Assessment of the impact of climate change in temperate zone on grain legume yield and N_2 fixation

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Climate change is likely to strengthen abiotic stresses on crops in temperate zones. Grain legumes and the associated provision of ecosystem services are the cornerstone of more sustainable cropping systems, yet the impact of climate change on their performance has not been extensively quantified. Based on previous experiments carried out in south-western France with low biotic stress, we calibrated the STICS soil-crop model for spring pea (SP), winter pea (WP) and winter faba bean (WF) and evaluated its quality of prediction on an independent dataset. STICS was used to explore the effect of climate change scenarios on the legumes performance. Assuming no change in crop management, mean and inter-annual variability of grain yield and N_2 fixation were assessed for historical (1995-2015), mid-term (2020-2040) and long-term (2060-2080) periods, considering projections from two Global Circulating Models (GCM) and two Representative CO_2 Concentration Pathways (RCP), *i.e.* RCP 4.5 and RCP 8.5. The GCMs consistently predicted no significant change in rainfall amounts and patterns but indicated a 1.7°C and 2.5°C increase in average temperature over the growth period in the long term under RCP 4.5 and RCP 8.5 respectively. Therefore, simulations indicated no extra water stress on grain yield and N_2 fixation of these legumes. The increase in temperature entailed a shortening in crop duration and a slight but significant increase in the temperature stress factor values for grain filling, for photosynthesis and for N_2 fixation during the reproductive period (+1% to +13 % depending on temperature stress, crop and RCP). Under RCP 4.5, yield decreased by 23 to 34% (depending on crop) in the long term. Average fixed N_2 decreased by 16% to 34%. Probability of yield failure (i.e. yield below

the 20th percentile of historical yield) increased from 20 to 50, 54 and 58% for WF, WP and SP respectively. Probability of N_2 fixation failure increased from 20 to 34, 50 and 53% for WP, WF and SP respectively. In contrast, under RCP 8.5, the CO_2 fertilisation effect would offset the decrease in yield due to the increase in temperature and simulations predicted a 8 to 13 % average yield increase in the long term. Average N_2 fixation would benefit from the increase in biomass and increase by 15 to 23%. Probability of yield failure would increase slightly, from 20 to 21, 25 and 27% for WF, WP and SP respectively. Probability of N_2 fixation failure would increase for spring pea (from 20 to 31%) but decrease for winter faba bean (from 20 to 13%) and winter pea (from 20 to 11%). The increased probability of yield and N_2 fixation failure simulated with the RCP 4.5 scenario indicates the need for technical and transformational adaptations for grain legumes to deliver the expected ecosystem services with future climate. Under RCP 8.5, better yield and N_2 fixation highlight the opportunity represented by climate change for inclusion of grain legume in cropping systems.

Key-words : STICS, pea, faba bean, risk