Supplementary material:

S1: Simulated (ERA5 control runs) versus measured harvest

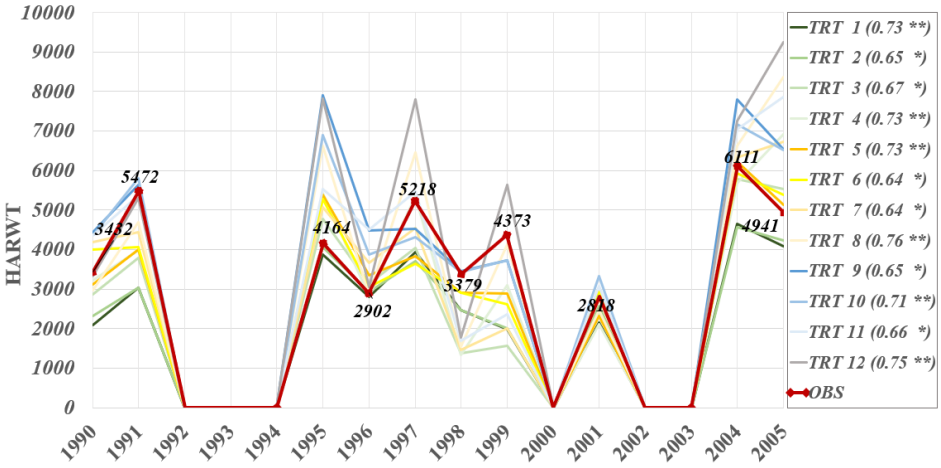

Fig.S1: Simulated (thin lines) vs. measured (red, thick) harvest in southern Romania for 12 management scenarios (Table 1, exper "3N"). Box: Pearson correlation between simulated treatments and measured Harvest (* p<0.01, ** p<0.05, * p<0.10; zero are missing values).**

S2: Sensitivity to changes in nutrients

Replicability for system portability on other pilot regions requires estimates of sensitivity to new local forcing. Sensitivity ensemble simulations were performed, with increasing soil Carbon and Nitrogen at the initial time by 20%, for a same control genotype (experiment setup E_1N_G0_soil+CN).

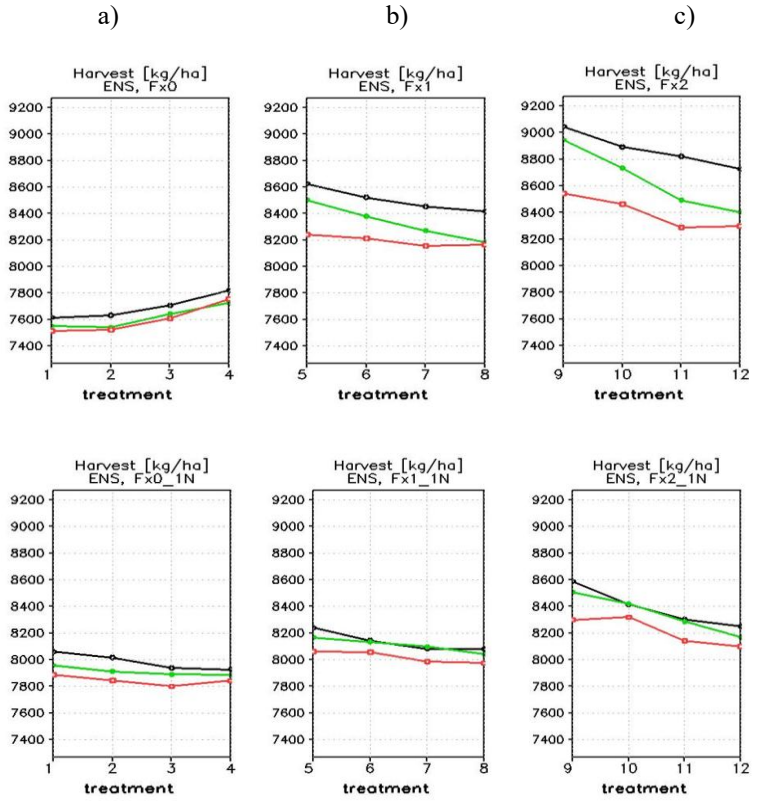

Fig.S2.1: Harvest ([kg/ha]) comparison between the experiment setup E_3N_G0 (top, same as Fig.7) and the experiment setup E_1N_G0_soil+CN (bottom). Panels are as in Fig7, for Fx0(a), Fx1 (b), Fx2 (c), ensemble time mean for Hist (black), RCP4.5 (green) and RCP8.5 (red), on Ox there is the treatment (1 to 12, Table 1).

Experiment E_1N_G0_soil+CN compared to E_3N_G0 (Fig.7) shows that Harvest loss is only up to 7% for about 60% reduction in fertilization (exper "1N" versus "3N", Table 1), when the soil nutrients content is increased by 20%. Also, the comparison shows that there are still options even under warmer climate to equal or exceed the historical Harvest if there is an appropriate soil composition (e.g. in RCP4.5 TR6 and TR7, Fig.S2.1b-bottom), also under RCP8.5 (TR10 and TR11, Fig.S2.1c-bottom), and even at lower fertilization levels (exp "1N", Table 1). A possible mechanism in this case involves delayed maturity (Fig.S2.2b), and consequent more precipitation accumulated (Fig.S2.2a, c). In practice this slower maturity

could be due to soil C/N composition influencing soil water holding capacity, moisture and temperature, slowing germination or plant growth. Previous research (Kakar et al. 2014; Khan et al., 2014) also reported delayed silking and maturity in the case of enhanced soil nitrogen when compared to control case, showing also a stronger response for early sowing.

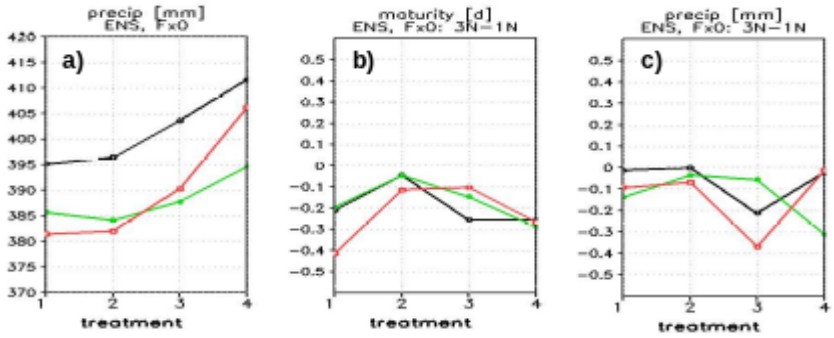

Fig.S2.2: Precipitation (mm) accumulated from the initial time of the simulation for experiment setup E_3N_G0 (a), (same as Fig.7); differences [dap] in the maturity date (b) and in precipitation accumulated until maturity (c) for the experiment setup E_3N_G0 minus the experiment setup E_1N_G0_soil+CN, (mm). Lines are for Hist (black), RCP4.5 (green) and RCP8.5 (red).

S3: Slopes of Pi genotype parameters in Hist and climate scenarios

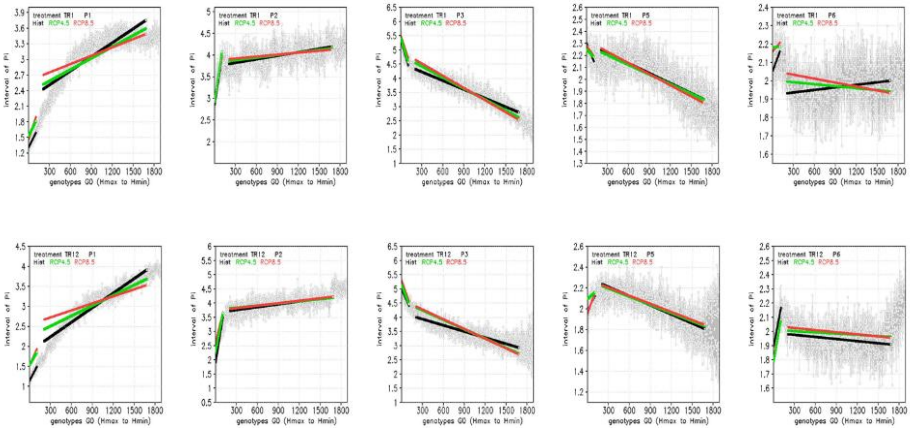

Fig.S3 The slopes (thick lines) of Pi genotype parameters (y-axis) as a function of decreasing ordered harvest (x-axis) for Hist (black), RCP4.5 (green and RCP8.5 (red) computed over 2 sub-intervals of highest 200 values of harvest and over the rest of decreasing ordered values (200-1890). The values (light grey) are plot for Hist, ensemble time mean, TR12 (as in Fig.10 bottom, grey).

S4: Percent changes in Pi in climate scenarios relative to Hist

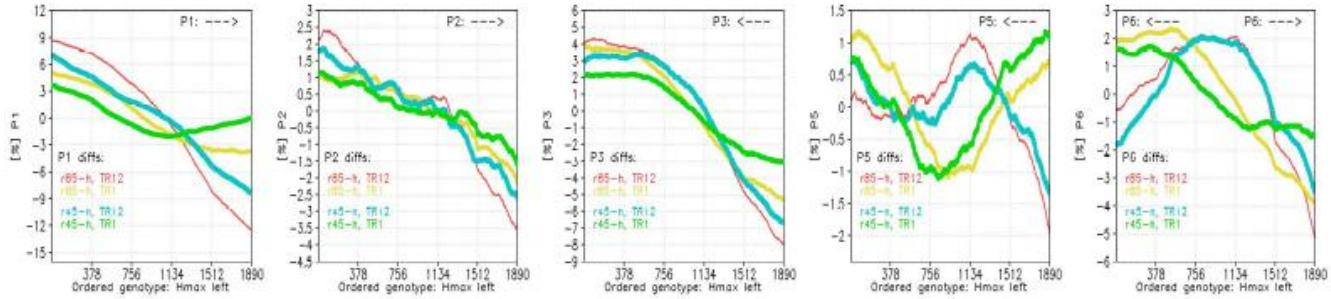

Fig.S4: Percent changes of Pi genotype parameters (y-axis) as a function of the ordered Harvest from highest (left, x-axis) to lowest (right, x-axis). Differences (running means over 378=P2xP3xP4xP5xP6 the product of discretization intervals for P1-P6) are shown for TR1 (yellow for RCP4.5 minus Hist) and green (RCP4.5 minus Hist) and for TR12 (red for RCP8.5 minus Hist) and blue (for RCP4.5 minus Hist). Percent changes are expressed as differences relative to Hist. Arrows indicate the monotony of Pi values that correspond to the ordered decreasing harvest (shown in Fig.10).