Yield prediction based on Sentinel-1 data

GWF 2023

GEOSPATIAL WORLD FORUM

May 2-5, 2023 | Rotterdam, The Netherlands

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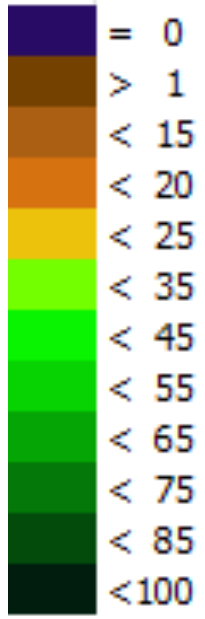
Fresh biomass index

ESVI

(enhanced SAR Vegetation Index)

- The product is derived entirely from Sentinel-1 SAR (C-Band) data
- Ideal for crop monitoring
  (time-series analysis and change detection)
- Useful for precision farming and crop insurance
  (zoning and change maps)
- Cross crop & seasonal scale from 0 – 100
- Processing chain fully automated
- The map product was calibrated with field trials and optical satellite data.
- Test areas in different countries in Europe, North and South America, Africa, Australia, Asia.
- The map product can be transformed into LAI (Leaf Area Index) and **yield prediction**.



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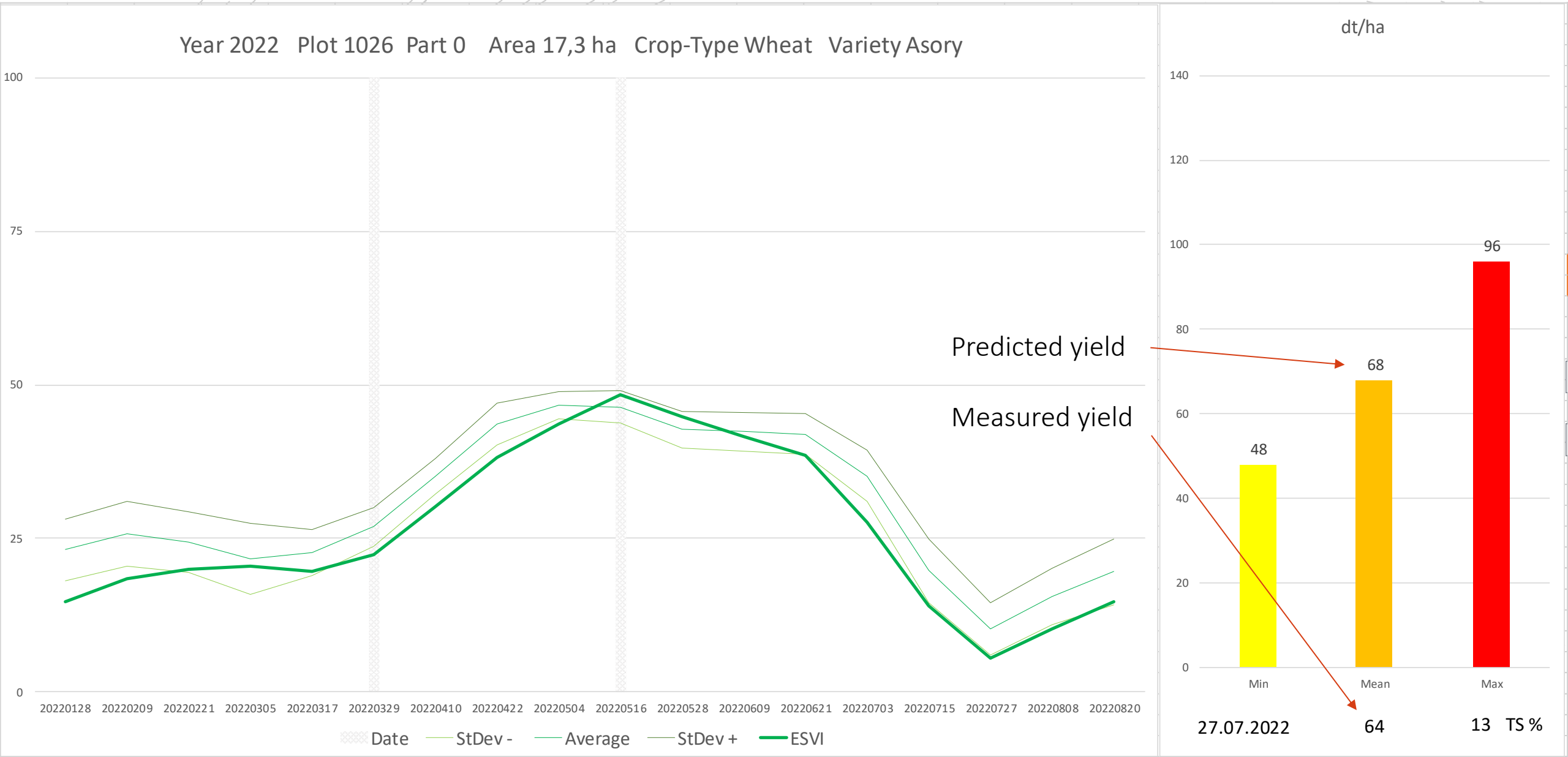
Example farm in Thuringia in Germany
Years 2018 – 2022. About **80** plots each year.
Crop-types Winter Wheat, Winter Barley and Winter Rapeseed.

Data: From each acquisition we generated a zonal statistic for each plot to retrieve the mean, minimum and maximum ESVI value.
No additional data like weather or soil data is needed.

Method: For all years we used the same transformation formula.
For each crop-type we use one weighing table over all years.
For the yield prediction we use 5 succeeding acquisitions of ESVI.



Results over five years from 2018 - 2022

The figures in the table show the deviation from the measured yield.
A value of **102** means, that the model overestimated the yield by **2%**.

Deviation from yield	Mid April	End April	Early May	Mid May	End May	Early June	Mid June	End June	Mid July	End July
All crops	96	99	100	101	102	101	103	102	102	92
Rapeseed	101	95	97	100	105	105	108	105	99	92
Wheat	96	103	105	107	107	103	102	101	103	89
Barley	90	96	96	97	96	97	99	100	104	97

Over all years, all plots and all varieties the result is close to **100 %** compared to the measured yield.
Yield prediction can be done with high reliability from early May to mid of June.

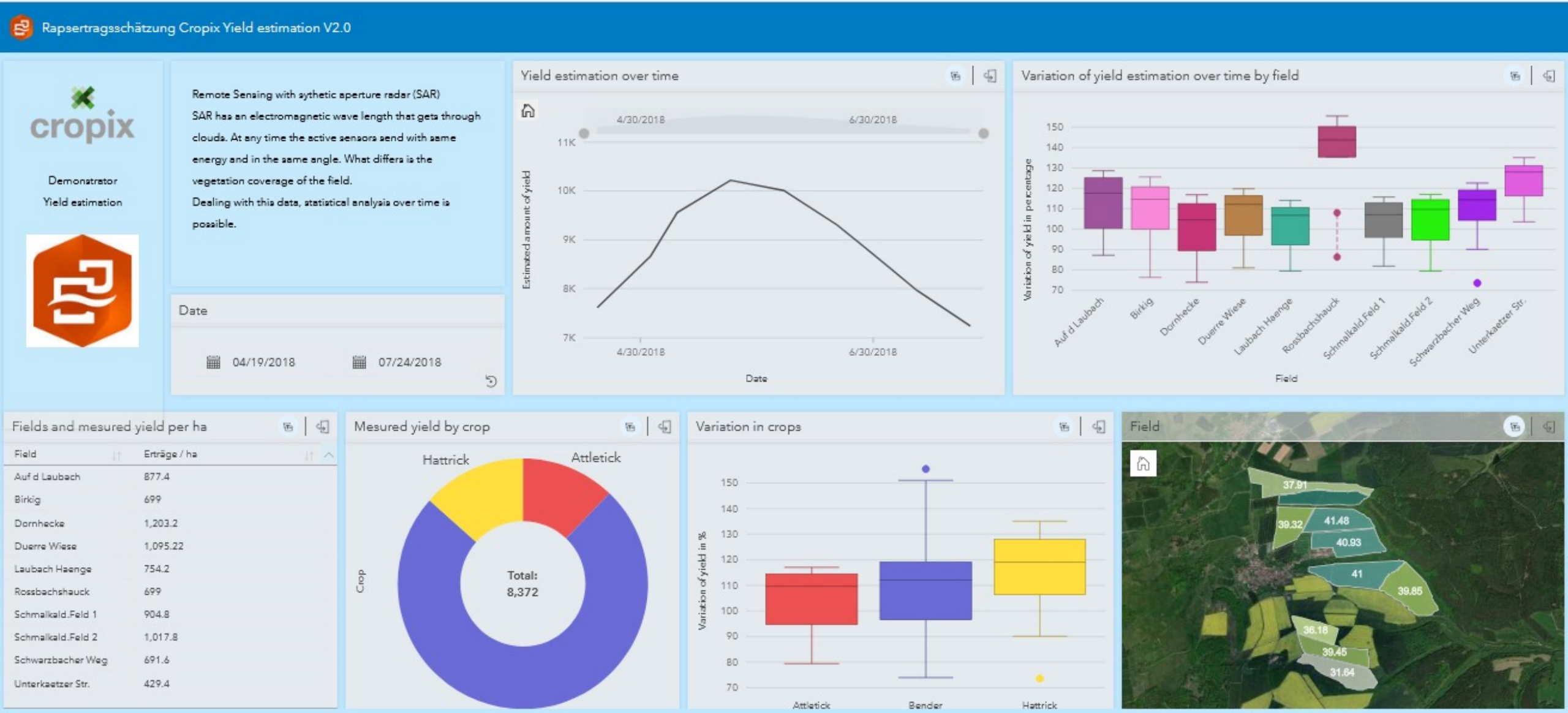
Standard Deviation	Mid April	End April	Early May	Mid May	End May	Early June	Mid June	End June	Mid July	End July
All crops	9,8	10,6	8,9	10,0	12,1	15,5	15,5	11,3	9,3	14,4
Rapeseed	8,8	4,5	5,7	9,8	11,3	9,1	9,2	6,8	9,2	14,0
Wheat	8,2	9,1	9,4	9,0	11,7	14,7	15,0	14,2	10,7	16,1
Barley	10,3	14,9	9,6	6,5	9,5	21,2	20,7	12,0	7,4	12,8

Yield prediction between early and mid May, for each **single crop** and over **all crop-types** deviates from the measured yield in **2** from **3** years by less than **10 %**.
Only in **1** from **20** years it has to be expected, that the predicted yield deviates by more than **20%**.

The results for each single year

2018	ha	20180407	20180419	20180501	20180513	20180525	20180606	20180618	20180630	20180712	20180724
Rapeseed	214	88	92	104	115	123	120	123	117	102	88
Wheat	220	93	113	113	112	116	117	117	118	113	89
Barley	167	99	117	108	107	111	129	129	117	106	92
2019	ha	20190402	20190414	20190426	20190508	20190520	20190601	20190613	20190625	20190707	20190719
Rapeseed	138	104	97	90	92	92	95	95	97	95	104
Wheat	241	110	104	112	117	122	114	109	107	111	98
Barley	177	72	75	82	89	88	82	85	86	93	89
2020	ha	20200408	20200420	20200502	20200514	20200526	20200607	20200619	20200701	20200713	20200725
Rapeseed	203	93	88	94	97	101	101	106	107	102	95
Wheat	207	90	93	94	94	100	103	108	109	109	89
Barley	116	95	95	94	95	99	103	105	105	103	89
2021	ha	20210403	20210415	20210427	20210509	20210521	20210602	20210614	20210626	20210708	20210720
Rapeseed	179	108	99	95	89	96	99	104	104	112	107
Wheat	234	87	92	94	98	88	75	73	76	94	109
Barley	201	91	97	102	98	87	74	75	93	114	119
2022	ha	20220410	20220422	20220504	20220516	20220528	20220609	20220621	20220703	20220715	20220727
Rapeseed	166	111	100	103	107	111	110	112	102	84	68
Wheat	161	98	113	113	112	107	104	103	97	86	61
Spelt	75	93	108	100	86	86	89	92	96	107	88

ArcGIS Insight Dashboard: ESRI implemented a dashboard for ESRI users for an ongoing yield prediction based on ESVI.



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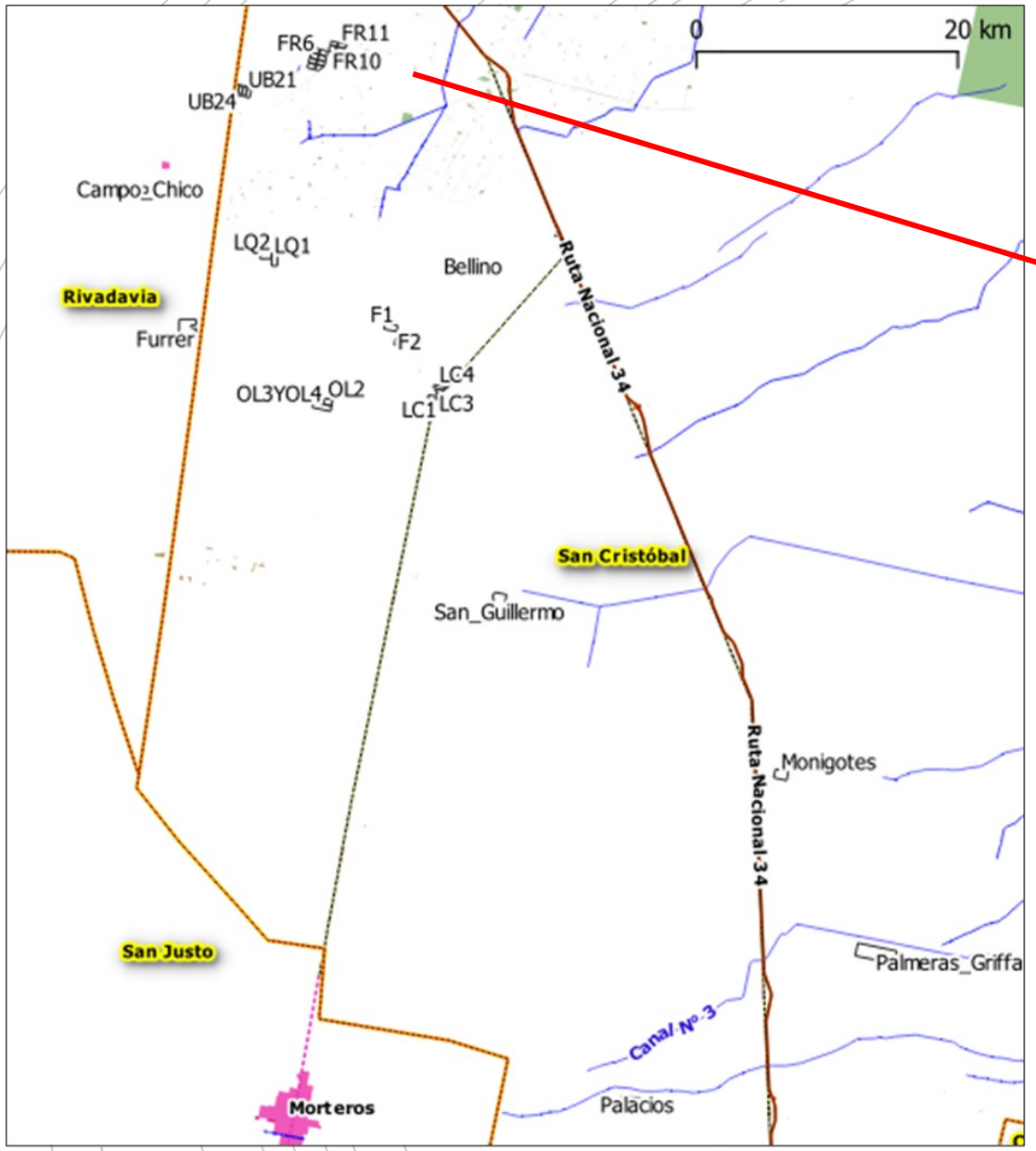
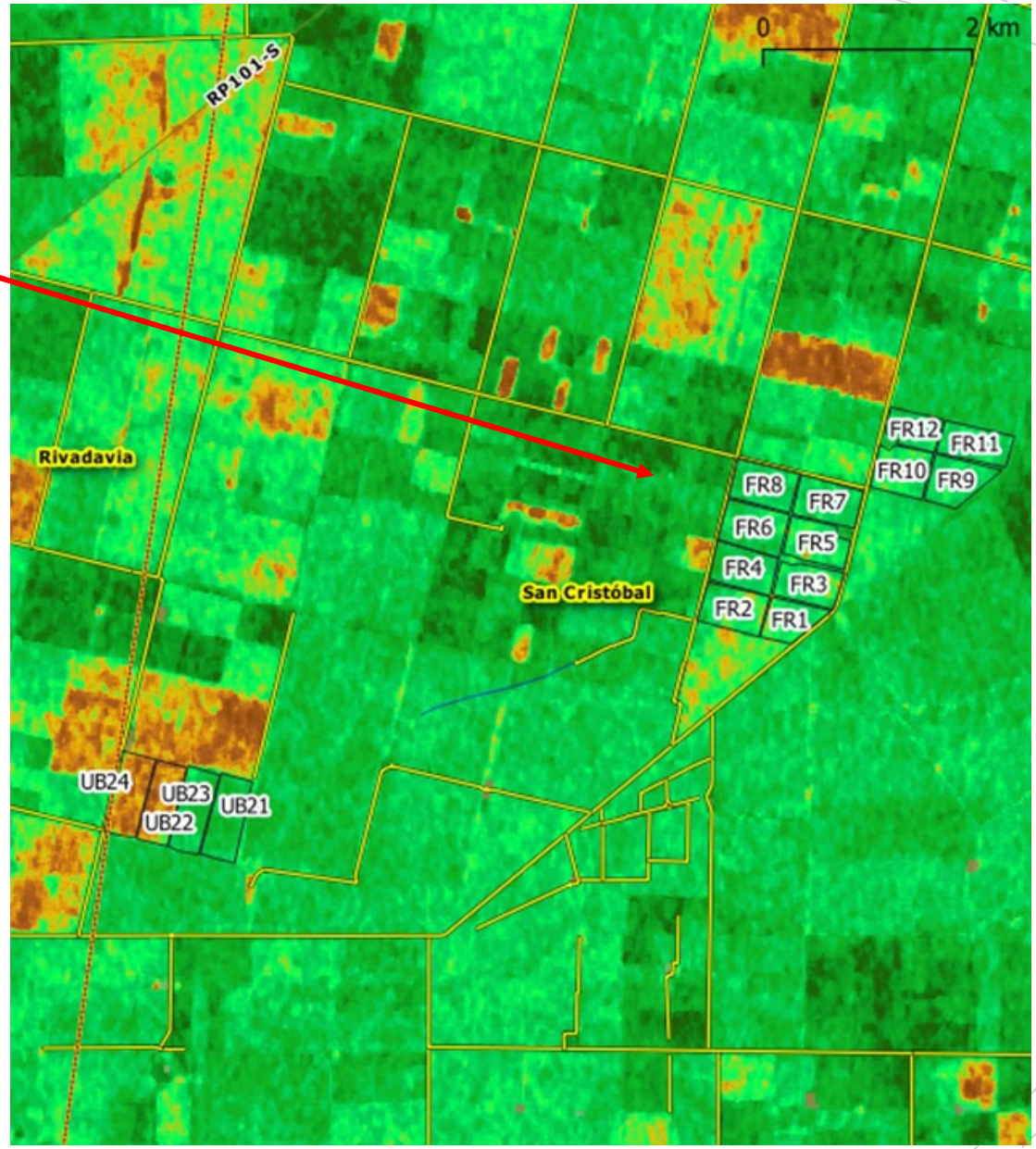
Examples from different farms in Santa Fé province Argentina

Years 2020 – 2022. Over all **68** plots.
Crop-types Wheat, Corn, Sorghum, Soyabeans and Sunflower.

Data: From each acquisition we generated a zonal statistic for each plot to retrieve the mean, minimum and maximum value.
From ESVI values we define the **start of season.**

Method: For all years we used the same transformation formula.
For each crop-type we use one weighing table over all years.
For the yield prediction we use 5 succeeding acquisitions of ESVI.





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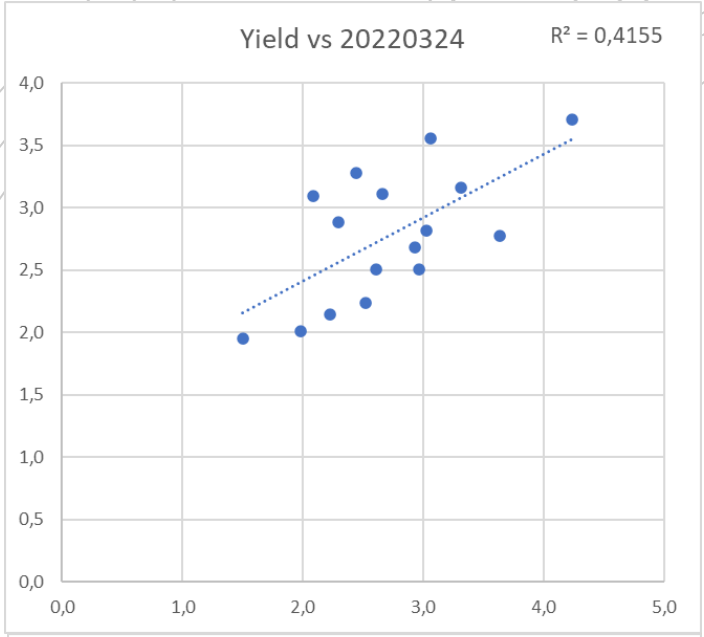
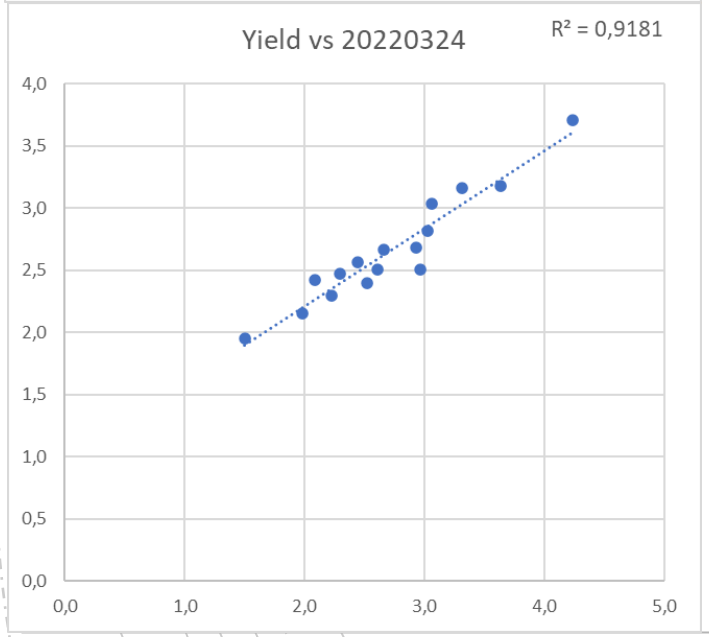




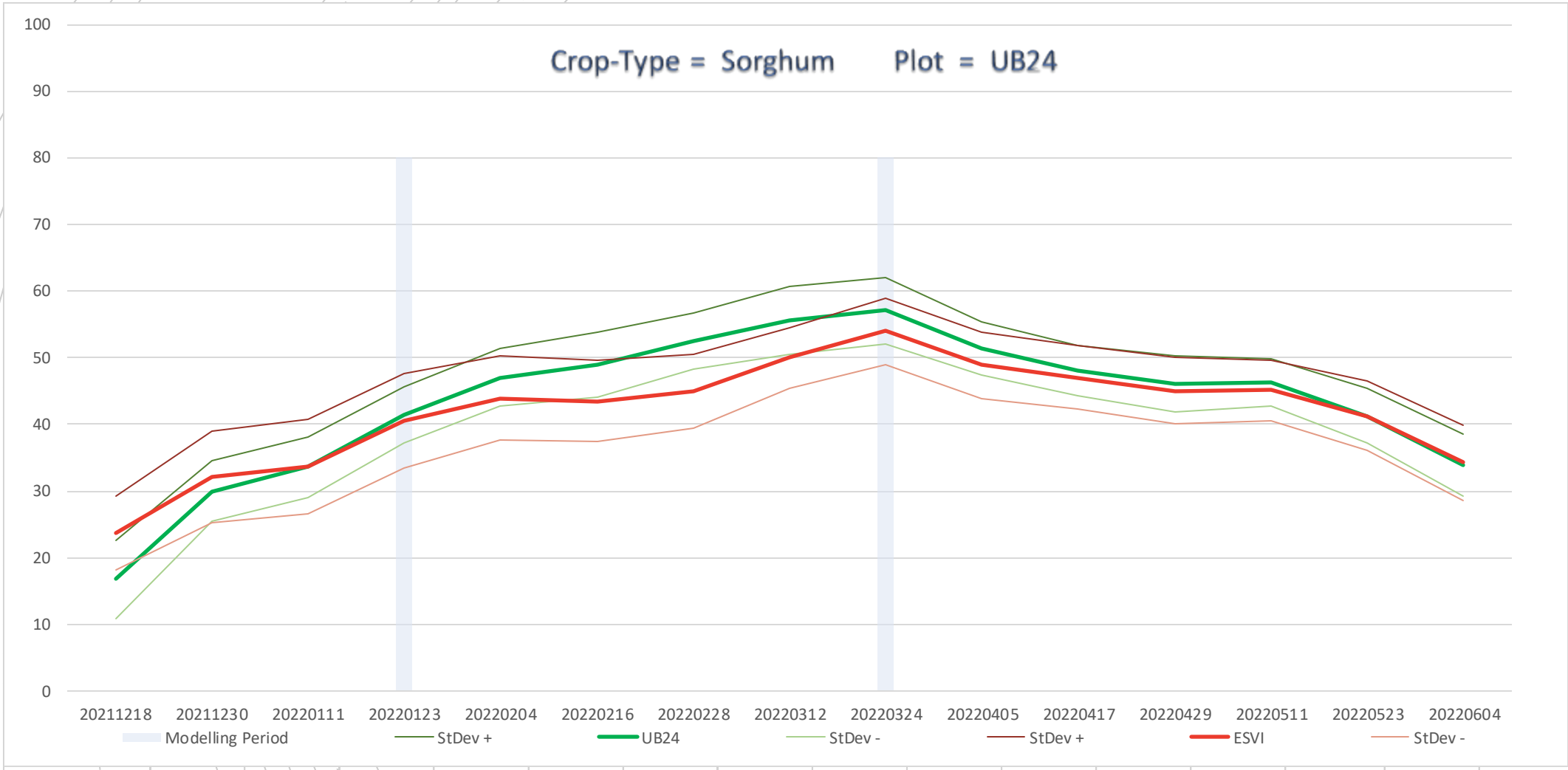
In Argentina, the planting dates of individual crops can vary by **several weeks** within one season.
Therefore, the **start of season** for each individual plot has to be recorded, in order to properly transform the biomass development into yield.

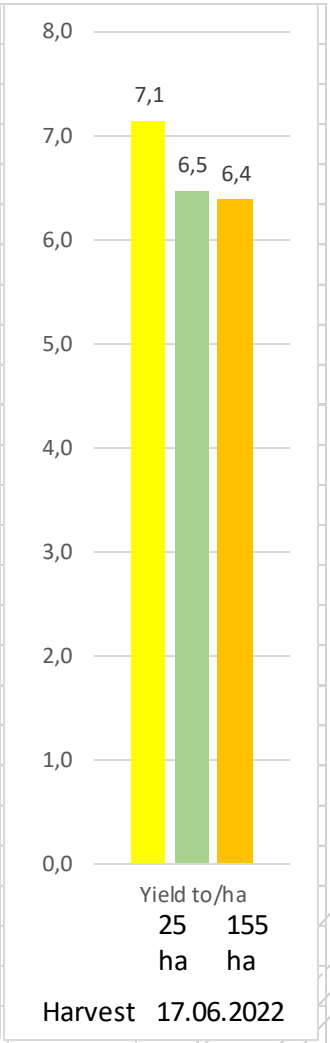
The correlation plots on the left side show the **predicted yield vs. the measured yield** for soyabeans.

In the upper example the start of season was set to the **same date** over all plots.

In the lower example the start of season was set according to the **increase of the ESVI curve** for each individual plot.

The **green lines** indicate the single plot „UB24“.
The **red lines** the average over all Sorghum plots.





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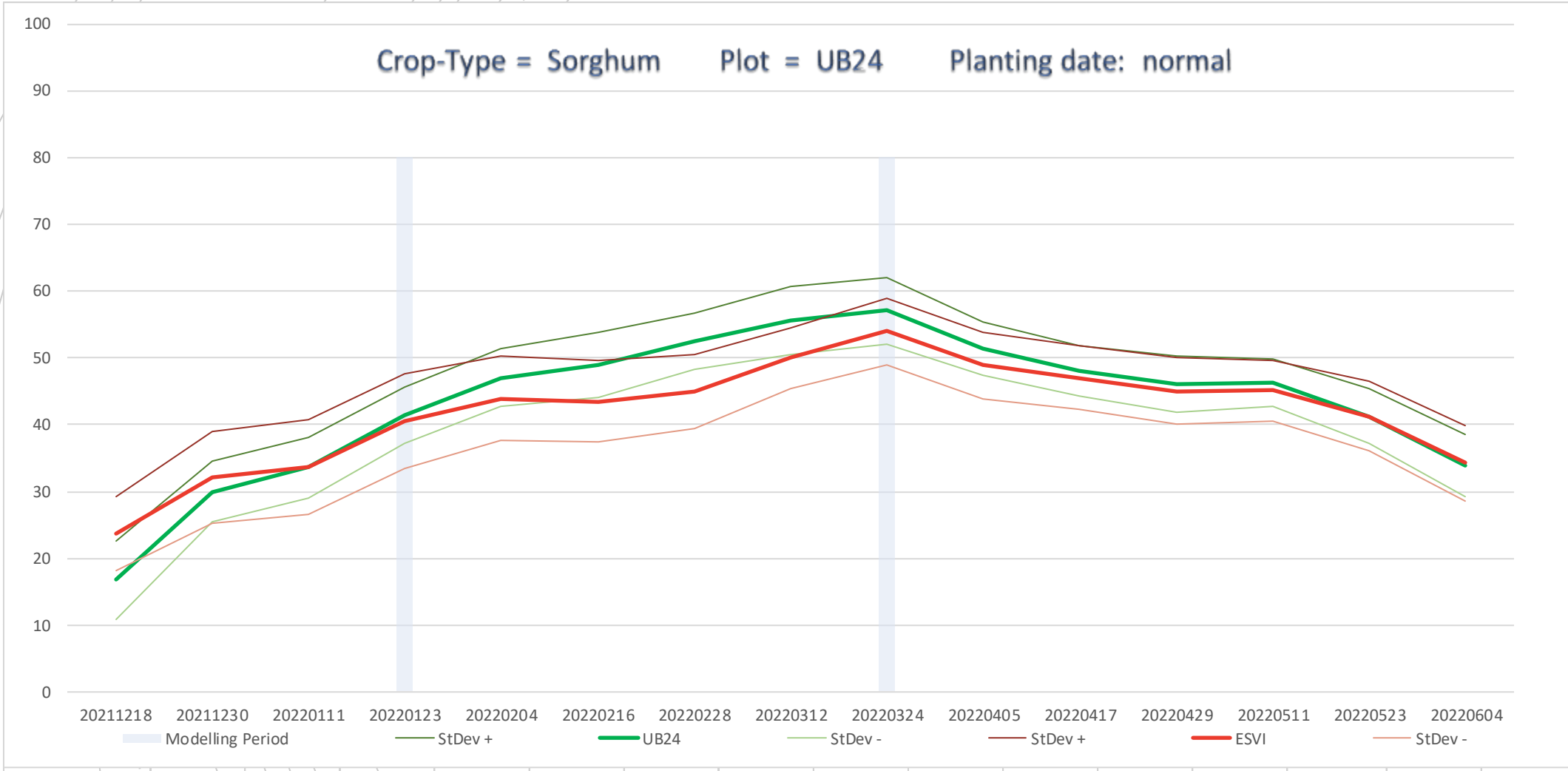
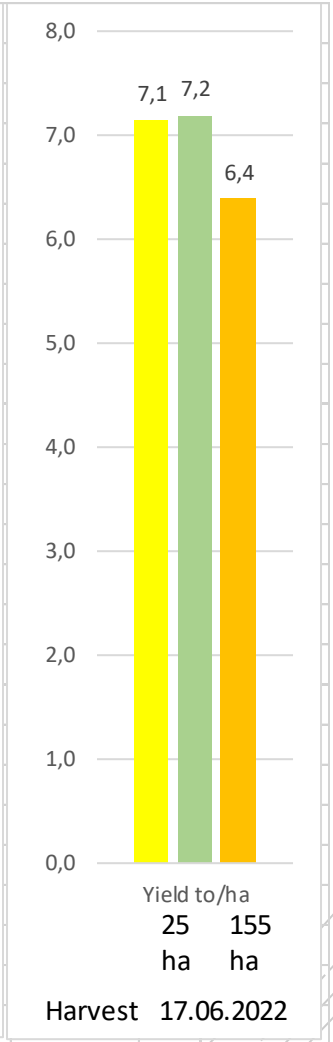
Yellow column: Measured yield single plot. **Orange column**: Measured yield over all plots. **Green column**: Modelled yield , here for the single plot.





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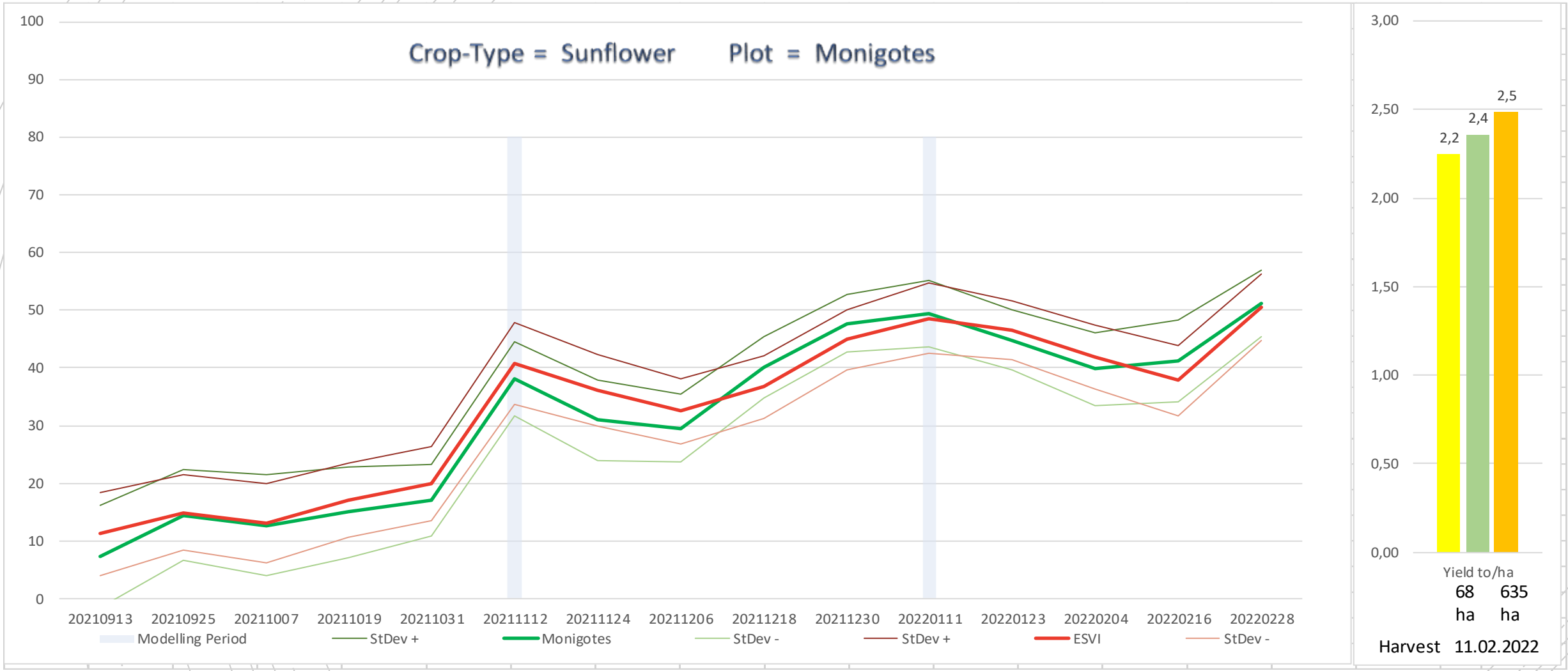

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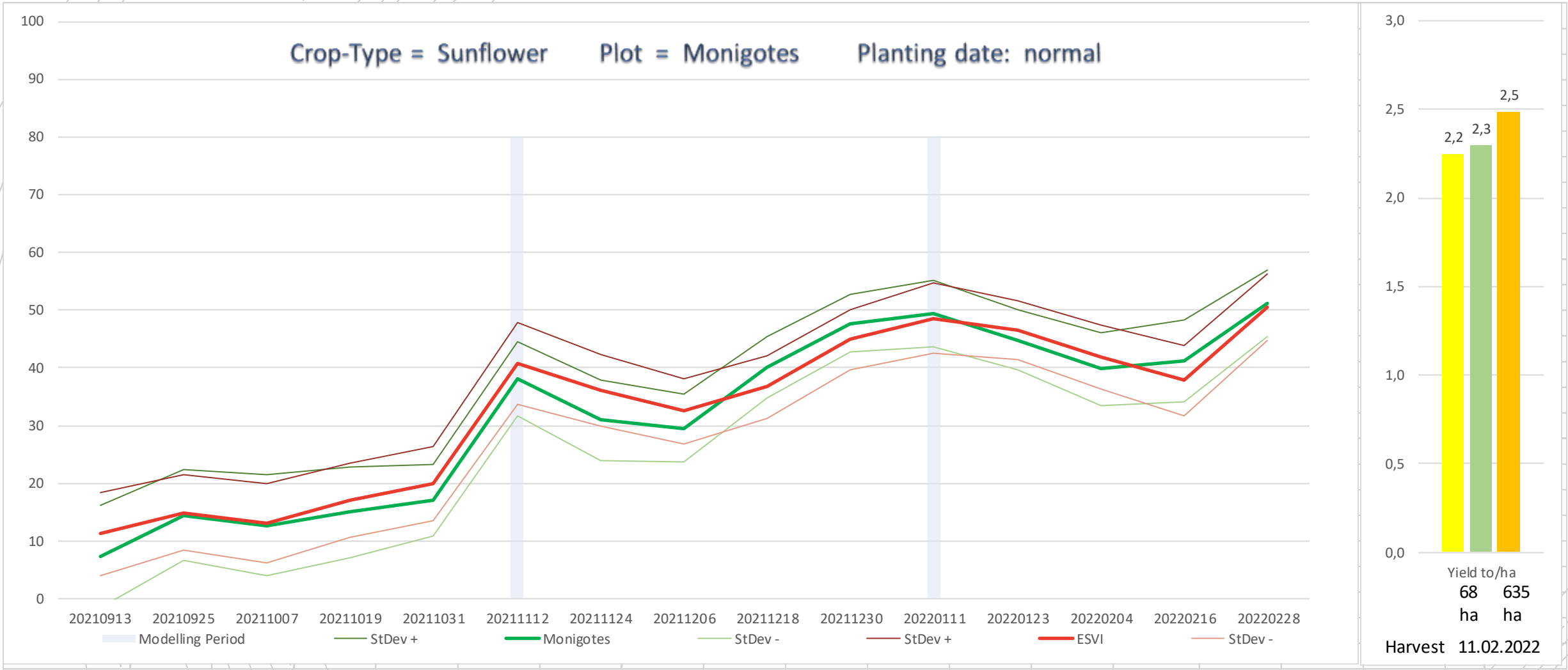
The modelled yield for the single plot is slightly overestimated.



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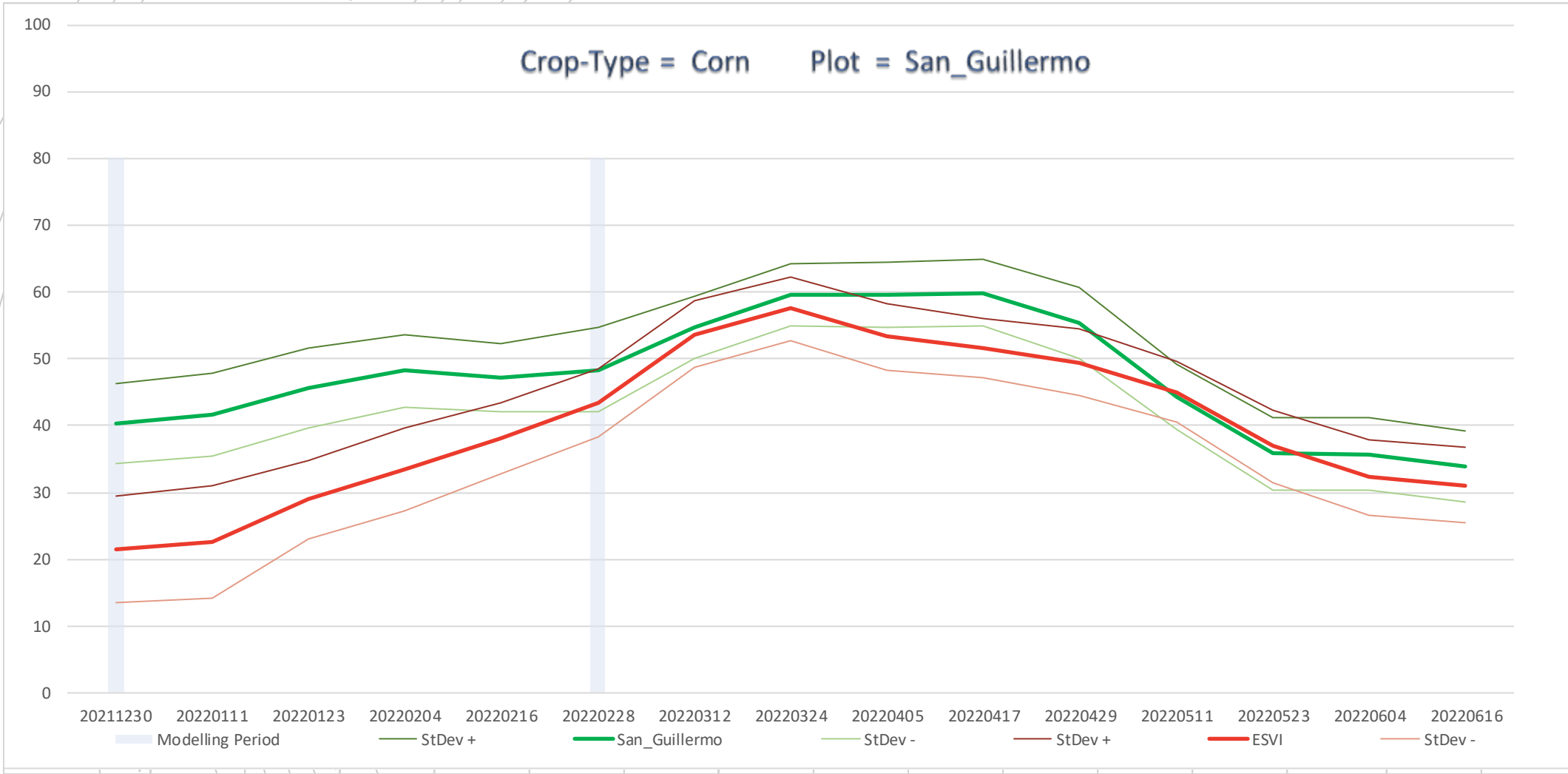
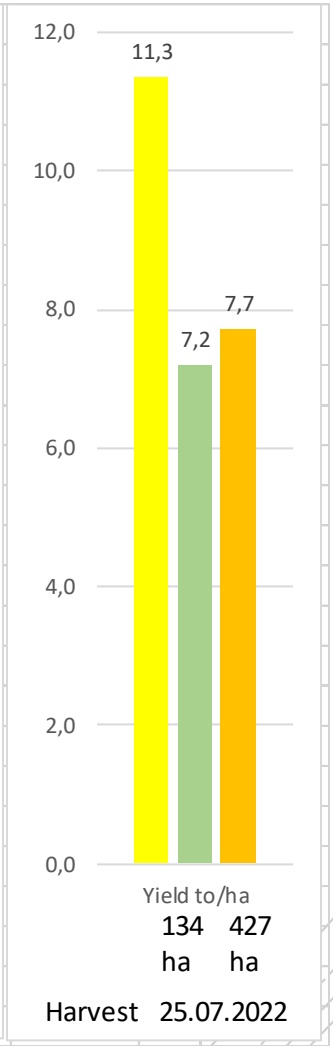
The single plot performs significantly above average concerning the ESVI curves. The modelled yield is here for the average over all plots.





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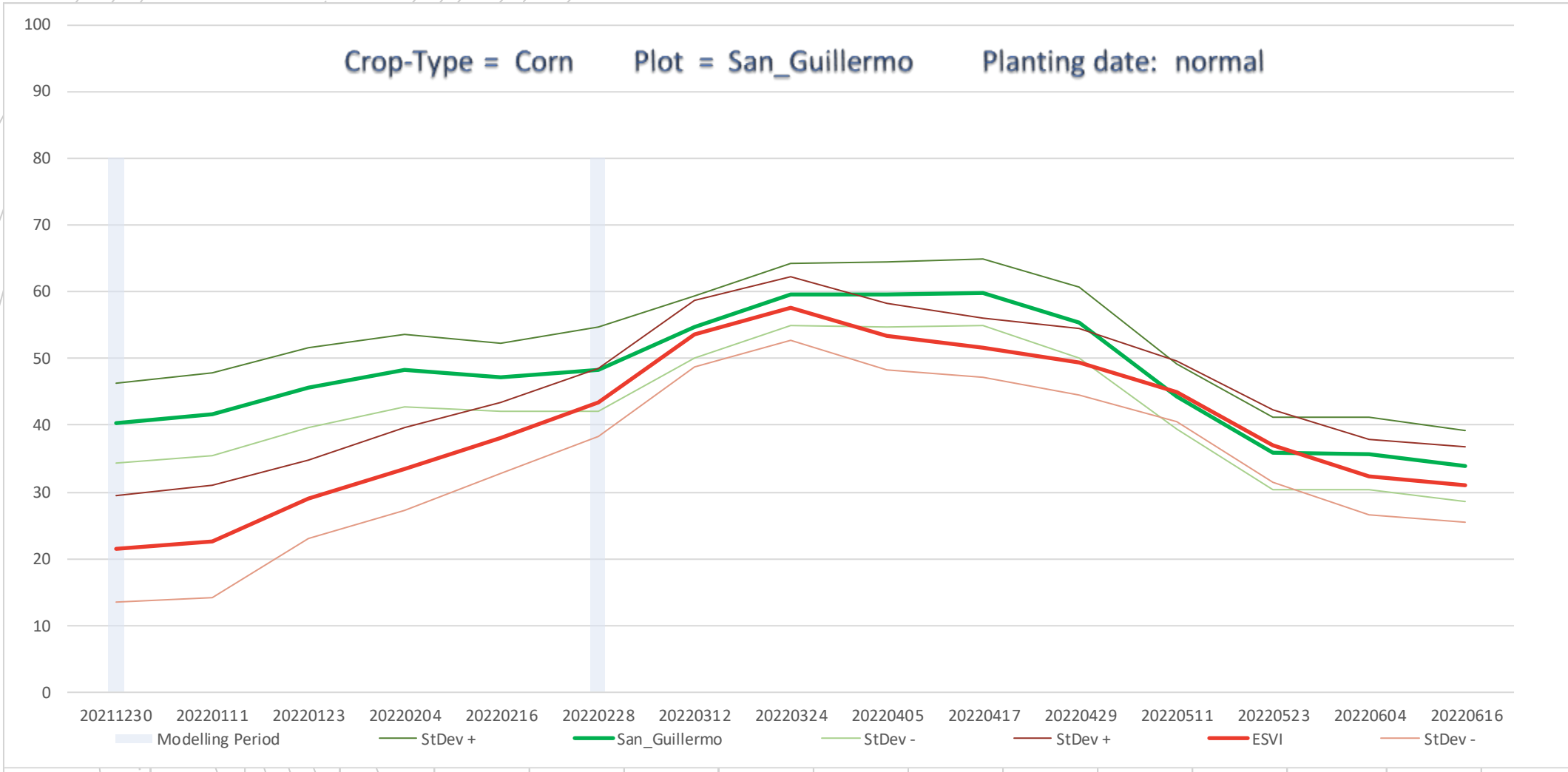
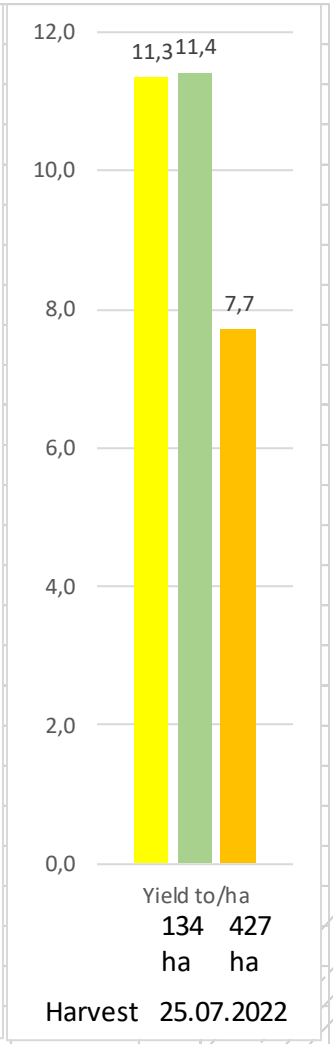
The model reflects a different biomass development and predicts the correct yield for the single plot.





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