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YIELD AND NITROGEN LEACHING TRENDS IN AN ARABLE CROPPING SYTEM UNDER PROJECTED FUTURE CLIMATE IN DENMARK

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INTRODUCTION

- Crop production affected by climate change by alteration of soil and plant processes.
- Impacts and consequences for crops and the environment are expected to vary with the agro-climatic zones.
- Adaptation and mitigation strategies and measures to be considered in a multi-scale level (local to international level)
- Projected changes in North Europe using RCM and GCM for the AB1 scenario for 2050 are the increase of average annual T (1.5-3 °C) and rainfall (5-10%) (Olesen, et al., 2011)
- Seasonal pattern in Denmark: highest T increase in autumn, increase of winter and spring precipitation, slight decrease of autumn and summer precipitation.

INTRODUCTION

- Increases of T are expected to reduce yields by shortening the crop cycle. Reduction of winter wheat yields in Denmark estimated in about 2-12% depending on the future period considered, soil and region (Kristensen et al., 2011)

- Results from modeling studies indicate that yield increases caused by elevated CO_2 concentrations compensate for the yield reduction caused by changes in T (Semenov et al., 1996, Weiss et al., 2003). Results based on simulation models most often do not consider pest or diseases.

- A risk of increasing N leaching with higher winter precipitation and shorter duration of crop cycle

AIM OF THE STUDY

- The work aims to investigate the impact of projected climate change scenarios on crop productivity and important environmental indicators in Denmark using a crop model. The results presented here are focused on yield and N leaching of a whole crop rotation.

- This is part of a larger study that includes other soil and locations as well as current and future rotations, and taking into account changes in CO_2 concentration in the future.

MATERIALS AND METHODS

- -Model tools:
  FASSET crop model(Berntsen et al., 2003)
  LARS-WG weather generator (Semenov 2007)
- -Regional circulation model (RCM): "**KNMI**" (Royal Netherlands Meteorological Institute)
- -Generated climate: baseline (1975), 2020, 2040, 2060 and 2080
- -Soil: loam
- -Locations: Western Zealand (Roskilde weather station, 55° 37'N, 12 ° 08'E)
- -Baseline (1961-1990) average T is 7.6 °C and precipitation 586 mm
- -Baseline [CO_2]
- -Adaptation strategies: operation dates according to climate.

MATERIALS AND METHODS

› Crop rotation

with catch crop (oil radish)	without catch crop
Winter wheat	Winter wheat
Winter wheat^{CC}	Winter wheat
Sugar beets	Sugar beets
Spring barley	Spring barley

› 30 model runs per projected scenario with randomly initiated years

› Crop rotation repeated five times within each single model run. Only results corresponding to the last rotation are included in the analysis.

MATERIAL AND METHODS

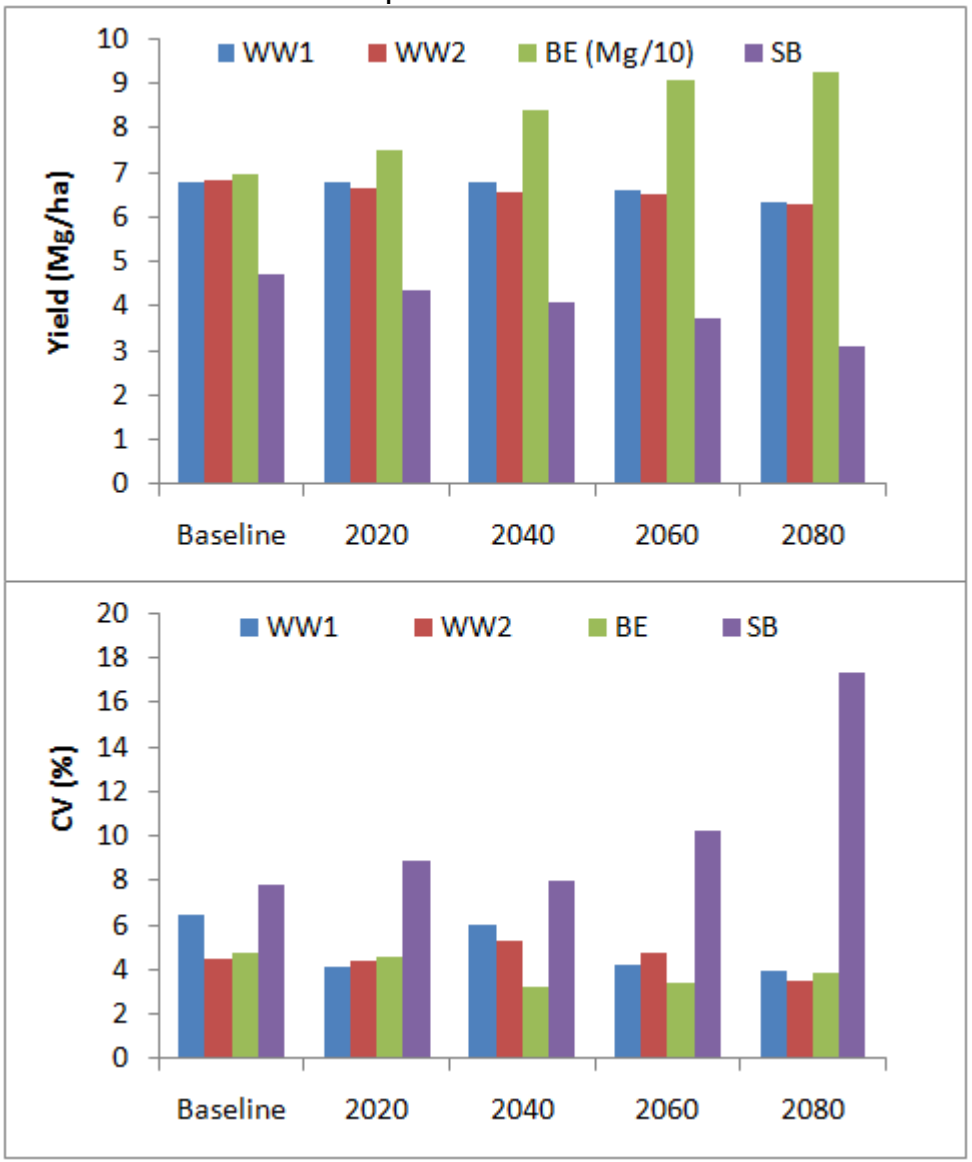
Average changes of temperature (T) and precipitation (P) in the KNMI model

Period	DJF - T	DJF - P	MAM - T	MAM - T	JJA-T	JJA-P	SON - T	SON -P
2020	0.1	1.1	0.9	1.0	0.7	0.9	0.7	1.1
2040	1.4	1.1	1.6	0.9	1.2	1.0	1.6	1.1
2060	2.0	1.1	2.1	1.1	1.8	1.0	2.3	1.0
2080	3.0	1.2	2.7	1.1	2.3	1.1	2.6	1.1
T: absolute °C ; precipitation (relative)								

RESULTS: YIELDS

- Winter wheat: 1-3% decrease by 2040 and 7-8% by 2080
- Spring barley: 13% decrease by 2040 and 35 % by 2080
- Beet yield increase 21% by 2040 and 33% - 39% by 2080
- CV increased only for spring barley (from 2060, lower yields)
- Little effect of CC in yield variability of winter wheat and beets.

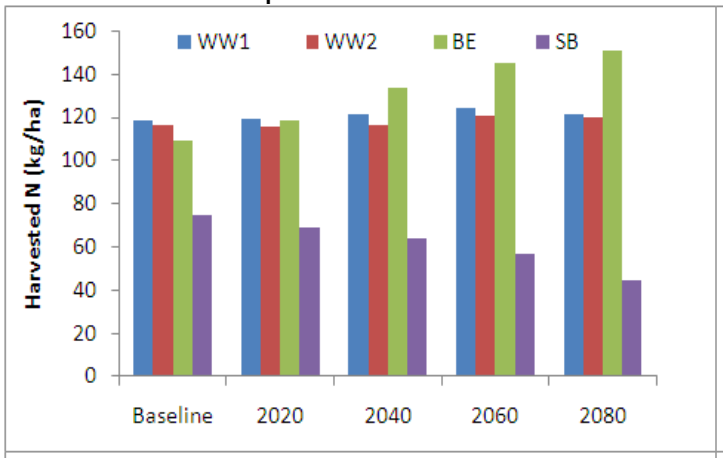
No catch crops

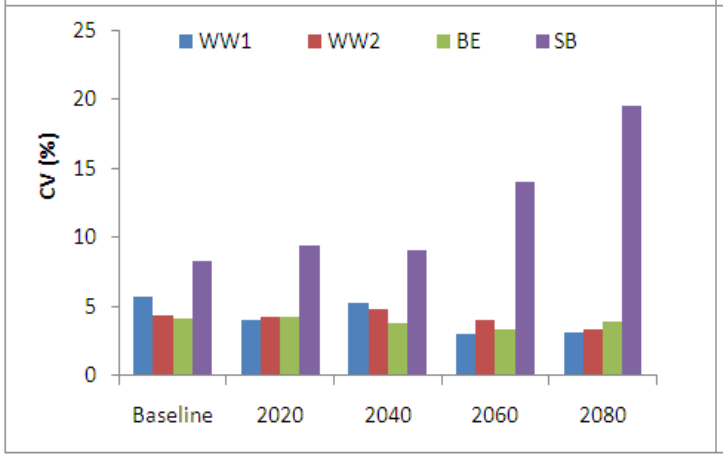


RESULTS

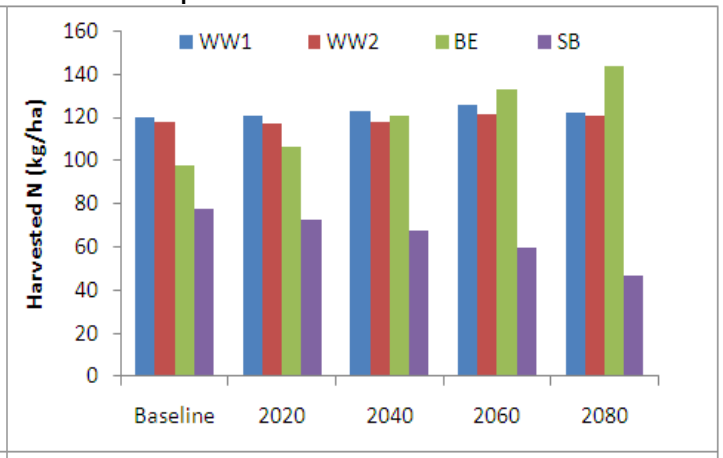
N in harvest

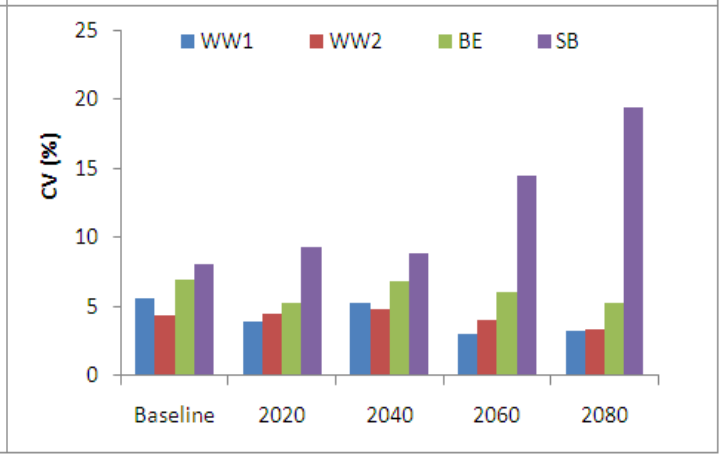
No catch crops





Catch crops





- Winter wheat: 2-3% increase by 2080
- Spring barley: 13% decrease by 2040 and 40 % by 2080
- Beet yield increase 23% by 2040 and 38% - 47% by 2080.
- Yield variability of spring barley higher from 2060
- Little effect of climate change on winter wheat yield variability
- Predicted catch crop effect on the yield and variability of beets

RESULTS

Number of days from **sowing** to **emergence**

	winter wheat_1	Date of sowing	winter wheat_2	Date of sowing	sugar beet	Date of sowing	spring barley	Date of sowing
Baseline	11	15 Sep	12	15 Sep	27	5 Apr	21	1 Apr
2020	11	19 Sep	12	19 Sep	27	1 Apr	20	27 Mar
2040	11	27 Sep	11	27 Sep	28	22 Mar	21	19 Mar
2060	11	5 Oct	12	1 Oct	30	13 Mar	21	11 Mar
2080	12	13 Oct	13	13 Oct	32	5 Mar	23	3 Mar

RESULTS

Number of days from **emergence** to **flowering**

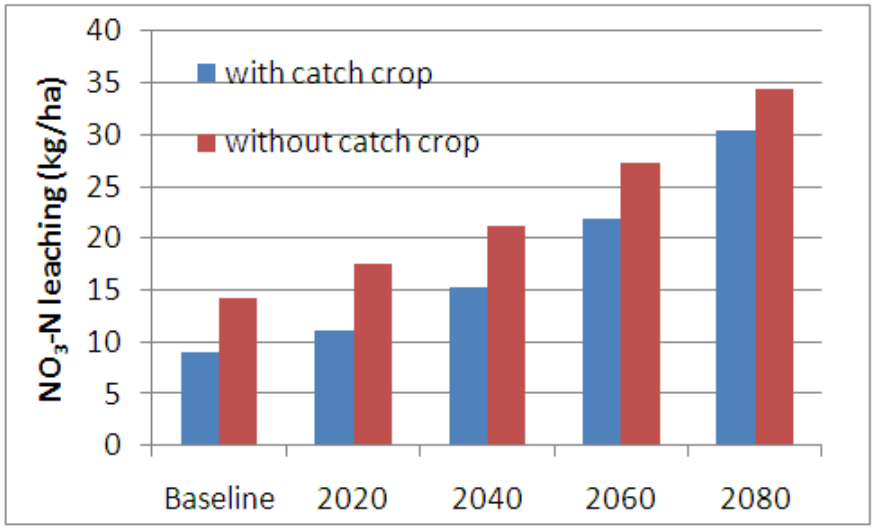
	winter wheat_1	winter wheat_2	sugar beet	spring barley
Baseline	262	259	91	59
2020	254	251	89	**61**
2040	243	240	89	**63**
2060	233	231	93	**67**
2080	222	220	94	**71**

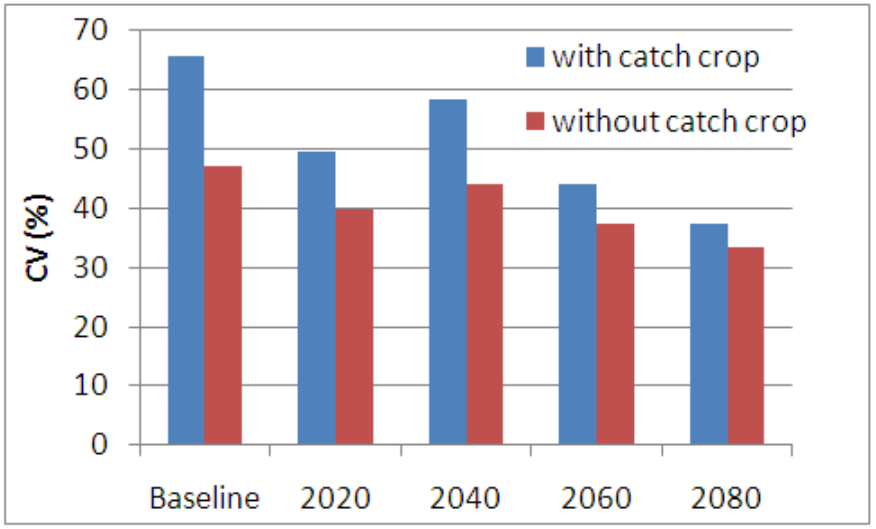
RESULTS

Number of days from **flowering** to **end of grain filling**

	winter wheat_1	winter wheat_2	spring barley
Baseline	44	44	46
2020	41	41	**43**
2040	40	40	**42**
2060	39	39	**38**
2080	38	38	**32**

RESULTS Yearly N leaching





› Important increases of N leaching are expected with projected CC irrespectively of the presence of catch crops

› These increases are on average 60% by 2040 and 290% by 2080 according to the modeling results

SUMMARIZING

- Cereals will be negatively affected by projected CC in Denmark in arable crop rotations, and this can be related to a reduction of the period from flowering to end of grain filling. On the contrary, improved sugar beet yields are expected due to a longer growing season.
- Grain protein of winter wheat is little affected by CC, while grain N is importantly reduced in spring barley
- Temperature increase in winter are probably the main factor explaining the different impact of CC on the yield of winter and spring cereals
- Leaching is expected to increase substantially with CC. This negative impact would be even higher for more coarse textures.

SUMMARIZING

- It will be important in the future to adjust crop management (soil covering, ploughing sowing, fertilization, etc.) to ensure the match between crop requirements and soil N availability while minimizing leaching and other N losses.

- Uncertainty of results must be addressed when deciding on adaptation or mitigation measures. Potential new pest or diseases in the future must be investigated.

THANKS FOR YOUR ATTENTION