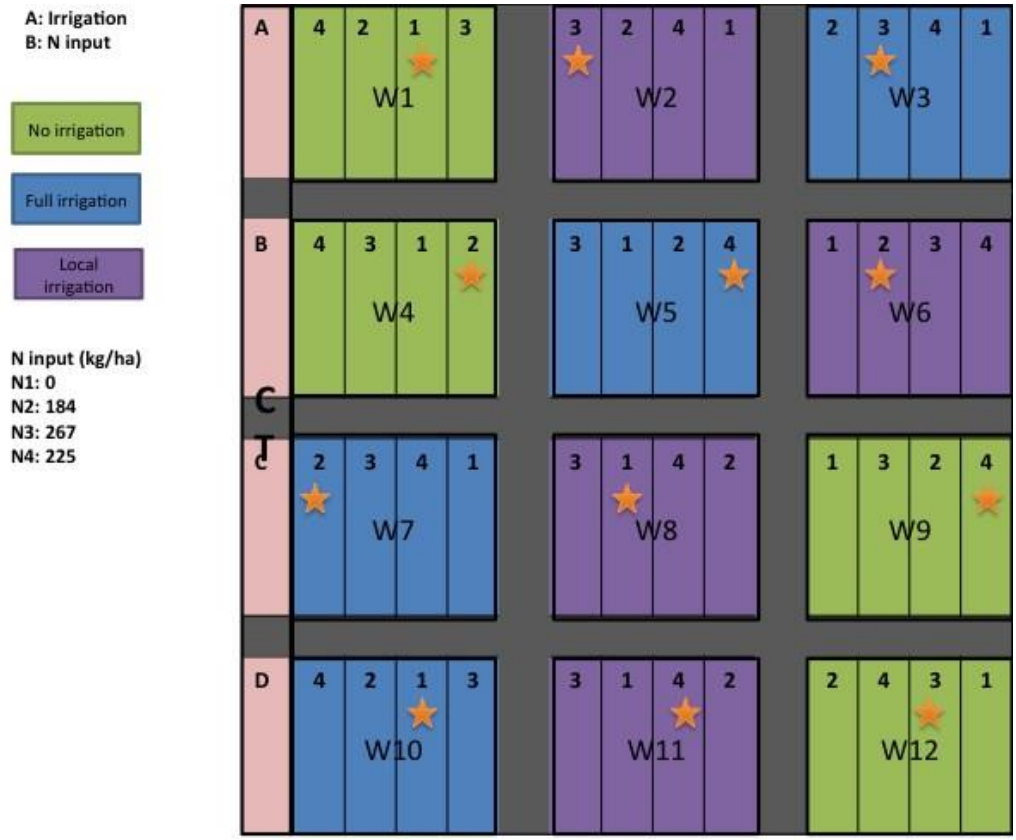

Figure S1. The diagram of the 2017 experimental design. The design was a randomized block split-plot design. There were four blocks with three main plots (irrigation treatment) per block and four subplots (nitrogen (N) treatment) per main plot. First, the three irrigation treatments were randomly assigned to the three main plots in each block, and the four N treatments were randomly assigned to each main plot. The yellow star indicates the location of the 12 soil moisture sensors (watermarks). W1-W12 indicates 12 main plots.

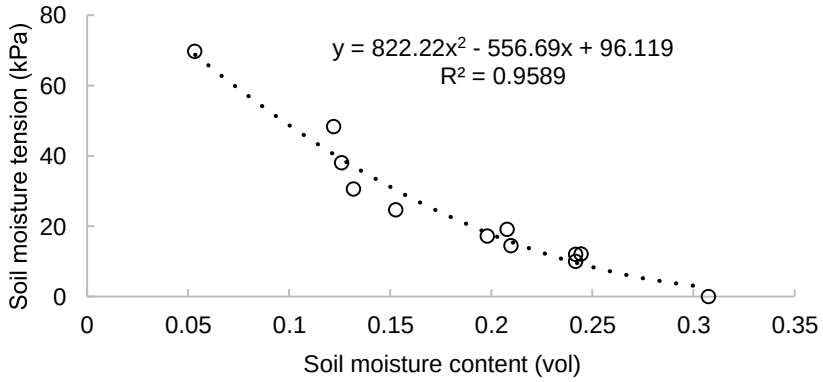

Figure S2. The relationship between soil moisture tension (kPa) measured by the watermark and the corresponding soil moisture content (volume, %) for the experimental field in 2017. For each soil moisture tension value, the soil sample (near the watermark) was collected using a cutting ring and was dried in the oven to measure the soil moisture content (volume, %). This relationship was used to guide the irrigation schedule for the full irrigation treatment (i.e., to maintain the soil moisture content above 80% of field capacity (FC)). The field capacity of the experimental field was 24% (see Section 5.2.2 Soil characteristics). In order to keep the soil

moisture level above 80% FC (i.e., 19%), the soil moisture tension should be below 20 kPa during the entire growing period.

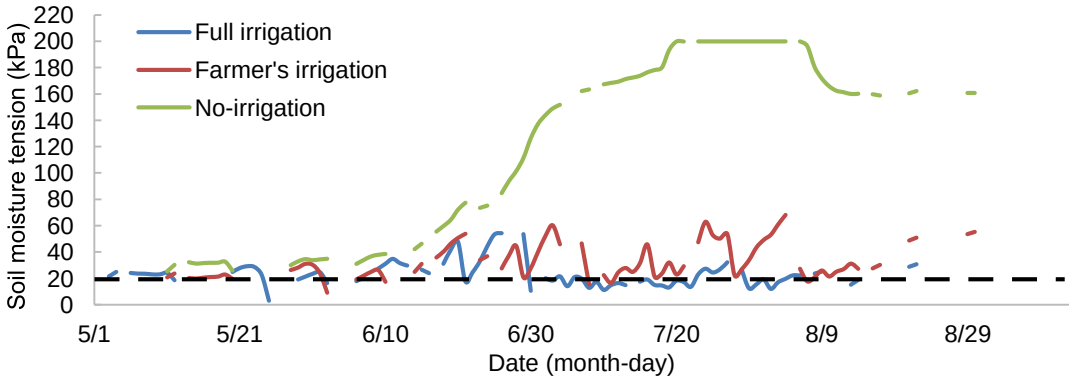

Figure S3. The daily soil moisture tension of the three irrigation treatments monitored by watermarks from planting till harvest in the 2017 field experiment. The average daily soil moisture tension of the four replications was calculated to represent the daily soil moisture tension of each irrigation treatment (i.e., Full irrigation, Farmer's irrigation, No-irrigation). For the full irrigation treatment, the irrigation was applied in order to keep the soil moisture tension below 20 kPa (the soil moisture content was above 80% of field capacity, see Fig. D3). The dashed line indicates the 20 kPa soil moisture tension.

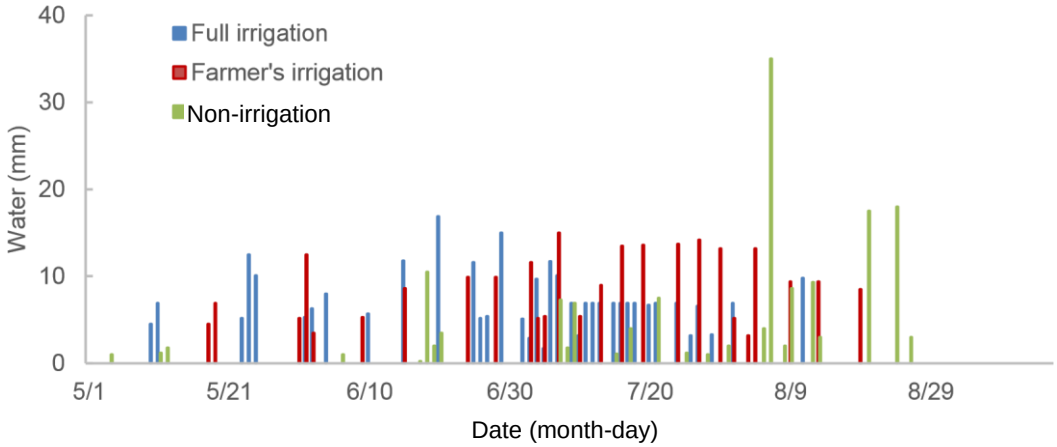

Figure S4. The daily rainfall and daily irrigation amount (for the farmer irrigation and full irrigation treatments) from planting till harvest in the 2017 experiment. For the no-irrigation treatment, the water input was rainfall water. For the farmer irrigation treatment, the irrigation time and amount of each irrigation followed the farmer's practice. For the full irrigation treatment, the irrigation time and amount depended on soil moisture condition. Irrigation was applied when the soil moisture tension (measured by watermark) approached 20 kPa. Approximately 7–10 mm water was applied at each irrigation.

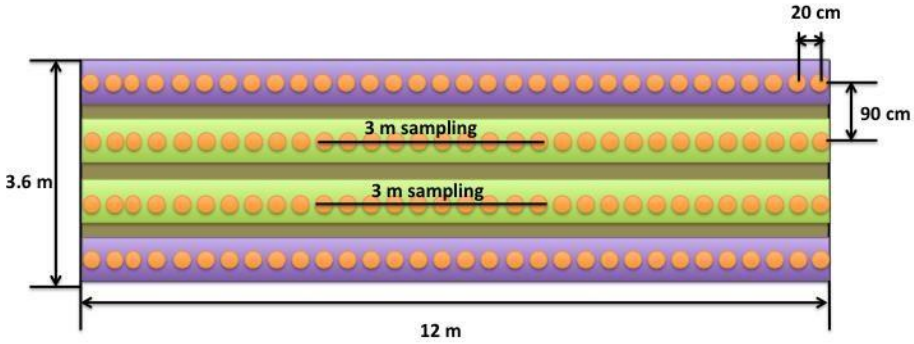

Figure S5. The "3-meter sample" collection for the 2017 field experiment. The figure represents a sub-plot unit, consisting of four ridges with 90 cm in width and 12 meters in length. The planting distance of the tubers was 20 cm. The "3-meter samples" were collected from the center of the middle two ridges.

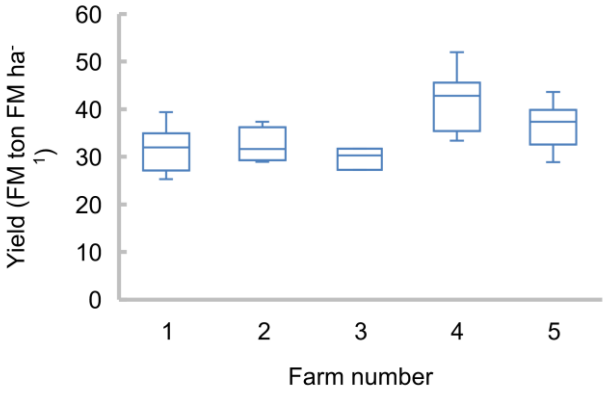

Figure S6. The variation in yield of different fields of the five 2018 experimental farms (Farm 1, 2, 3, 4 and 5). The yield was obtained in 2017.

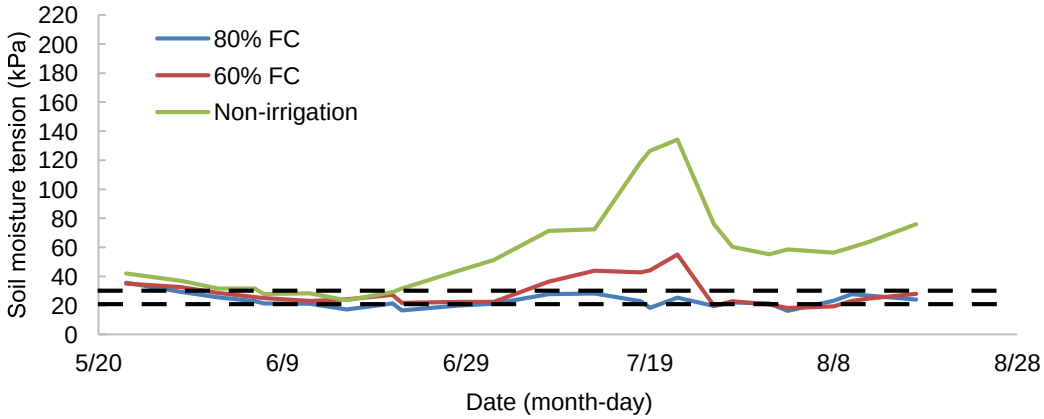

Figure S7. The daily soil moisture tension monitored by watermarks for the three irrigation treatments in the 2018 field experiment. For the two irrigation treatments (60% of field capacity, 80% of field capacity), the irrigation was applied in order to keep the soil moisture tension below 33 kPa (60% of field capacity, upper dashed line) and 20 kPa (80% of field capacity, lower dashed line), respectively.

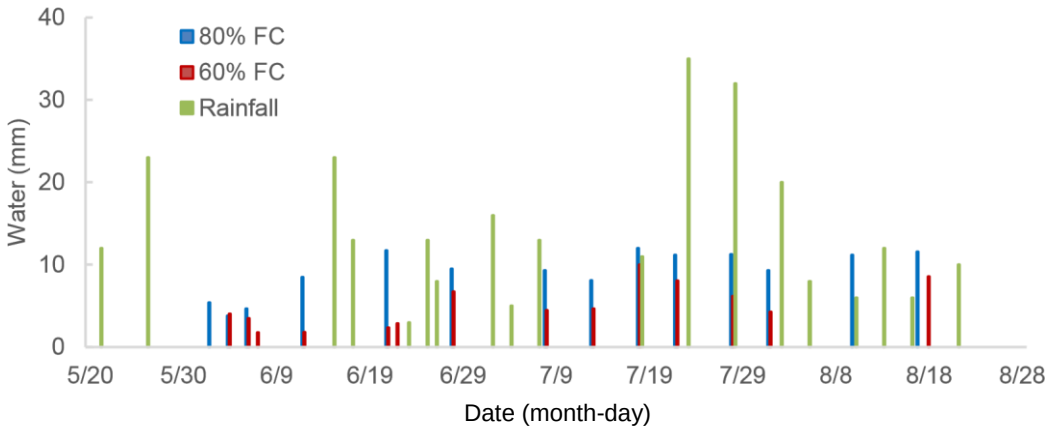

Figure S8. The daily water input from planting until harvesting for the three irrigation treatments of the 2018 experiment. The three irrigation treatments were (1) no-irrigation treatment, the water input was rainfall water; (2) 60% FC treatments, the soil moisture content was maintained above 60% of field capacity (FC) and (3) 80% FC treatments, the irrigation was applied to maintain the soil moisture content above 80% of FC.

Table S1. The amount of N, P, K fertiliser applied by farmers at planting, tillage and via irrigation in the 10 experimental fields of the five farms in 2018. Solid fertiliser was applied to the soil at planting and during tillage in all fields of the five farms. For the fertiliser applied through irrigation, urea (for N) and/or various types of compound fertiliser (N, P_2O_5, K_2O) were used in different farms; types and amounts of fertiliser were the same for the two experimental fields in the same farm.

Location		Fertiliser applied through soil application (kg ha^{-1})			Fertiliser applied through irrigation (kg ha^{-1})			Total fertiliser input (kg ha^{-1})		
Farm No.	Field No.	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	1	153	175	164	81	48	240	234	223	404
1	2	153	175	164	81	48	240	234	223	404
2	3	173	143	225	56	12	255	228	155	480
2	4	173	143	225	56	12	255	228	155	480
3	5	168	192	180	56	12	255	224	204	435
3	6	168	192	180	56	12	255	224	204	435
4	7	180	204	348	9	0	11	189	204	359
4	8	180	204	348	9	0	11	189	204	359
5	9	135	230	311	117	0	115	252	230	426
5	10	135	230	311	117	0	115	252	230	426

Table S2. The water input (irrigation, rainfall) and water surplus of potato production in the 10 experimental fields in 2018. The irrigation type was sprinkler irrigation in all fields.

Region	Farm No.	Field No.	Farmer perceived field	Irrigation (mm)	Rainfall (mm)	Total water input (mm)
Chenqi	1	1	Good	175	269	444
Chenqi	1	2	Poor	158	269	427
Xiertala	2	3	Good	161	278	439
Xiertala	2	4	Poor	159	278	437
Xiertala	3	5	Good	118	278	396
Xiertala	3	6	Poor	136	278	414
Hailer	4	7	Good	70	231	301
Hailer	4	8	Poor	82	231	313
Hailer	5	9	Good	100	253	353
Hailer	5	10	Poor	100	253	353

Testing procedure for the Alkali-hydrolysable N

Principles

Soil alkali-hydrolysable N includes inorganic N (NH_4-N and NO_3-N) and easy hydrolysed organic N (amino acid, ammonium amide and easy hydrolysed protein). When the soil is treated with lye, the easy hydrolysed organic N and ammonium N are converted to ammonia, and the nitrate N is converted to ammonium by ferrous sulfate. The ammonia is absorbed by boric acid and titrated with a standard acid to estimate the hydrolysable N in the soil.

Preparing reagents:

(1) 1 mol L^{-1} NaOH: Weighting 40 g of NaOH and dissolving it in water (1 L).

(2) Ferrous sulfate powder: Grounding $FeSO_4.7H_2O$ (third grade), passing it through a 0.25 mm aperture sieve, and placing it in a brown glass bottle.

(3) Alkaline glycerol: Adding 40 g of gum arabic and 50 ml of water in a beaker, and warming it to 70–80 °C, stirring to dissolve, and cooling (1 hour). Adding 20 ml of glycerin and 20 ml of saturated K_2CO_3 aqueous solution and stirring. Putting it in a centrifuge to remove foam and insoluble matter. The supernatant is stored in a glass bottle for use.

(4) 0.01 mol L^{-1} H_2SO_4 standard solution: Taking 8.35 ml of H_2SO_4 (1:9), and dissolving it in water (1 L).

(5) 20 g L^{-1} Boric acid solution.

(6) Indicator solution (bromocresol green and methyl red).

Testing steps:

1. Weighing 1–2 g of air-dried soil sample and 0.2 g of ferrous sulfate powder; uniformly spreading them on the outer chamber of the diffusion dish, and gently rotating the diffusion dish horizontally to flatten the soil sample.

2. Add 2 ml of 20 g L^{-1} boric acid solution in the inner chamber of the diffusion dish, applying alkaline glycerin on the outer edge of the dish, covering the frosted glass, and rotating it so that the edge of the frosted glass and the diffuser is completely adhered. Slowly turning the side of the frosted glass, exposing the diffuser to a slit, quickly adding 10 ml of 1 mol L^{-1} NaOH solution to the outer chamber of the diffuser, and immediately seal the frosted glass tightly.

3. Rotating the frosted glass horizontally on the bench. Gently rotating the diffuser to mix the solution thoroughly with the soil. Then carefully placing it in a 40 ° C incubator (24 +/- 0.5 hrs).

4. Measuring the amount of ammonia absorbed by the boronic acid solution in the inner chamber of the diffusion dish using a microtiter tube and a droplet of 0.01 mol L^{-1} of H_2SO_4. The ending point is purple-red.

5. Taking another diffusion dish, do a blank test (no soil).

Calculation

Soil alkali-hydrolysable N is estimated according to the following formula:

$$\text{Soil alkali-hydrolysable N (mg kg}^{-1}) = [C \times (V - V_0) \times 14 / W] \times 1000$$

C: concentration of H_2SO_4 standard solution (mol L^{-1})

V: the volume of the H_2SO_4 standard solution used for sample determination

V_0: the volume of the H_2SO_4 standard solution used for blank determination

14: molar mass of nitrogen

1000: conversion factor

W: soil sample weight (g)