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Climate change and biomass production: impact of increased weather fluctuations[1]

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The increased demand for biomass feedstocks to fulfill targets for bioenergy production and reduction of GHG emissions has added to already rising feedstock prices. It is unclear what prices may be expected in the future and whether sufficient biomass will be available. Studies assessing future biomass availability suggest yield increases under improved crop management but few take account of the potential effects of climate change on crop production. On the one hand, yield levels may rise due to increased CO2-concentrations and higher temperatures. On the other hand, unfavourable weather conditions - extreme precipitation, severe droughts and storms - may negatively affect yield. It remains unclear what the net effect on crop production and biomass availability will be. This paper studies effects of climate change for production of winter wheat in the Netherlands using a modelling approach.

Climate change

The effects of climate change on crop production in the Netherlands have been described by Schapendonk *et al.*[2]. Crop production is effected through changes in CO_2-concentration, temperature and precipitation, the impact being crop and location specific. Expected effects include yield increases of 15-50% due to a doubling of CO_2-concentrations, which may be limited (to 10-30%) due to heat stress and early crop maturing. Water use is expected to remain at comparable levels, positive reduction in water use related to the higher CO_2-concentrations being neutralised by increased transpiration and elevated temperatures. Increased wheather dynamics and extreme events will further affect risk of crop failure and loss of crop quality.

Modelling crop growth

Crop yields after climate change were simulated using WOFOST, a dynamic simulation model using daily data on radiation, temperature and water and nutrient availability. Winter wheat cultivation was modelled under standard culitvation practices, applying 120 kg N/ha on a poor sandy soil in the north of the Netherlands. We modelled three production situations: 'potential' crop growth, not limited by input availability (A), nutrient and water limited production (B), as (B) but with additional irrigation (C). Crop yields were calculated using weather data simulated for 2020, using temperature, precipitation, evaporation and wind data generated by the Dutch Royal Meteological Institute, selecting the G+ scenario of strong wind circulation[3].

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Results

Crop yields after climate change are presented in Table 1. Average potential yields (A) amount to 11.5 ton/ha. Average yield under conditions of nutrient and water limitation (B) is reduced to 6.6 ton/ha or 58% of the potential. Application of additional irrigation (C) increases yields to 8.9 ton/ha (78% of potential yield). The impact of weather variations is depicted by calculating average yields for the five best and five worst years, respectively. The difference between input delimited and potential yields in good years is 2.3 ton/ha; for irrigated plots this is only 0.7 ton/ha. Duting years of unfavourable weather conditions differences increase to 6.2 and 3.8 ton/ha respectively. In all cases, climate change increases differences between potential and input limited yields (whether irrigated or not). On the whole, potential yields in worst years are only 67% of those realised in the best years. This is 40% for irrigated and only 23% for input delimited yields.

		All years	Best years	Worst years	Worst/ Best (%)
Potential (A)	Avg St. dev. Id (%)	11.5 1.6 13.9	13.0 0.2 1.7	8.7 1.0 11.2	67.0
Delimited (B)	Avg St. dev. Id (%)	6.6 2.9 43.9	10.8 1.0 0.9	2.5 0.8 30.2	23.0
Irrigated (C)	Avg St. dev. Id (%)	8.9 2.7 29.9	12.3 0.2 1.8	4.9 1.0 20.9	39.7

Table 1 Potential, input delmited and irrigated wheat yields after climate change

Discussion and conclusion

In the future, under conditions altered by climate change, weather variability will seriously affect wheat yields, especially if nutrients and water availability is limited. Average wheat yields in input delimited situations are only 57% of the potential yields. Under irrigation, this is 83% (the gap being more than halved). Yields in the most unfavourable years are one third (input delimited) or half (irrigated) of the average levels, differences with above-average years obviously being langer.

References

[1]Based on a paper presented at the 16th European Biomass Conference and Exhibition, Valencia (Spain), 4 June, 2008. 2 Schapendonk, et al., 1998. (In Dutch) Effecten van klimaatverandering op fysieke en economische opbrengst van een aantal landbouwgewassen. NOP Report 410 200 016. 3 Van Den Hurk, et al. (2006). KNMI Climate Change Scenarios 2006 For The Netherlands. WR 2006-01. Bilthoven (The Netherlands): Royal Netherlands Meteorological Society.

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