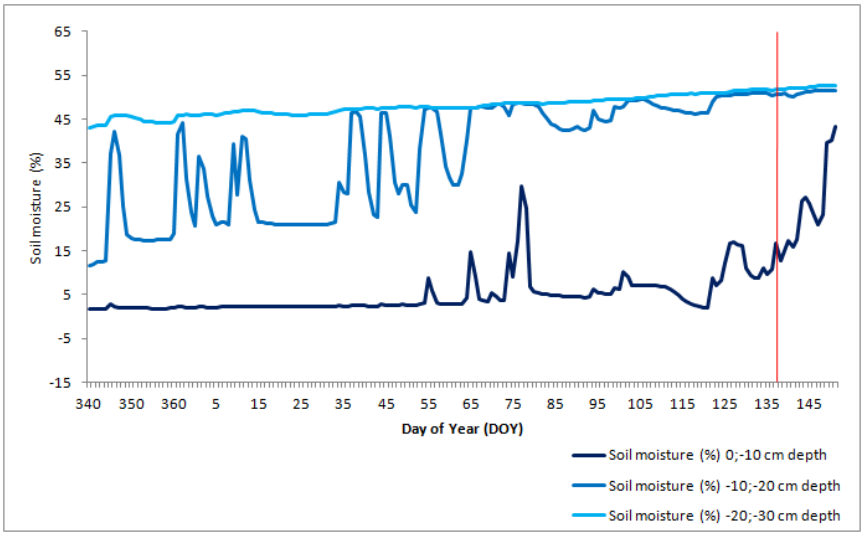

Figure 15. Daily soil moisture in Demo Farm SP3 demonstrative vineyard from 06/12/17 to 31/05/18. Cut was on day 136 (red line)

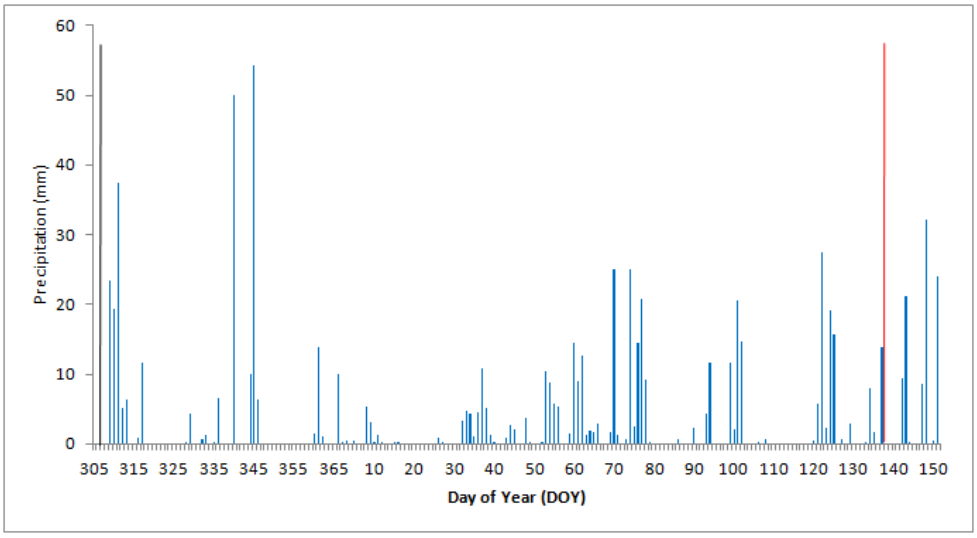

Figure 16: Precipitation (mm) in Demo Farm SP3 demonstrative vineyard from 01/11/17 to 31/05/18. Sowing was on DOY 308 (black line), cut was on day 136 (red line)

UCSC and HORTA visited Demo Farm SP3 demonstrative vineyard 4 times after sowing (20/02/18, 20/03/18, 09/05/18, 01/06/18) (*Figure 17*). During visits the covering of grass was visually assessed. Water logging was identified as main threat in each visit and growth of biomass was inhibited by the excess of water in soil (*Figure 15,16*) due to abundant precipitation during growing season (from sowing to cut a total of 665.8 mm).
Figure 15 shows soil water content (%) at 10, 20, 30 cm depth during growing period.
As reported in *Figure 17 (1 June)* soil was compacted by wheel passage during late Spring, characterized by severe rainy days, when water logging was present and rills were evident and depth.
Vines health condition were compromised, during 2018, impact and presence of *Esca disease* and *Flavescence dorée* were severe and diffuse.

Figure 17: Demo Farm SP3 demonstrative vineyard at different monitoring dates in 2018

DEMO FARM SP4_Az.Vini Colombi

Activities		Notes
Sowing	23rd April 2018	**Grass A** was sowed in Spring 2018 *(Figure 18)*. Unfortunately, after sowing, temperature were very low (*Figure 19*) making not the best conditions for seed germination Sowing dose was 55 kg/ha
Cut		Only one cut was performed by the farmer in May (17/05)

Figure 18: Demo Farm SP4 demonstrative vineyard during sowing

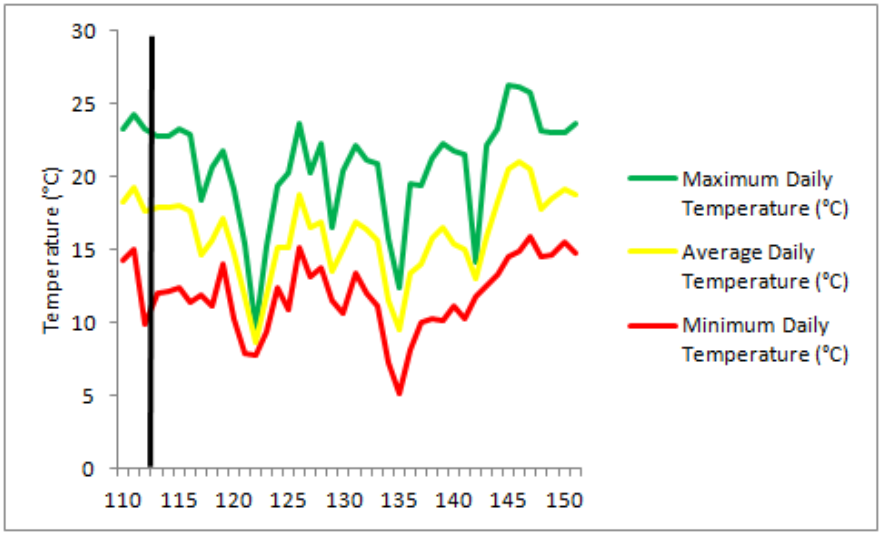

Figure 19: temperature in Demo Farm SP4 demonstrative vineyard from 20/04/18 to 31/05/18. Sowing was on DOY 113 (black line)

UCSC and HORTA visited Demo Farm SP4 demonstrative vineyard one time after sowing (10/10/18*) (Figure 20).*
During visit the covering of grass was visually assessed. Covering was uniform in inter-rows not affected by track-laying passage, while rills were evident in others rows, but impact was less than in the traditional management.
No water logging was recognizable in the corner identified in the action plan, but in that area grass growth was limited and soil was exposed to weather conditions.

Figure 20: Demo Farm SP4 demonstrative vineyard (10/10/18)

DEMO FARM VT1_Az.Agr. La Pagliara

Activities		Notes
Sowing	3rd November 2017	**Green Manure A** was sowed to reduce soil erosion, soil compaction and hard pan and increase soil organic matter content. Sowing dose was 90 kg/ha *(Figure 21)* Due to high soil moisture and unfavorable weather conditions it was not possible to sow *Phacelia tanacetifolia* buffer area zone to enhance soil biodiversity. Sowing will be performed in Autumn 2018.
Cut	18th May 2018	
Soil incorporation	19th June 2018	After cut biomass should have been left on soil for few days to dry before soil incorporation. Unfortunately, as indicate in Figure 23, a rainy period started just after biomass cut and incorporation into the soil could only be performed in the middle of June.

Figure 21: Demo Farm VT1 demonstrative vineyard during sowing

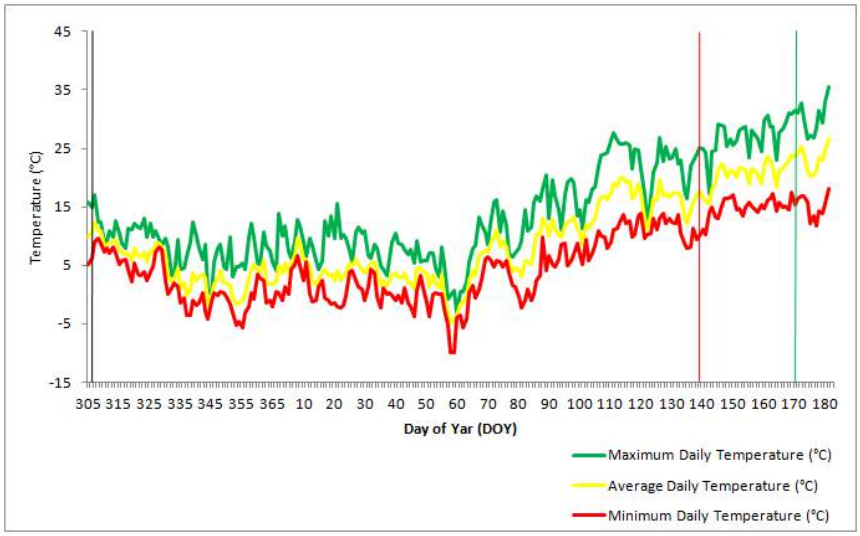

Figure 22: temperature in Demo Farm VT1 demonstrative vineyard from 01/11/17 to 30/06/18. Sowing was on DOY 308 (black line), cut was on day 138 (red line) and incorporation was on day 170 (green line)

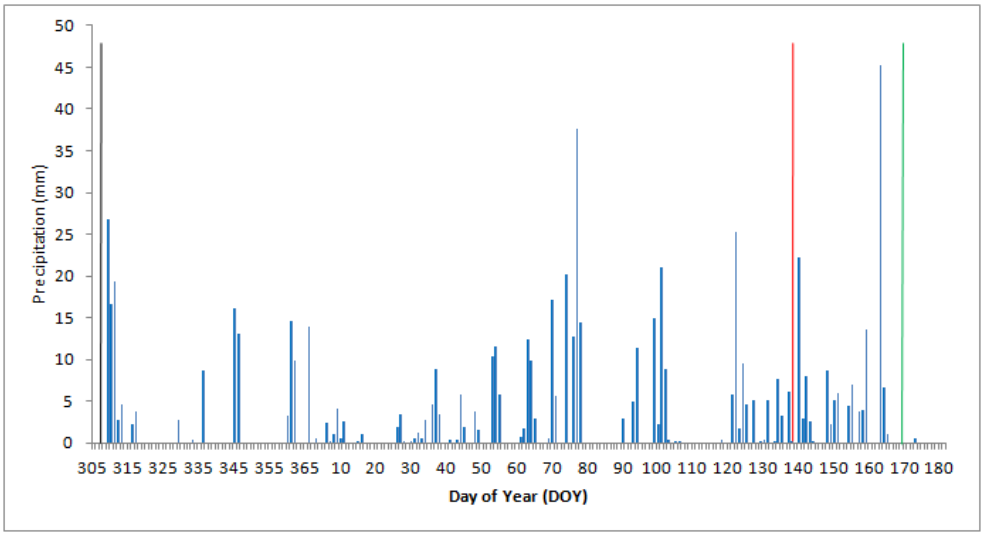

Figure 23: Temperature in Demo Farm VT1 demonstrative vineyard from 01/11/17 to 30/06/18. Sowing was on DOY 308 (black line), cut was on day 138 (red line) and incorporation was on day 170 (green line)

UCSC and HORTA visited Demo Farm VT1 demonstrative vineyard 5 times after sowing (20/02/18, 21/03/18, 05/04/18, 18/04/18 and 08/05/18) (*Figure 24 a-h*).

Growing period was characterized by severe precipitation and low temperature (*Figure 22 and 23*) that influenced seed emergence and growth.

During the visit on the 20/03 in lower part of the vineyard, across the service track, deep rills were found (*Figure 24*) caused by a severe rainy period (85 mm in 5 days with 37.6 mm in a single event on 18/03).

Growth of seeded plants did not start until the end of April, but then, in May a good growth was reported *(Figure 24)*.

When cut was performed (on 18/05/18; *Figure 25*) *Legumes* and *Phacelia tanacetifolia* were dominant while *Grasses* (*Lolium* spp., *Avena* spp that represent 58% of total species composition) were not completed mature.

During cutting UCSC collected biomass in three sampling points along inter-row to quantify average biomass production. Fresh biomass was weighted in the vineyard and put in oven at 105° for few days until weight was stable.

Fresh biomass production was 204.76 g/mq and dry biomass was 77.47 g/mq corresponding to 35.61%.

At soil incorporation date some species developed again, especially *Lolium spp,* and new biomass was incorporated into the soil with dried one.

Figure 24: Demo Farm VT1 demonstrative vineyard at different monitoring dates in 2018

Figure 25: cut of green manure at Demo Farm VT1

DEMO FARM VT2_Az.Agr. Carrà Stefano (Castello di Montichiaro)

Activities		Notes
Sowing	3rd November 2017	**Green Manure A** was sowed to reduce soil erosion, soil compaction and hard pan and increase soil organic matter content. Sowing dose was 90 kg/ha (*Figure 26*)
Cut	18th May 2018	*Figure 30*
Soil incorporation	19th June 2018	After cut biomass should have been left on soil for few days to dry before soil incorporation. Unfortunately, as indicate in *Figure 28*, a rainy period started just after biomass cut and incorporation into the soil could only be performed in the middle of June.

Figure 26:Demo Farm VT2 demonstrative vineyard during sowing

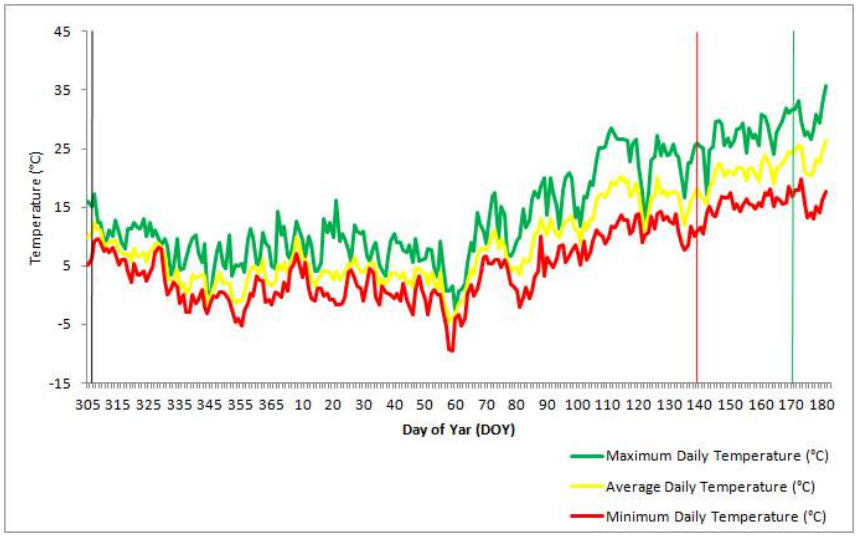

Figure 27: temperature in Demo Farm VT2 demonstrative vineyard from 01/11/17 to 30/06/18. Sowing was on DOY 308 (black line), cut was on day 138 (red line) and incorporation was on day 170 (green line)

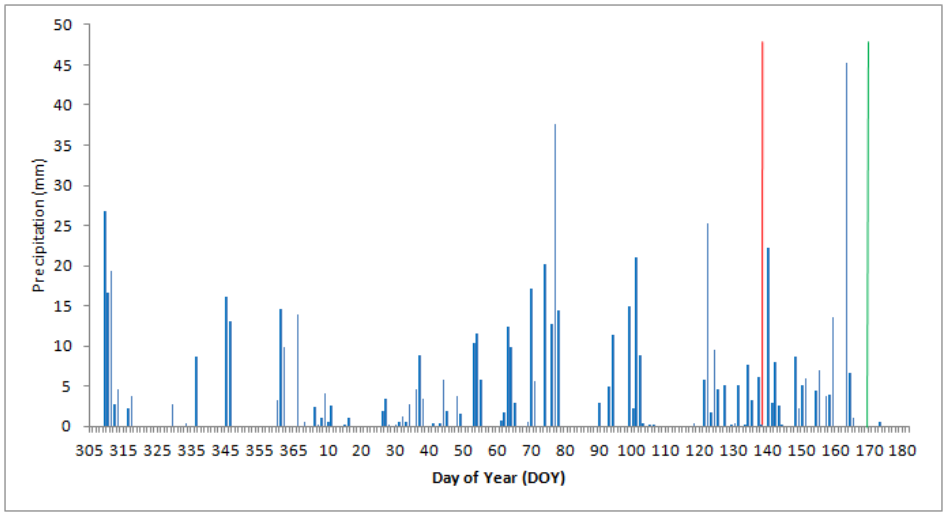

Figure 28: precipitation in Demo Farm VT2 demonstrative vineyard from 01/11/17 to 30/06/18. Sowing was on DOY 308 (black line), cut on day 138 (red line) and incorporation on day 170 (green line)

UCSC and HORTA visited Demo Farm VT2 demonstrative vineyard 5 times after sowing (20/02/18, 21/03/18, 05/04/18, 18/04/18 and 08/05/18) (*Figure 29*).
Growing of biomass was uniform along slope. In early monitorings (20/02/18 and 21/03/2018) *Grasses* were dominant and *Faba minor* was recognizable. From April biodiversity increased and all species of the seed mixture were identified in the vineyard.

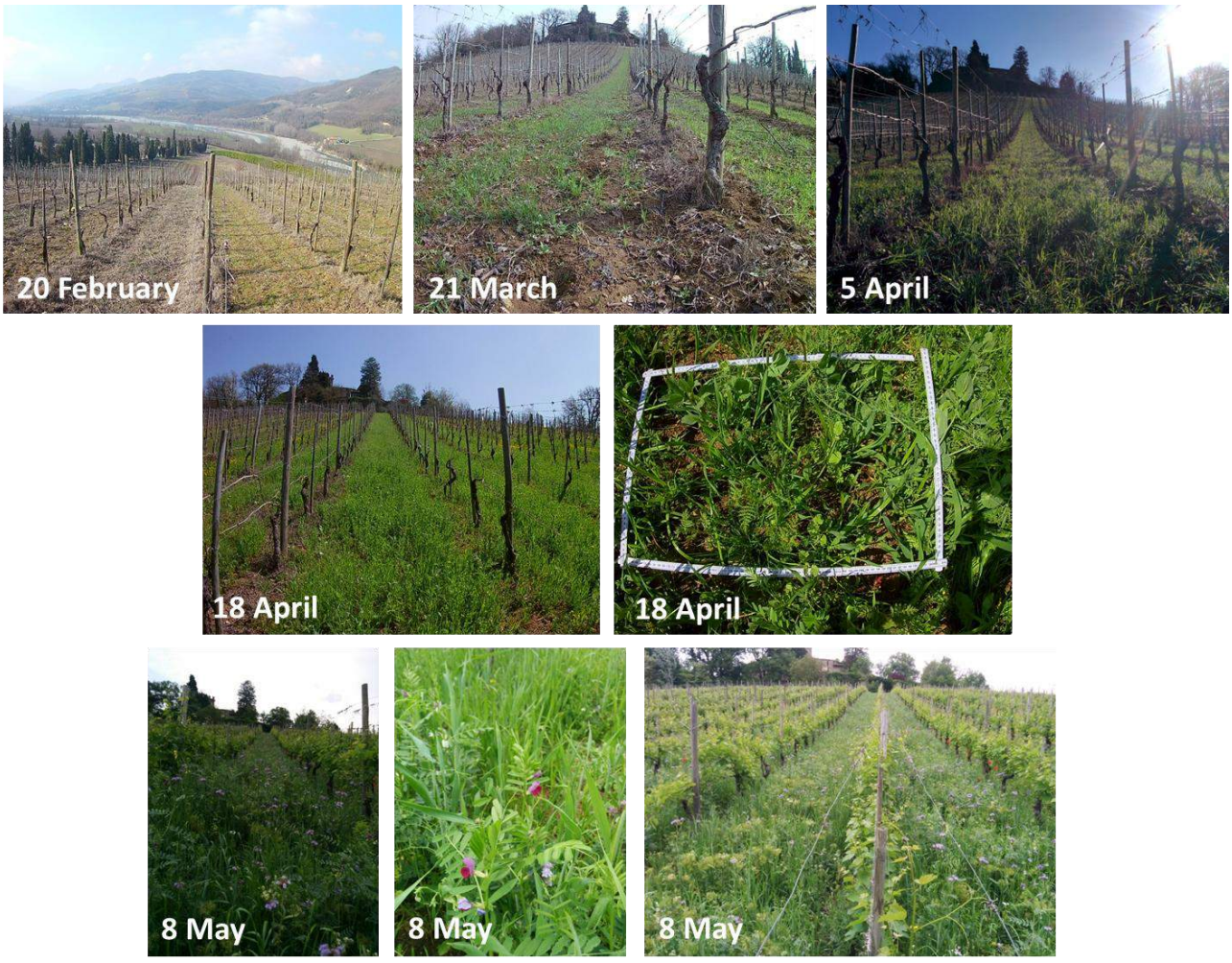

Figure 29: Demo Farm VT2 demonstrative vineyard at different monitoring dates in 2018.

During cutting (*Figure 30*) UCSC collected biomass in three sampling points along inter-row to quantify average biomass production. Fresh biomass was weighted in vineyard and put in oven at 105° for few days until weight was stable. Fresh biomass production was 1313.80 g/mq and dry biomass was 294.37 g/mq corresponding to 22.75%.
At soil incorporation date some species developed again, especially *Lolium spp,* and new biomass was incorporate into the soil with dried one (*Figure 31*).

Figure 30: cut of green manure in Demo Farm VT2

Figure 31: Demo Farm VT2 - on the left biomass after soil incorporation, on the right spontaneous grass that represent traditional management

DEMO FARM TBC1_Az. Monte delle Vigne

Activities		Notes
Sowing	23rd April 2018	Spring 2018 was considerably rainy and soil was not in proper moisture condition for sowing until the end of April (*Figure 32*). Unfortunately, after sowing, temperature were very low (*Figure 33*) making not the best conditions for seed germination. This demonstrative vineyard presents a gravel strip in the middle of the slope that was not sowed due to the dimension of stones. Sowing dose was 55 kg/ha
Cut	18th May 2018	Two cuts were made in May (08/05/18) and June (22/06/18). No cuts were necessary during Summer.

Figure 32: Demo Farm TBC1 demonstrative vineyard during sowing, on the right the area with big stones that was not sowed.

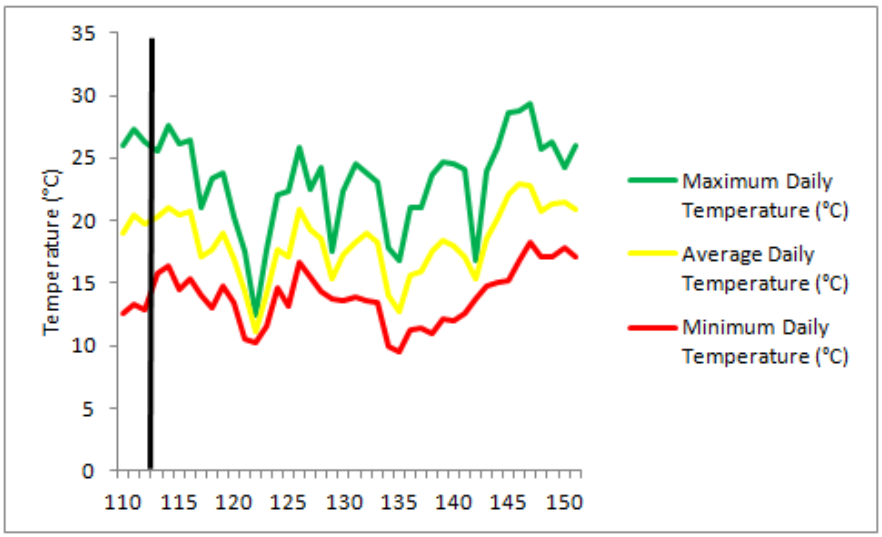

Figure 33: temperature in Demo Farm TBC1 demonstrative vineyard from 20/04/18 to 31/05/18. Sowing was on DOY 113 (black line)

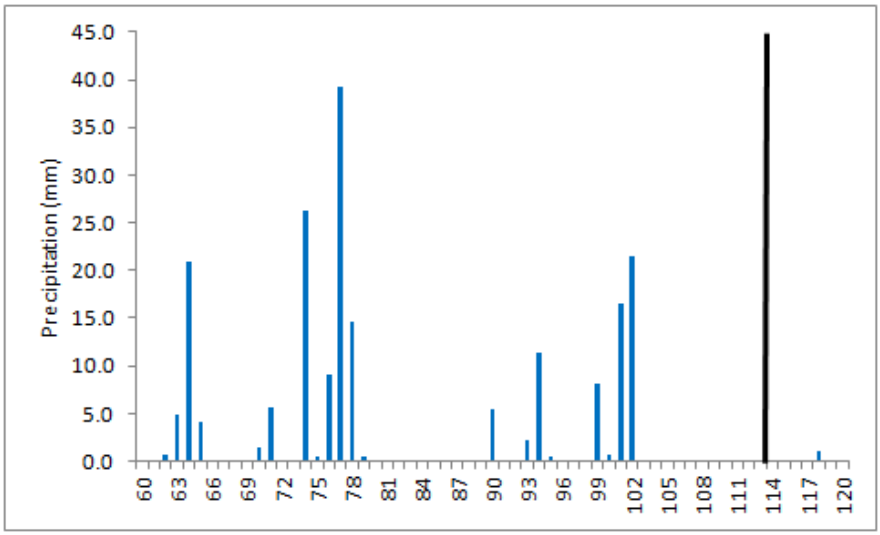

Figure 34: precipitation in Demo Farm TBC1 demonstrative vineyard from 01/03/18 to 30/04/2018. Sowing was on DOY 113 (black line)

UCSC and HORTA visited Demo Farm TBC1 demonstrative vineyard 4 times after sowing (23/05/18, 11/06/18, 17/08/18, 08/10/18) (*Figure 35*). During visits the covering of grass was evaluated.
Demonstrative action scheme is composed by 2 plots (A from row 1 to 12 and B from row 12 to row 23) and each one is divided in 2 blocks (one with traditional management and one with demonstrative action). Unfortunately differences were visibile in the sowed blocks of the two plots (*Figure 35, for the same date 1 picture per plot).* Moreover, spontaneous species (in particular *Cynodon spp.*) were strongly present in block B and sowed species were absent. Block A was characterized by little growth both of sowed and spontaneous species.
To enhance production of grass biomass, sowing will be repeated in October 2018 according to action plan scheme. Sowing dose will be higher than the one used in 2018 to enable a better grass covering. In Spring 2019 biomass will be evaluate and, if it will be enough according to literature, it will be distributed on rows to control weeds with specialized machinery.

Figure 35: Demo Farm TBC1 demonstrative vineyard at different monitoring dates in 2018.

DEMO FARM TBC2_Az. Vitivinicola Palazzo

Activities		Notes
Sowing	not yet completed	Demonstrative action foresees sowing of legumes mixture on existing grass to enhance nutrients availability for vines. Weather conditions, in particular low temperature during Autumn 2017 and precipitation in Spring 2018, were unfavorable for sowing and in the few time-windows with favorable conditions it was not possible to organize the agricultural operation due to low availability of the Demo Farmer. Sowing will be performed in October 2018.

DEMO FARM RES1, RES2 and RES DEMO

Activities		Notes
RES1 – Drainage and sowing of headline	March 2017	Canalization for preliminary superficial water control (*Figure 36)*
	3rd November 2017	Sowing of selected permanent grass was performed by hand following the scheme included in the Action Plan of deliverable B2.1. Unfortunately weather conditions were very adverse and water logging in the seeded area did not enable seed germination. Moreover, soil movements for underground drainage severely damaged the area *(Figure 37)*.
	16-19 May 2018	Underground drains were positioned (*Figure 38 and 39*) according to scheme in *Figure 40*.
RES2 - Drainage	December 2017	Canalization for preliminary superficial water control
	not yet completed	Positioning of drains and recovery of damaged row in demonstrative vineyard RES2 will be made in Autumn 2018 because soil was not in proper conditions in Spring 2018 and impact on vines would have been too strong.
RES DEMO - sowing	3rd November 2017, 23 April and 9 July 2018	Green manures and permanent artificial grassing were sowed (*Figure 41*) according best weather conditions and timing of the different plant species, following the scheme provided in the Action Plan in Deliverable B2.1

Figure 36: canalization for superficial water control in RES1 demonstrative vineyard

Figure 37: headline seeded with different permanent grasses in sever water logging conditions (RES1 demonstrative vineyard)

Figure 38: Drainage installation in RES1 demonstrative vineyard

Figure 39: Particular of the final tap of the drainage RES1 demonstrative vineyard

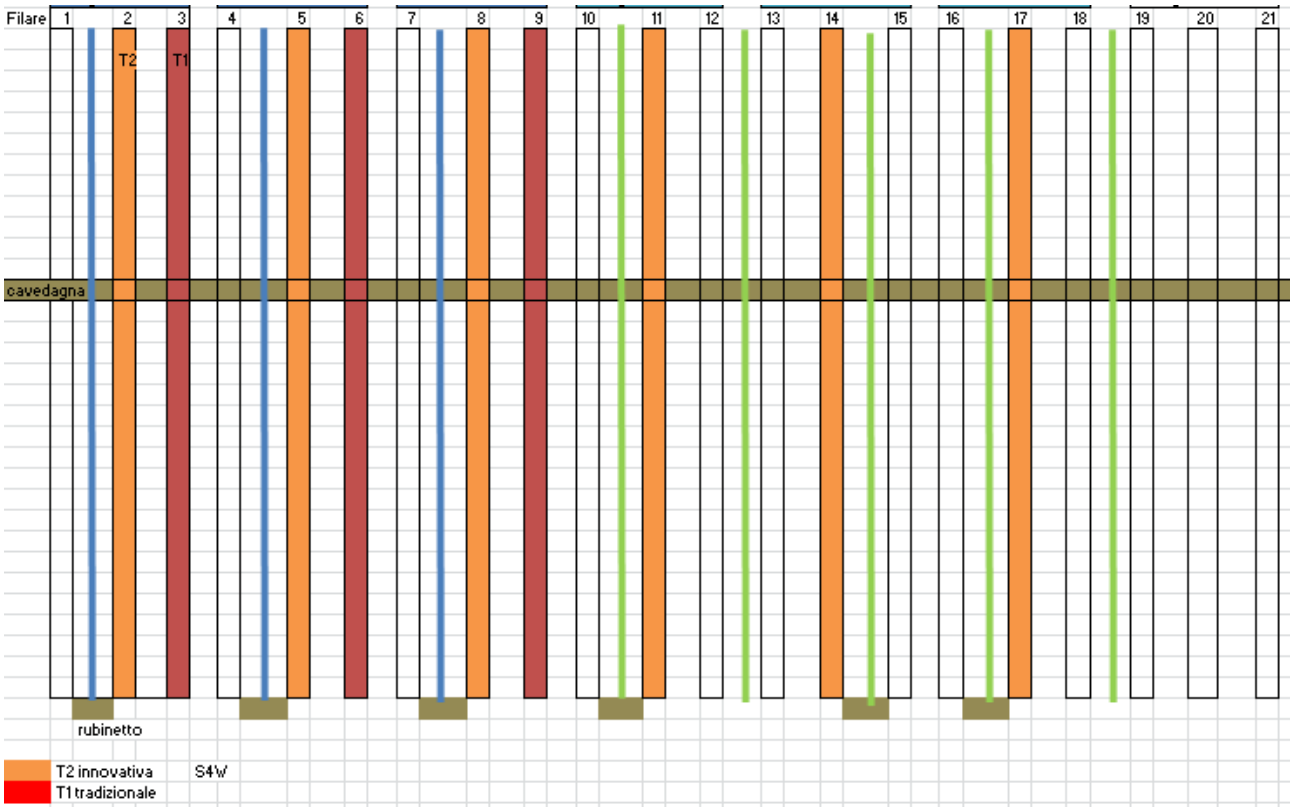

Figure 40: drainage (blue and green lines) scheme in RES1 demonstrative vineyard

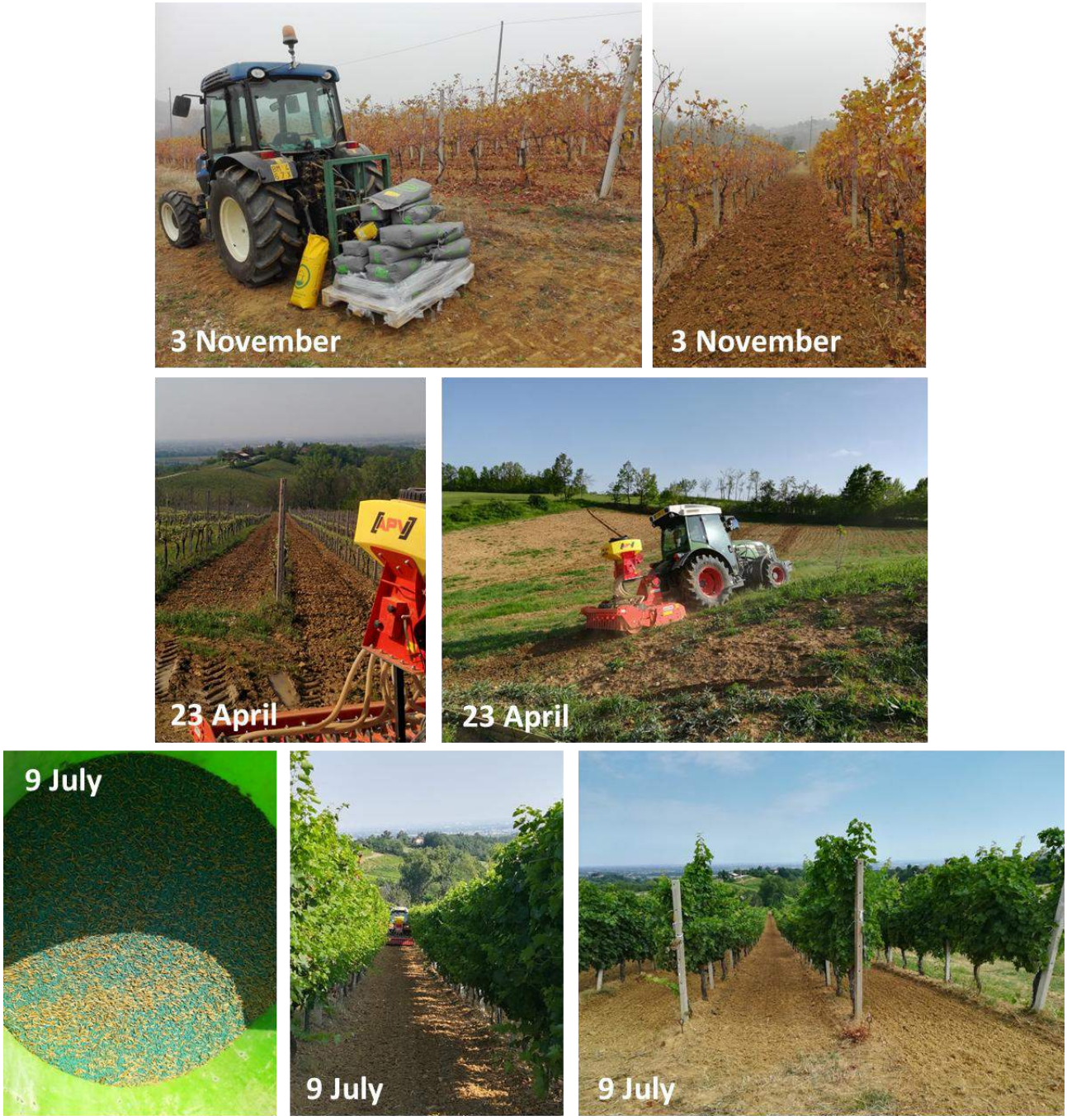

Figure 41: Sowing of different plant species at different timings (2017-2018) at RES_DEMO demonstrative vineyard

Discussion

Implementation of action plans in demonstrative vineyards clearly suffered the particular weather conditions of Autumn 2017 and Winter-Spring 2018: Sowing was delayed due to very dry conditions until beginning of November 2017, seed germination was limited by low temperatures in Winter, and plant emergence in Spring, as well as Spring sowing, were negatively influenced by very wet conditions (severe precipitations).
Therefore, effects of green manure on soil protection to erosion were not so evident, in fact soil was not completely covered by biomass during rainy period (before March 2018, except for SP2 farm).
In Demo Farms where water logging was the main threats, the limited plant growth due to continuous excess of water and low temperature, was not enough to reduce the threat (that was particularly evident in 2018 due to severe precipitations).
Permanent grasses met obstacles due to low temperature in the first days after sowing and did not completely cover the inter-row space and did not produce enough biomass to be moved under the row to control weeds.

For the second demonstration trials year some few changes will be necessary to the Action Plans to try to increase the success of the implementation of mitigation actions, notwithstanding better weather conditions: Autumn sowing will be anticipated to obtain early growing in more favorable conditions, thus enabling soil cover with *winter cereals* and *Brassicas* to protect soil against rain erosion; permanent grasses will be completely sowed again or integrated by performing hand sowing in bare soil areas.