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SUPPLEMENTARY INFORMATION

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Speed breeding in growth chambers and glasshouses for crop breeding and model plant research

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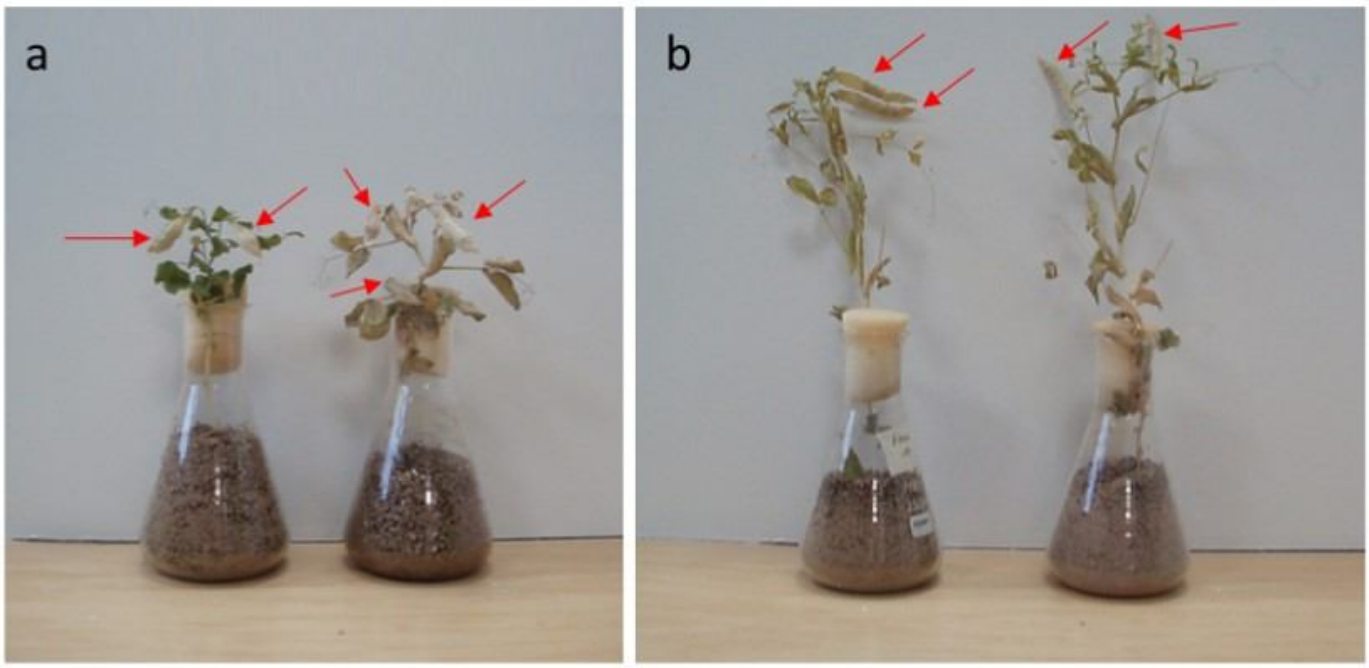


Supplementary Figure 1

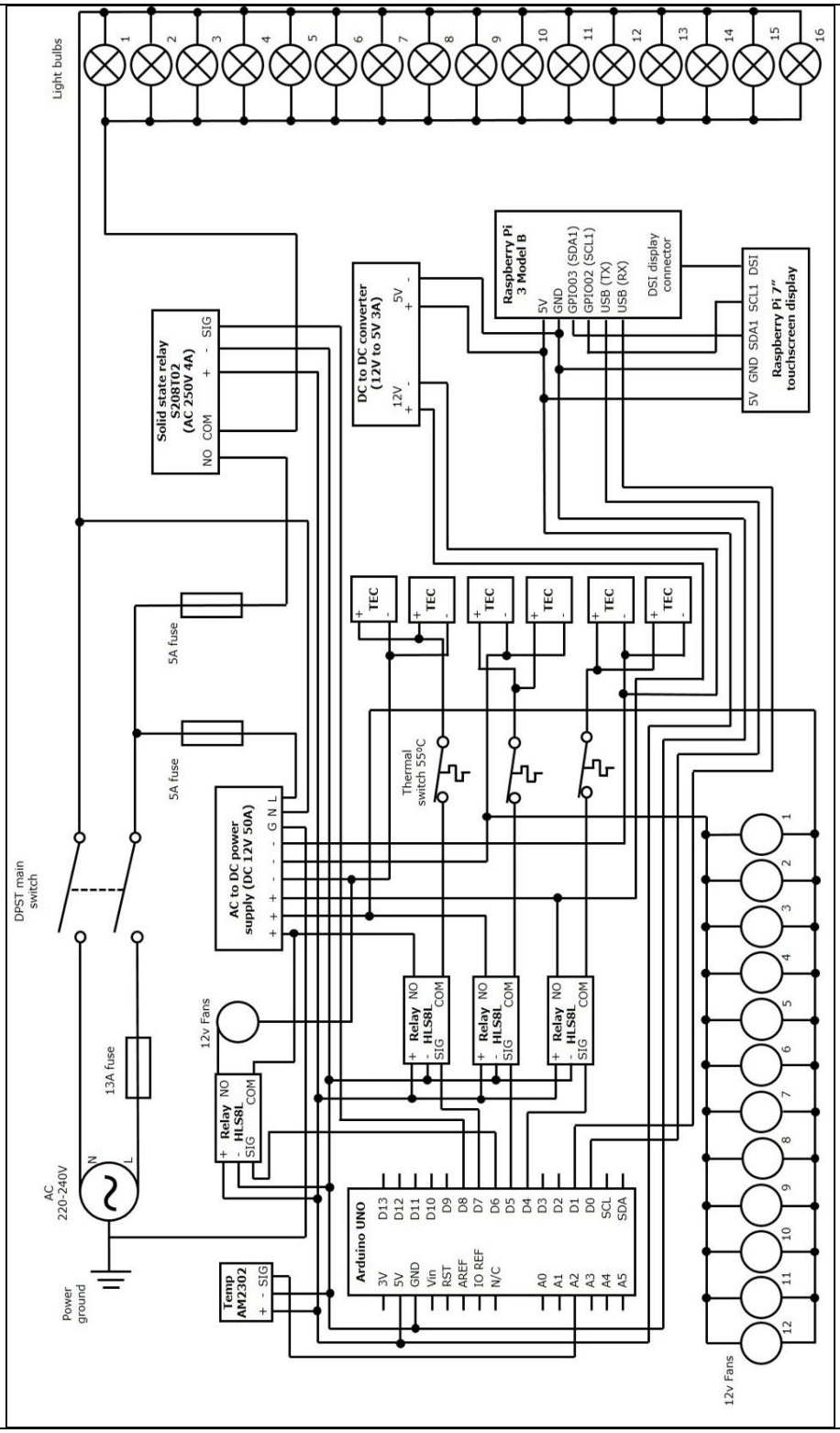
Mature eight-week-old pea plants grown in limited media and nutrition ("flask method") in order to achieve rapid generation advancement

Pisum sativum (a) accession JI 2822 and (b) cv. Frisson. Dry seeds were sterilised in 10% sodium hypochlorite, rinsed in sterile water, chipped and left to germinate in the dark for 3 days on sterile, wet filter paper. Germinating seeds were transferred to flasks containing 250 mL fine perlite and silver sand (mixed 50:50) and FP nutrient media which had been sterilised (composition described in Supplementary Table 49). Flasks were placed in the dark for a further 5 days. The seedlings were inoculated with *Rhizobium*, and the elongated shoot passed through the neck of the flask and held in place with a bung. The base of the flask was covered with a black plastic bag. Plants were grown in a Controlled Environment Room at constant 22 °C with a 16-hour photoperiod. After 3 weeks, flasks were watered with 50 mL FP media once a week. After 8 weeks post germination, plants had mature dry seed ready to harvest as shown (indicated by red arrows). JI 2822 plants grown in the glasshouse under lights required 12 weeks post sowing before mature dry seed were ready for harvest.

Supplementary Figure 2

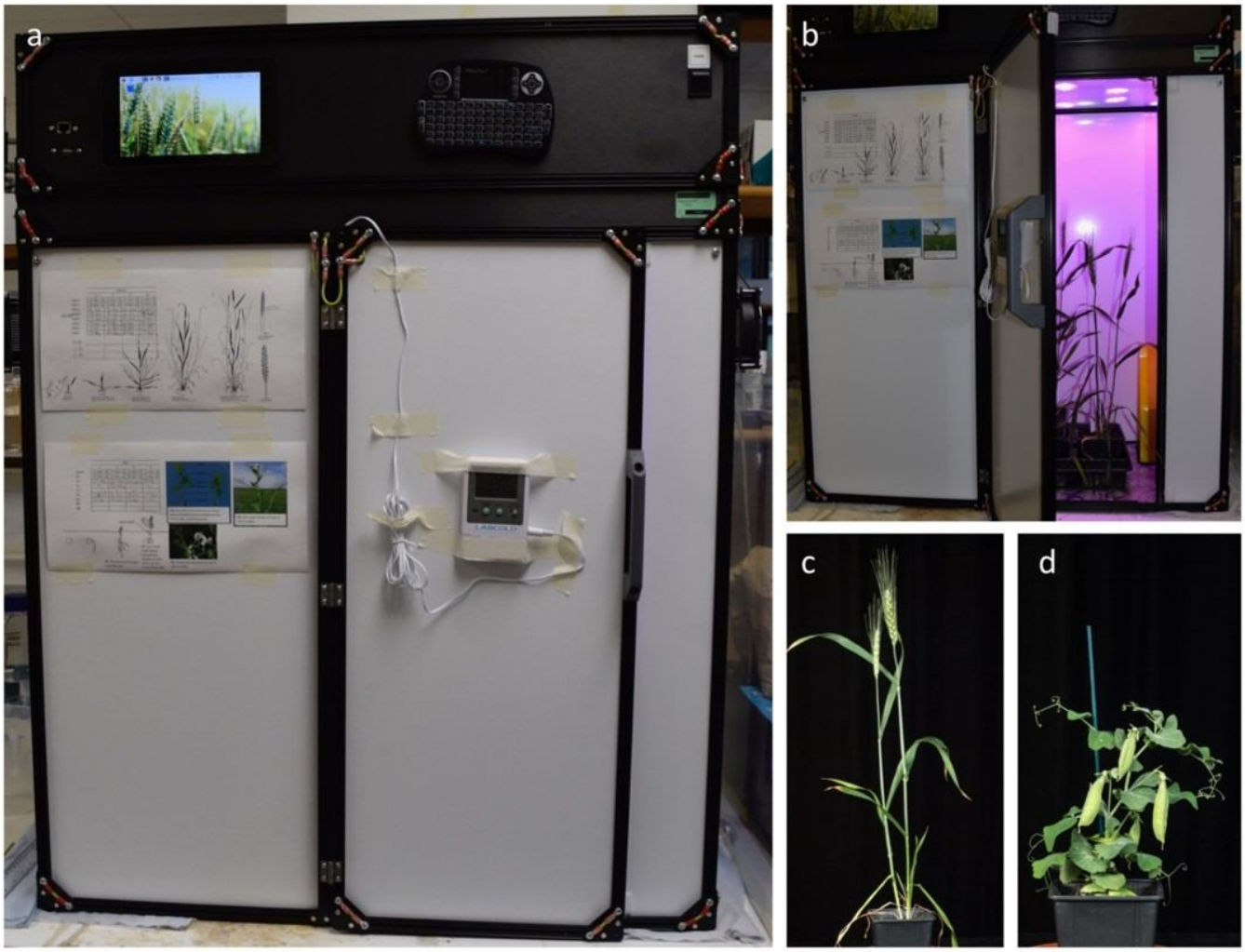
Symptoms of calcium deficiency in wheat grown under speed breeding conditions

Right: Small, circular depressions on the leaf blade; Left: Tip leaf necrosis.



Supplementary Figure 3

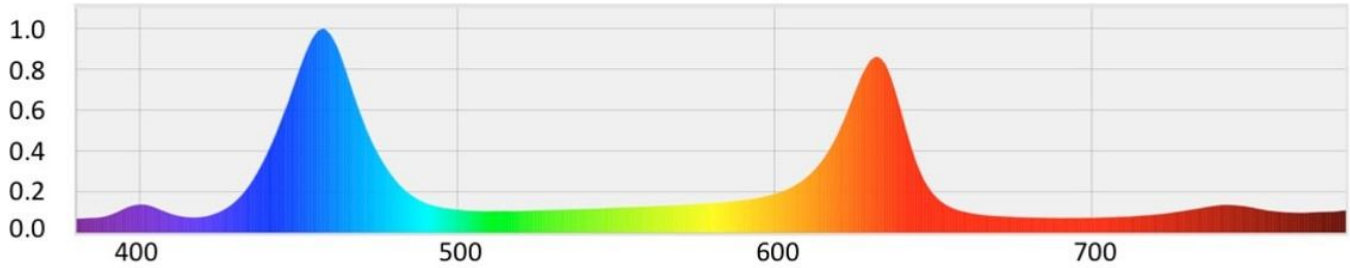
Circuit diagram of the monitoring and control system of the benchtop growth cabinet



Supplementary Figure 4

Benchtop cabinet for conducting speed breeding

(a) Front view of the cabinet. **(b)** Front view of the cabinet with the door open to show the lighting and wheat plants (*Triticum aestivum* cv. Apogee) growing inside. **(c)** Apogee wheat plant grown in the cabinet, photographed at 55 DAS (Days after sowing). **(d)** Pea (*Pisum sativum*) variety JI 2822 grown in the cabinet, photographed at 50 DAS.



Supplementary Figure 5

Light spectrum measurements in in the benchtop growth cabinet 20cm below one of the LED bulbs

The x-axis represents the wavelength of light in nanometres, and y-axis is the normalised spectral power distribution. (Power distribution is measured in $mW \cdot m^{-2}$, and all values on y-axis are divided by the maximum value in the distribution in order to obtain normalised values). Graph was produced from measurements made by the MK350S LED meter from UPRtek, using the uSpectrum software produced by the same manufacturer.

Supplementary Figure 6

Barley spikes from plants grown under Heliospectra LED lights

Barley cv. Golden Promise from 22-hour light regime (left) and 16-hour light regime (right). Scale bar is 5 cm.

Supplementary Figure 7

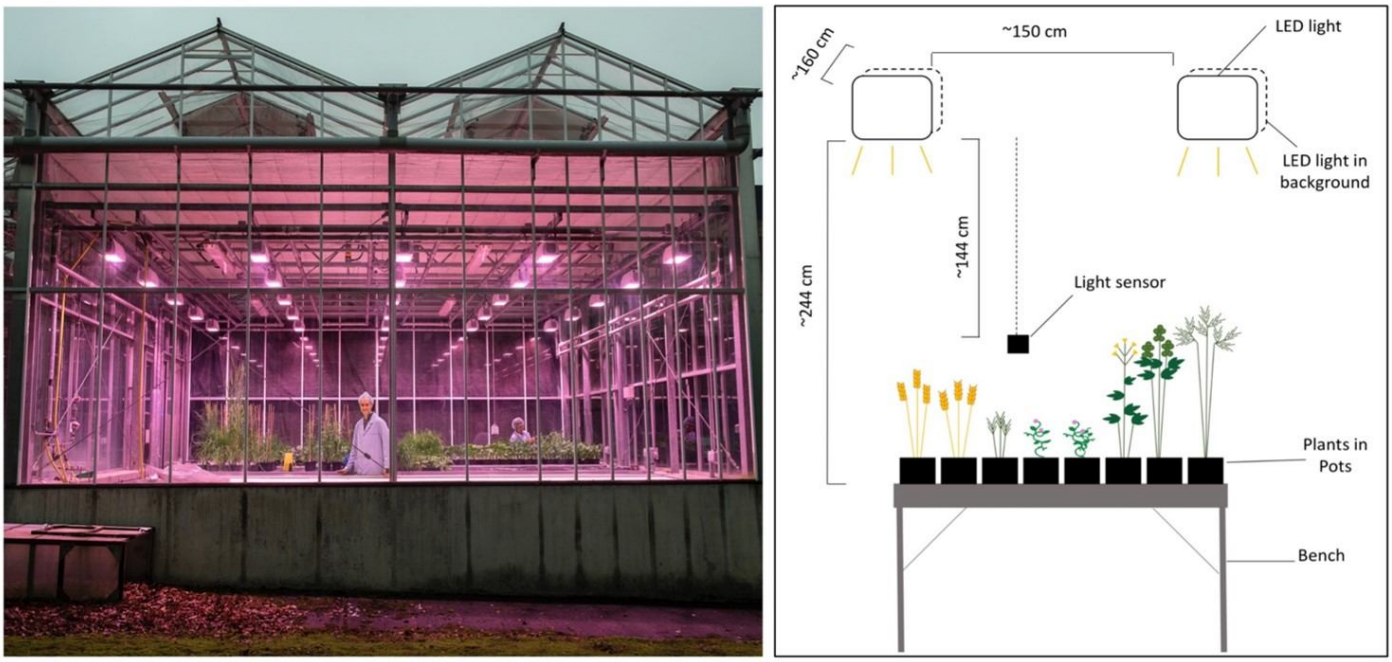
Pods from *Brassica rapa* R-0-13 grown in LED-supplemented glasshouses at the John Innes Centre, UK

Plants grown under (a) a 22-hour photoperiod or (b) a 16-hour photoperiod.

Supplementary Figure 8

Pods harvested from *Brassica napus* RV31 grown in LED-supplemented glasshouses at the John Innes Centre, UK

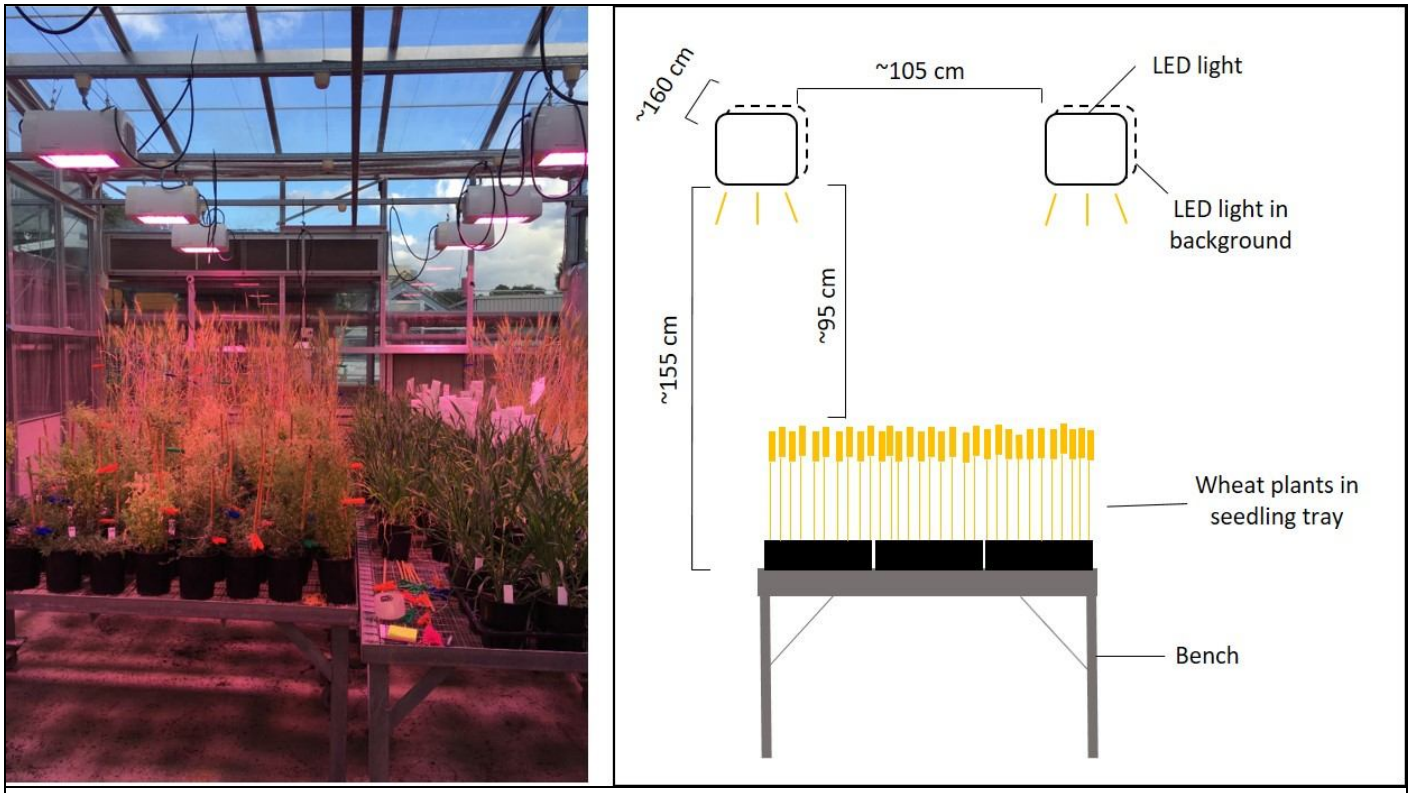
Plants grown under (a) a 22-hour photoperiod or (b) a 16-hour photoperiod.



Supplementary Figure 9

Layout of the glasshouse used for speed breeding at the John Innes Centre, UK

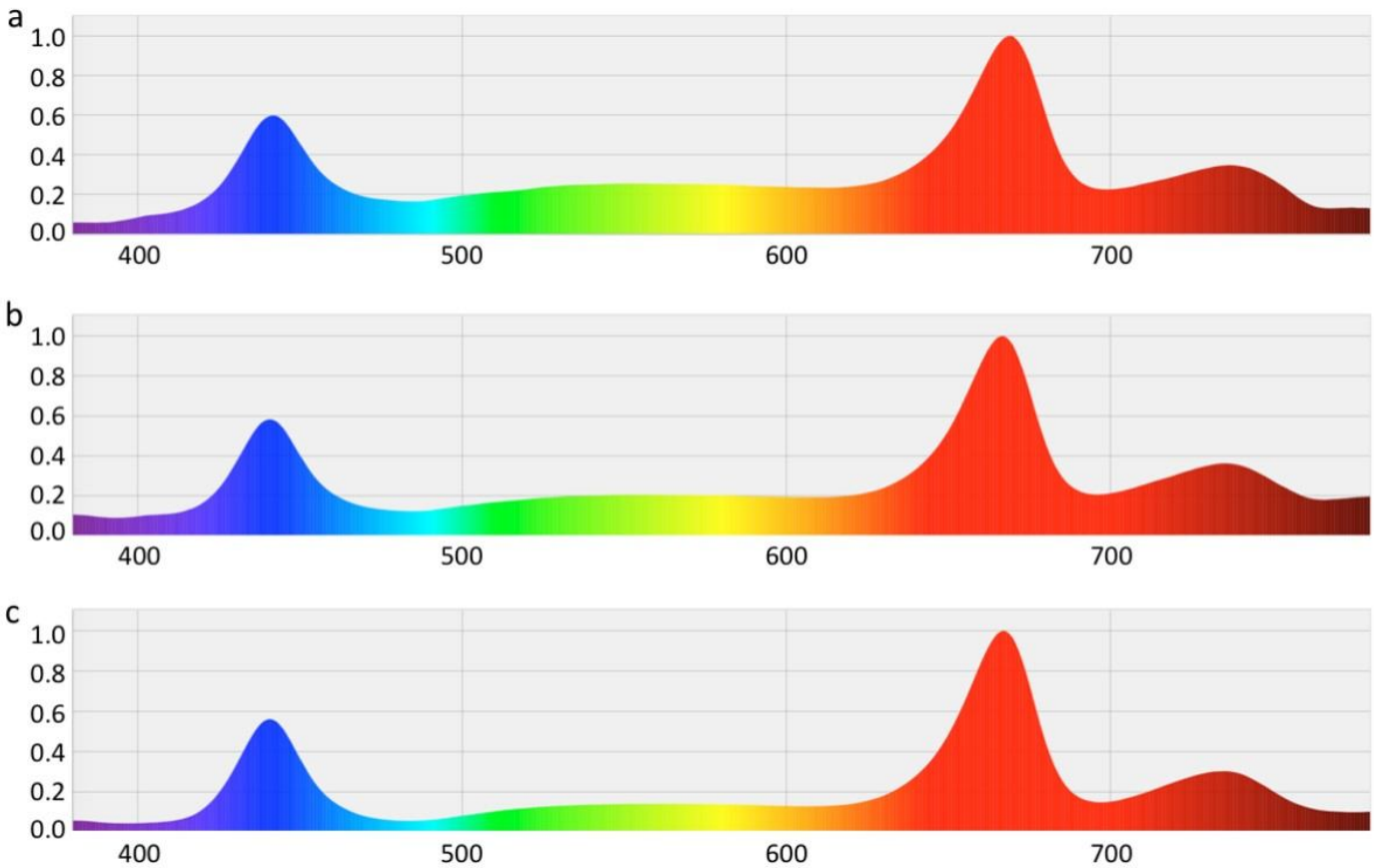
(Left) Photograph with Heliospectra LX60C2 LED supplementary lighting; (Right) Schematic of light positioning within the glasshouse relative to the bench, plants and other light fixtures



Supplementary Figure 10

Layout of the glasshouse used for speed breeding at The University of Queensland, Australia

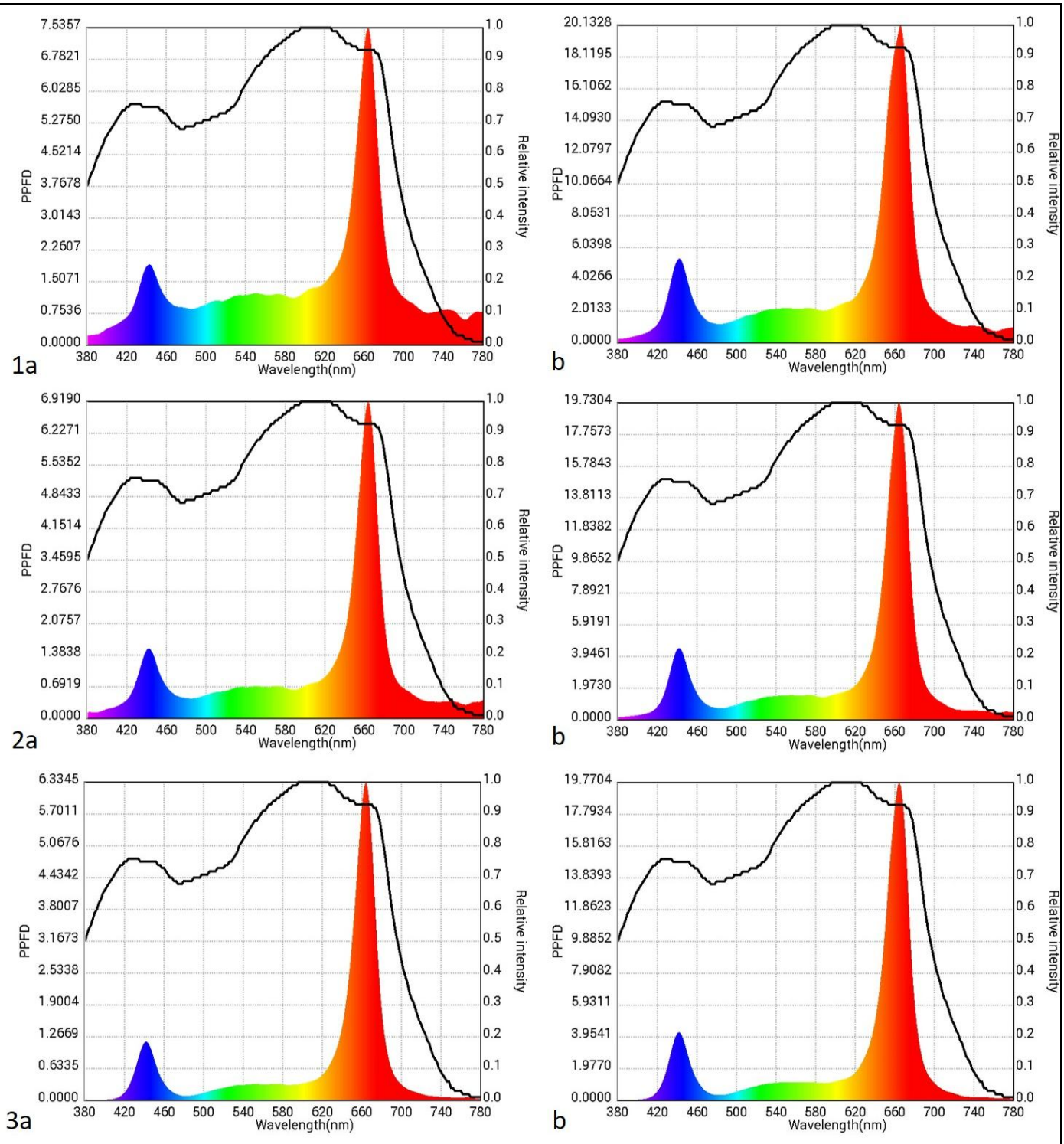
(Left) Photograph with Heliospectra E602G LED supplementary lighting; (Right) Schematic of light positioning within the glasshouse relative to the bench, plants and other light fixtures.



Supplementary Figure 11

Light spectrum measurements under a Heliospectra LX602C LED fixture in JIC glasshouses

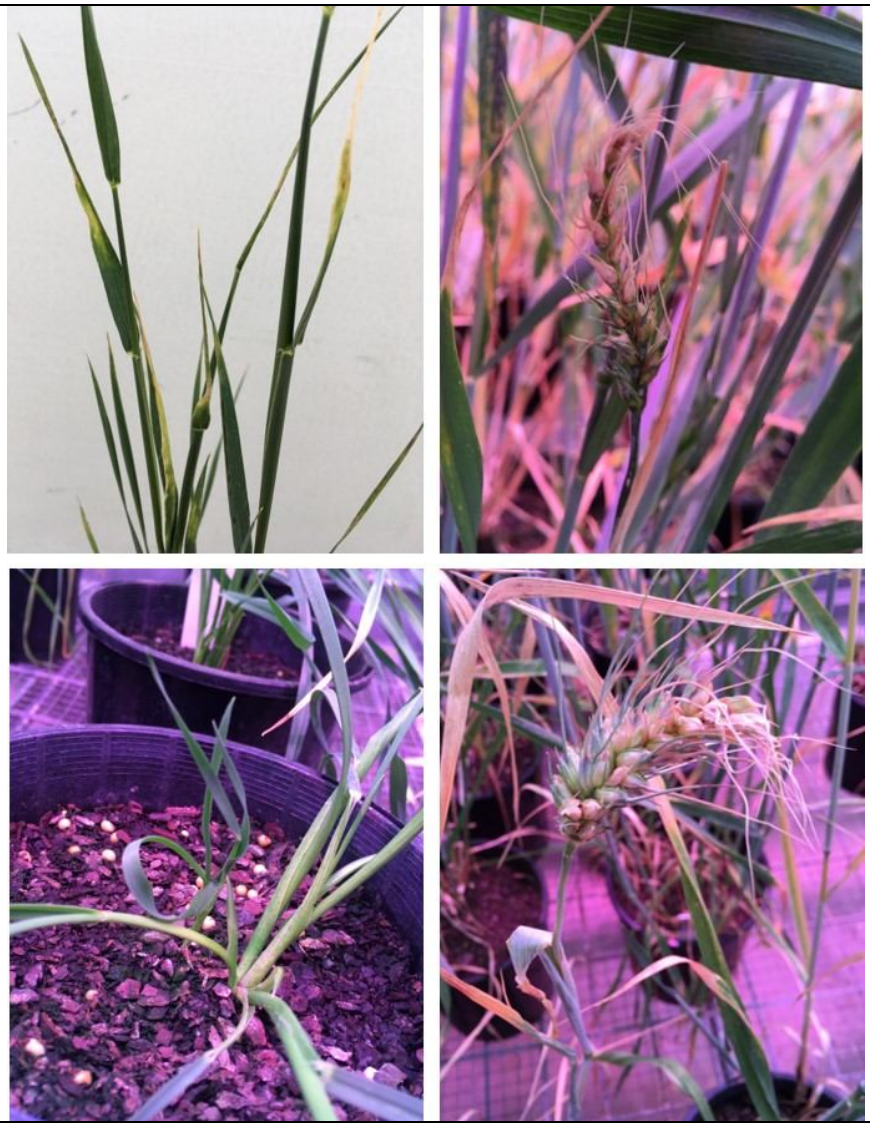
(a) Spectrum measurement in the glasshouse at bench level (244 cm from light fixture) on a clear, sunny day at 12 noon **(b)** Spectrum measurement in the glasshouse at bench level (244 cm from light fixture) on a cloudy day at 12 noon. **(c)** Spectrum measurement in the glasshouse at bench level (244 cm from light fixture) at night. The x-axis of all three graphs represents the wavelength of light in nanometres, and y-axis is the normalised spectral power distribution (Power distribution is measured in $mW \cdot m^{-2}$, and all values on y-axis are divided by the maximum value in the distribution in order to obtain normalised values). All graphs were produced from measurements made by the MK350S LED meter from UPRtek, using the uSpectrum software produced by the same manufacturer.



Supplementary Figure 12

Light spectrum measurements under a Heliospectra E602G LED fixture in the UQ glasshouse

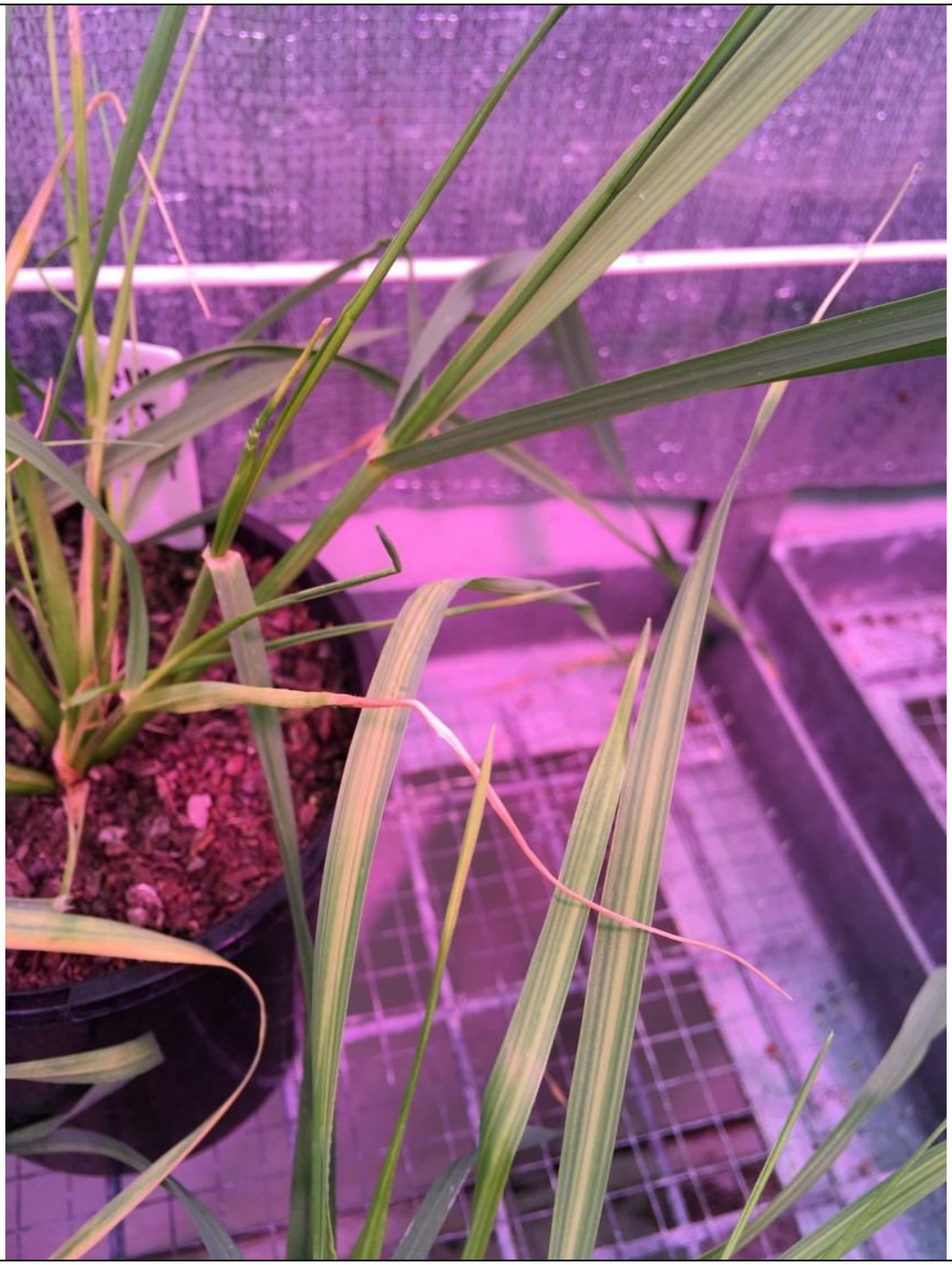
Weighted McCree action spectrum and photosynthetic photon flux density (PPFD; $\mu mol \cdot m^{-2} \cdot s^{-1}$) from under a Heliospectra E602G light using the Spectrum Genius Essence Lighting Passport light sensor and associated Spectrum Genius Agricultural Lighting app (AsenseTek Inc., Taiwan). (1) Centre measurement at 12 noon on a clear, sunny day, (2) Centre measurement at 12 noon on an overcast day and, (3) Centre measurement at night; a, bench level (155 cm from light) and b, approximate wheat spike height (95 cm from light). Figures were exported from the software.



Supplementary Figure 13

Symptoms of copper deficiency in wheat grown under speed breeding conditions

Left (top): Curling and death of young leaf tips and down the leaf blade; Left (bottom): Young leaves becoming stuck as they emerge and forming loops or curling; Right (top and bottom): Spikes wither and turn white at the tips. No seed is produced in these areas and spikes may be twisted.



Supplementary Figure 14

Symptoms of iron deficiency in wheat grown under speed breeding conditions

Young leaves appear striped with yellowing of the interveinal spaces.

Supplementary Tables

Supplementary Table 1 | **Growth rate of spring wheat (cv. Apogee) in a benchtop speed breeding cabinet.** Days to key growth stages and measurement of key growth parameters of wheat (*T. aestivum* cv. USU-Apogee) grown in a small benchtop cabinet set up for speed breeding (22-hour photoperiod with 22 °C during the photoperiod and 17 °C during the 2-hour dark period). Seeds were germinated for 4 days and sown on 22 March 2018 in 600 mL of JIC Cereal Compost Mix. Values indicated are mean ± standard deviation based on four replicates.

[1]GS11 – Emergence of first leaf (DAS)[2]	4.3 ± 0.5
GS13 – Emergence of third leaf (DAS)	13.0 ± 1.2
GS39 – Flag Leaf Emergence (DAS)	28.0 ± 0.8
GS45 – Mid-boot (DAS)	31.3 ± 1.7
GS55 – 50% ear emergence (DAS)	36.3 ± 1.3
GS59 – full ear emergence (DAS)	38.3 ± 1.3
GS65 – mid-anthesis (DAS)	40.5 ± 1.3
GS77 – Grain milk (DAS)	51.0 ± 0.0
GS85 – Grain Dough (seed harvested)[3] (DAS)	63.0 ± 0.0
No. of tillers	2.0 ± 0.0
100 seed weight (g)	2.1 ± 0.3
Germination percentage of 30 harvested seeds (%)	90.8 ± 8.8

[1] Growth stages (GS) measured for the first tiller according to the Zadoks scale (Zadoks et al., 1994).

[2] DAS, days after sowing. Seeds were stratified at 4 °C in the dark for two days and germinated at room temperature on Petri dishes for two days before being sown.

[3] Plants were subjected to seven days of water stress before seeds were harvested. Seeds were not at physiological maturity (GS90) when harvested.

Supplementary Table 2 | **Growth rate of pea (accession JI 2822) in a benchtop speed breeding cabinet.** Days to key growth stages and measurement of key growth parameters of pea (*Pisum sativum* accession JI 2822) grown in a small benchtop cabinet set up for speed breeding (22-hour photoperiod with 22 °C during the photoperiod and 17 °C during the 2-hour dark period). Seeds were scarified and sown on 22 March 2018 in pots containing 600 mL of JIC Cereal Compost Mix. Values indicated are mean ± standard deviation based on four replicates.

Epicotyl emergence from soil (DAS)[1]	6.0 ± 0.8
Appearance of scale leaves (DAS)	10.0 ± 1.4
Flower bud appearance at one or more nodes (DAS)	24.8 ± 1.3
First open flower at one or more nodes (DAS)	30.5 ± 1.3
Node number at first flower	7.3 ± 0.5
No. of side shoots	0.0 ± 0.0
Node no. at maturity	12.0 ± 0.0
Harvest DAS[2]	62.0 ± 0.0
No. of pods	3.8 ± 0.5
No. of seeds	9.8 ± 1.7
Germination percentage of harvested seed[3] (%)	97.2 ± 5.6

[1]DAS, days after sowing, with Day 1 being the day the seeds were sown.

[2]Plants were subjected to seven days of water stress (no watering) before pods were harvested. Pods were not harvested at physiological maturity, but slightly earlier.

[3]All seeds harvested were subjected to germination tests as each plant produced <30 seeds.

Supplementary Table 3 | **Components and costs of the speed breeding benchtop growth chamber.**

Qt.	Catalogue No.	Description	Unit Cost (£)	Total Cost[1] (£)	Supplier
1	B072M7P7QJ	Power Supply Unit 600 W (12 v, 50 A Constant Voltage)	28.99	28.99	Amazon
1	B00G890MIC	Power Supply 12 V to 5 V 3 A DC/DC Buck Converter Module	6.49	6.49	Amazon
1	B002M8RVKA	USB Extension Cable (30 cm)	4.69	4.69	Amazon
1	B077V421QH	Ethernet Extension Cable (30 cm)	5.99	5.99	Amazon
1	B00CGU1VOG	Arduino UNO	6.95	6.95	Amazon
3	B01M2ZBBVM	Thermoelectric Cooler (120 W power) 12 v @10A	23.99	71.97	Amazon
16	B071J3BC1W	LED Full Spectrum Grow Light	6.95	111.20	Amazon
16	E27-SD04-2	E27 Lamp Holder	0.93	14.88	Sinolec Components Ltd
1	2525225	Raspberry Pi 3 Model B	28.49	28.49	CPC-Farnell
1	2473872	Raspberry Pi Display 7" Touchscreen	51.19	51.19	CPC-Farnell
1	MK00343	Grove Temperature & Humidity Sensor Pro	11.99	11.99	CPC-Farnell
1	SC13822	Arduino Base Shield v2	8.99	8.99	CPC-Farnell
4	MK00330	Grove Relay	3.01	12.04	CPC-Farnell
1	713-103020004	Grove Solid State Relay	18.38	18.38	Mouser
6	CP027-03	White Aluminium Composite panel (757 x 307 x 3 mm)	8.59	51.54	Cut Plastics Ltd
1	CP027-03	White Aluminium Composite panel (757 x 357 x 3 mm)	9.99	9.99	Cut Plastics Ltd
1	CP027-03	White Aluminium Composite panel (757 x 107 x 3 mm)	3.00	3.00	Cut Plastics Ltd
1	CP027-03	White Aluminium Composite panel (757 x 757 x 3 mm)	21.19	21.19	Cut Plastics Ltd
2	CP015-03	Black PVC Foam Board (757 x 157 x 3 mm)	1.95	3.90	Cut Plastics Ltd

1	CP015-03	Black PVC Foam Board (757 x 141 x 3 mm) to be further cut	1.75	1.75	Cut Plastics Ltd
2	CP015-03	Black PVC Foam Board (757 x 307 x 3 mm)	3.82	7.64	Cut Plastics Ltd
1	CP001-03	Clear Perspex Acrylic Sheet (757 x 307 x 3 mm)	3.91	3.91	Cut Plastics Ltd
4	4451-900	OpenBeam – 1000 mm Long Black Anodised Beam	8.27	33.08	Technobotsonline Group Unit
13	4451-750	OpenBeam – 750 mm Long Black Anodised Beam	6.59	85.67	Technobotsonline Group Unit
10	4451-300	OpenBeam – 300 mm Long Black Anodised Beam	3.01	30.1	Technobotsonline Group Unit
4	4446-013	MakerBeam – 90 Degree Corner Bracket	0.58	2.32	Technobotsonline Group Unit
36	4450-003	OpenBeam – 'L' Joining Plate	1.87	67.32	Technobotsonline Group Unit
2	4450-004	OpenBeam – 'T' Joining Plate	1.87	3.74	Technobotsonline Group Unit

[1]Grand total cost £707.39.

Supplementary Table 4 | **UQ Compost Mix composition.** Compost mix components and fertilisers designed by Mr K. Hayes, Central Glasshouse Services, University of Queensland, Australia. The pH is balanced with either FeSO (when pH is high) or Dolomite (when pH is low).

Component Measure
Composted pine bark (0-5 mm) 70% (Fernland Agencies, Queensland, Australia)
Coco peat 30% (Fernland Agencies, Queensland, Australia)
Fertilizer
Yates Flowtrace® (Yates, Padstow, NSW, Australia) 1 kg m^{-3}
Iron sulphate heptahydrate 1 kg m^{-3} (Amgrow Specialty, New South Wales, Australia)
Superphosphate 0.4 kg m^{-3} (Swancorp, Queensland, Australia)
Copper sulphate 0.03 kg m^{-3} (Searles, Queensland, Australia)
Gypsum 1 kg m^{-3} (Qld Organics, Queensland, Australia)

Supplementary Table 5 | **JIC Cereal Compost Mix composition.** Compost supplied by Petersfield Growing (Leicester, UK).

Component	**Measure**
Medium Grade Peat (Brinkman (Horticultural Service) UK Ltd)	40%
Sterilised Soil (horticultural grade) (Petersfield Growing Mediums – Leicester, UK)	40%
Horticultural Grit (grade 3 -7mm washed grit – Composts Direct)	20%
Fertilizer	
PG Mix™ 14-16-18 + Trace Elements (TE) Base Fertiliser	1.3 kg/m³
Osmocote® Exact Mini 16-8-11+ 2MgO + TE 0.02% Boron	1.0 kg/m³
H2Gro® (Wetting Agent) from ICL Specialty Fertilizers (Ipswich, UK)	
Maglime (dolomitic limestone) (Berrycroft Horticultural Sundries)	3.0 kg/m³
Insecticide	
Exemptor® from ICL Specialty Fertilizers (Ipswich, UK)	300 g/m³

Supplementary Table 6 | JIC Peat and Sand Mix composition. Compost supplied by Petersfield Growing (Leicester, UK).

Component	**Measure**
Fine peat (Bulrush 0 -12 mm fine peat) (Brinkman (Horticultural Service) UK Ltd)	85%
Grit (grade 3 -7mm washed grit – Composts Direct)	15%
Fertilizer	
PG Mix™ 14-16-18 + Trace Elements (TE) Base Fertiliser	1.0 kg/m^3
Osmocote® Exact Mini 16-8-11 + 2MgO + TE 0.02% Boron	2.7 kg/m^3
H2Gro® **(**Wetting Agent) from ICL Specialty Fertilizers (Ipswich, UK)	
Maglime (dolomitic limestone) (Berrycroft Horticultural Sundries)	4.0 kg/m^3

Supplementary Table 7 | Sources and contact information for germplasm used in speed breeding experiments in this paper.

Crop and Cultivar	Germplasm collection/ References/ Contact information
Spring bread wheat (*Triticum aestivum*)	
-cv. Paragon	https://www.seedstor.ac.uk/ (entry number WBCDB0040)
-cv. Cadenza	https://www.seedstor.ac.uk/ (entry number W9368)
-cv. Fielder	https://www.seedstor.ac.uk/ (entry number W8354)
-cv. Suntop	commercial variety, Australian Grain Technologies
-cv. Apogee	https://www.seedstor.ac.uk/ (entry number W10285)
-cv. BR18	Embrapa Trigo, Passo Fundo, Brazil (Trigo BR18 Terena)
-cv. BRS179	Embrapa Trigo, Passo Fundo, Brazil (BRS197)
Spring durum wheat (*Triticum durum*)	
-cv. Kronos	https://www.seedstor.ac.uk/ (W10282)
Winter bread wheat (*Triticum aestivum*)	
-cv. Trinity	commercial variety, KWS UK Ltd.
-cv. Crusoe	commercial variety, Limagrain (UK) Ltd.
Spring barley (*Hordeum vulgare*)	
-cv. Nigrate	https://npgsweb.ars-grin.gov/ (entry number CIho 2444)
-cv. Manchuria	https://npgsweb.ars-grin.gov/ (entry number CIho 2330)
-cv. Golden Promise	https://www.seedstor.ac.uk/ (entry number B4015)
-cv. Baronesse	commercial variety, Nordsaat Saatzucht GmbH, Germany
-cv. Commander	commercial variety, University of Adelaide, Australia
Brachypodium distachyon	
- accession Bd21	https://npgsweb.ars-grin.gov/ (entry number W6 36678)
- accession Bd21-3	https://npgsweb.ars-grin.gov/ (entry number W6 39233)
- accession Bd3-1	https://npgsweb.ars-grin.gov/ (entry number W6 46203)
Pea (*Pisum sativum*)	
- Line JI 2822	https://www.seedstor.ac.uk/ (entry number JI2822)
- cv. Princess	https://www.seedstor.ac.uk/ (entry number JI2623)
- cv. Cameor	https://www.seedstor.ac.uk/ (entry number JI3253)
Grasspea (*Lathyrus sativus*)	
- cv. Mahateora	Released cultivar in India. Can be ordered through ICARDA or available on request from Dr. Cathie Martin at the John Innes Centre
Brassica napus	
- line RV31	Available on request from Rachel Wells, John Innes Centre, UK
Brassica rapa	
- line R-0-18	Available on request from Rachel Wells, John Innes Centre, UK
Brassica oleracea	
- line DH1012	Available on request from Rachel Wells, John Innes Centre, UK
Quinoa (*Chenopodium quinoa*)	
- accession QQ-74	https://npgsweb.ars-grin.gov/ (PI 614886)
- cv. Titicaca	commercial variety (bred by Sven-Erik Jacobsen, UK)
Oat (*A. strigosa*)	
- accession S75	Institute of Grasslands and Environmental Research, Aberystwyth, Wales, UK

Supplementary Table 8 | **Tray dimensions for single seed descent demonstration**. Specifications of the plastic cell trays used for comparison of different plant densities under speed breeding in a glasshouse with LED supplementary lighting in Queensland, Australia.

Tray type	**Volume of individual cell (mL)**	**Cell dimension (Length x Height x Width, mm)**	**Extrapolated density (plants per m^2)**
30-cell tray	100	50 x 60 x 50	300
64-cell tray	60	35 x 50 x 40	640
100-cell tray	18	25 x 45 x 30	1000

Supplementary Table 9 | **Energy consumption calculations for two kinds of lighting for SB purposes in a glasshouse in JIC.** Energy consumption information for LED-Supplemented versus Sodium Vapour Lamp-supplemented glasshouses at the John Innes Centre, UK. The values indicated are for the same glasshouses, with the Sodium Vapour Lamps being tested in December 2016, and the LED Lamps being tested in December 2017. Values indicated are the average per metre square in a 30-day cycle.

	LED lamps (25 x 600 W fittings)		**Sodium Vapour Lamps (40 x 440 W fittings)**	
	22 h	**16 h**	**22 h**	**16 h**
Lighting energy requirements (kWh/m^2)	4.97	3.61	5.83	4.24

Supplementary Table 10 | **Growth rate of spring bread wheat (cv. Suntop) in SSD trays in the LED-supplemented glasshouse setup at UQ.** Development stages of spring wheat (*T. aestivum* cv. Suntop) under speed breeding at three plant densities in a glasshouse with LED supplementary lighting in Queensland, Australia. Sown on 3 February, 2018. Values are expressed as mean days after sowing[1] ± standard deviation based on three replicates.

Developmental stage	30-cell tray (100 mL)	64-cell tray (60 mL)	100-cell tray (18 mL)
1st leaf (GS11)[2]	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0
3rd leaf (GS13)	10.7 ± 0.5	11.0 ± 0.0	11.0 ± 0.0
Elongation (GS39)	22.0 ± 0.0	21.3 ± 0.5	21.7 ± 0.5
Anthesis (GS65)	31.3 ± 1.2	30.0 ± 0.0	31.0 ± 0.0

[1] Seeds were pre-germinated prior to sowing.

[2] GS = growth stage from Zadoks et al. (1974).

Supplementary Table 11 | **Characteristics of harvested spring bread wheat (cv. Suntop) grown in SSD trays in the LED-supplemented glasshouse setup at UQ.** Plant height, spike number per plant, seed number per plant, spike weight per plant, single seed weight and germination percentage of immature and mature seed of spring wheat (*T. aestivum* cv. Suntop) under speed breeding at three plant densities in a glasshouse with LED supplementary lighting in Queensland, Australia. Sown on 3 February 2018. Values expressed as mean days after sowing[1] ± standard deviation based on three replicates.

Trait	30-cell tray (100 mL)	64-cell tray (60 mL)	100-cell tray (18 mL)
Plant height (cm)	65.5 ± 1.4	62.4 ± 2.4	58.1 ± 2.9
Spike number per plant	1.6 ± 0.0	1.0 ± 0.0	1.0 ± 0.0
Seed number per spike	22.7 ± 2.1	18.6 ± 2.3	12.3 ± 1.4
Spike weight per plant (g)	2.5 ± 0.2	1.2 ± 0.2	0.7 ± 0.0
Single seed weight (mg)	43.3 ± 0.9	47.9 ± 2.1	39.6 ± 0.7
Immature[1] germination[2] (%)	93.9 ± 5.4	77.2 ± 14.2	87.9 ± 1.4
Mature[3] germination (%)	99.1 ± 1.6	100.0 ± 0.0	100.0 ± 0.0

[1] Harvested 14 days post-anthesis (all plants in the case of trays).

[2] After 5 days at 35°C, seeds underwent 1 day of imbibition at room temperature followed by 4 days at 4°C after which they were moved to room temperature for germination.

[3] Maturity was when all green colouration had been lost from the peduncle.

Supplementary Table 12 | Growth rate of spring barley (cv. Commander) in SSD trays in the LED-supplemented glasshouse setup at UQ. Development stages of spring barley (*H. vulgare* cv. Commander) under speed breeding at three plant densities in a glasshouse with LED supplementary lighting in Queensland, Australia. Sown on 3 February, 2018. Values expressed as mean days after sowing[1] ± standard deviation based on three replicates.

Developmental stage	30-cell tray (100 mL)	64-cell tray (60 mL)	100-cell tray (18 mL)
1st leaf (GS11)[2]	7.7 ± 0.5	7.3 ± 0.5	7.0 ± 0.0
3rd leaf (GS13)	14.0 ± 0.0	13.3 ± 0.5	13.7 ± 0.5
Elongation (GS39)	22.0 ± 0.0	19.7 ± 0.5	20.3 ± 0.5
Awn peep (GS49)	27.3 ± 2.1	24.7 ± 0.5	24.0 ± 1.0

[1] Seeds were pre-germinated prior to sowing.

[2] GS, growth stage from Zadoks et al. (1974).

Supplementary Table 13 | Characteristics of harvested spring barley (cv. Commander) grown in SSD trays in the LED-supplemented glasshouse setup at UQ. Plant height, spike number per plant, seed number per plant, spike weight per plant, single seed weight and germination percentage of immature and mature seed of spring barley (*H. vulgare* cv. Commander) under speed breeding at three plant densities in a glasshouse with LED supplementary lighting in Queensland, Australia. Sown on 3 February, 2018. Values expressed as mean days after sowing[1] ± standard deviation based on three replicates.

Trait	30-cell tray (100 mL)	64-cell tray (60 mL)	100-cell tray (18 mL)
Plant height (cm)	53.1 ± 1.0	51.9 ± 3.3	47.5 ± 4.0
Spike number per plant	2.5 ± 0.3	2.4 ± 0.2	1.7 ± 0.5
Seed number per spike	9.8 ± 0.9	10.0 ± 0.5	6.2 ± 1.7
Spike weight per plant (g)	1.2 ± 0.0	1.1 ± 0.0	0.4 ± 0.0
Single seed weight (mg)	44.8 ± 3.5	41.1 ± 4.0	40.0 ± 7.8
Immature[1] germination[2] (%)	46.2 ± 27.9	37.6 ± 13.5	32.4 ± 19.9
Mature[3] germination (%)	97.8 ± 3.8	98.8 ± 2.1	95.6 ± 1.7

[1] Harvested 21 days post-awn peep (all plants in the case of trays).

[2] After 5 days at 35°C, seeds underwent 1 day of imbibition at room temperature followed by 4 days at 4°C after which they were moved to room temperature for germination. Seeds were bulked for germination testing.

[3] Maturity was when all green colouration had been lost from the peduncle.

Supplementary Table 14 | **PPFD measurements for the LED-supplemented glasshouse setup at JIC.** Photosynthetic photon flux density (PPFD; µmol m^{-2} s^{-1}) measured at a central location in the LED-supplemented glasshouses (GH) at John Innes Centre, UK, using the UPRTek MK350S spectrometer and associated uSpectrum software (UPRTek, Taiwan). Values are the mean of five measurements ± the standard deviation taken in a metre square area under a light fixture.

Position	Day (12 noon) - Sunny	Day (12 noon) – Overcast	Night
Pot height[1]	320.4 ± 9.6	311.3 ± 33.6	222.7 ± 15.9
Sensor height[2]	341.5 ± 14.6	334.7 ± 28.0	244.4 ± 19.8

[1] Pot height was 228 cm from the light fixture.

[2] Sensor height was taken as 100 cm from the bench level, or 144 cm from light fixture.

Supplementary Table 15 | **PPFD measurements for the LED-supplemented glasshouse setup at UQ.** Photosynthetic photon flux density (PPFD; µmol m^{-2} s^{-1}) measured under a Heliospectra E602G light using the Spectrum Genius Essence Lighting Passport light sensor and associated Spectrum Genius Agricultural Lighting app (AsenseTek Inc., Taiwan). Values indicated are the mean ± standard deviation based on five measurements at the corner and centre of a 1 m^2 area under a light fixture at a central location in the glasshouse.

Position	Day (12 pm) - Sunny	Day (12 pm) – Overcast	Night
Bench height[1]	956.5 ± 185.0	356.8 ± 16.5	253.9 ± 12.7
Spike height[2]	972.6 ± 126.4	753.4 ± 92.6	701.7 ± 56.8

[1] Bench height was 155 cm from the light fixture.

[2] Spike height was taken as 95 cm from the light fixture, representing the approximate height of an adult wheat plant.

Supplementary Table 16 | Growth rate of spring wheat (cvs. Fielder and Cadenza) in the LED-supplemented glasshouse setup at JIC. Days to key growth stages of wheat (*Triticum aestivum* cvs. Fielder and Cadenza) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 directly into 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean days after sowing (DAS)[1] ± standard deviation based on six replicates.

	***T. aestivum* cv. Fielder**		***T. aestivum* cv. Cadenza**	
Development stage[1,2]	**22 h**	**16 h**	**22 h**	**16 h**
3rd leaf	10.0 ± 0.0	15.5 ± 1.2	9.0 ± 0.0	14.0 ± 0.0
GS31[3]	31.1 ± 0.5	38.8 ± 1.3	23.7 ± 0.5	33.7 ± 1.2
Flag leaf	31.4 ± 0.5	42.0 ± 0.0	27.3 ± 0.5	52.5 ± 1.8
Head (GS51)	42.1 ± 0.3	55.1 ± 1.9	42.0 ± 0.0	57.0 ± 0.6
Anthesis	49.2± 1.5	64.9 ± 1.8	49.5 ± 1.5	65.3 ± 2.4
Mature seed harvest	96.5 ± 0.0	104.0 ± 0.0	92.5 ± 0.0	111.0 ± 0.0
Height (cm)	83.6 ± 2.7	93.8 ± 4.3	73.7 ± 0.7	78.8 ± 3.5

[1] DAS refers to the number of days (post-transfer of germinated seedlings) to reach the indicated developmental growth stages.

[2] All measurements are with respect to the main tiller.

[3] Growth stages measured according to Zadok's scale.

NOTE: Plants were phenotyped every 3-5 days. This may cause whatever differences there might be between replicates or varieties to even out at the time of measurement.

Supplementary Table 17 | **Seed germination rates of harvested spring wheat (cvs. Fielder and Cadenza) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of 30 seeds harvested at physiological maturity from wheat (*Triticum aestivum* cvs. Fielder and Cadenza) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Values indicated are mean ± standard deviation based on 3 replicates of 30 seeds under each photoperiod condition. All seeds were kept at 4°C for 2 days prior the germination.

Cultivar	**Fielder**		**Cadenza**	
	16 h	**22 h**	**16 h**	**22 h**
Germination Percentage (%)	100.0 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0

Supplementary Table 18 | **Growth rate of Brazilian spring wheat (cvs. BRS179 and BR18) in the LED-supplemented glasshouse setup at JIC.** Measurement of key growth stages and growth and development parameters for Brazilian spring wheat (*T. aestivum* cvs. BRS179 and BR18) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 15 November 2017 directly into 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean ± standard deviation based on 9-10 replicates.

***T. aestivum* cultivar**	**Mean days to anthesis**		**Mean plant height (cm)**		**Mean tiller number**		**Harvest window[1,2]**		**Mean grain yield (g)**	
	22 h[1]	**16 h[1]**	**22 h**	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
BRS179	50.0 ± 0.0	64.9 ± 4.7	102.2 ± 7.2	89.8 ± 6.9	6.2 ± 0.4	7.8 ± 1.5	87.0	119.0	8.2 ± 0.6	14.0 ± 2.4
BR18	43.0 ± 0.0	55.4 ± 0.5	75.3 ± 7.4	79.4± 4.3	6.9 ± 1.6	7.9 ± 0.8	87.0	119.0	8.9 ± 1.7	11.6 ± 2.3

[1]Days calculated from date of sowing.

[2]Material was harvested at physiological maturity. Plants were dried at 30°C for 7 days prior to weighing.

Supplementary Table 19 | Seed germination rates of harvested Brazilian spring wheat (cvs. BRS179 and BR18) grown in the LED-supplemented glasshouse setup at JIC. Seed viability demonstrated through germination percentages of seed harvested at physiological maturity from two cultivars of rapid-cycling Brazilian wheat (*T. aestivum* cvs. BRS179 and BR18) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. All plants were harvested when the ears on individual plants were drying and most ears had turned brown. Plants were dried at 35°C for 7 days post-harvest. Germination tests were conducted with five replicate Petri dishes with 29-34 seeds per dish. After wetting, seeds were kept for 24 hours at 4°C then moved to 22°C. Germination was assessed after 72 hours at 22°C. Values indicated are mean ± standard deviation.

	BRS179		**BR18**	
	22 h	**16 h**	**22 h**	**16 h**
Germination percentage (%)	100 ± 0.0	100 ± 0.0	100 ± 0.0	100 ± 0.0

Supplementary Table 20 | Growth rate of spring durum (cv. Kronos) and bread wheat (cvs. Paragon and Cadenza) in the LED-supplemented glasshouse setup at JIC. Days to key growth stages and measurement of key growth parameters of spring growth habit durum wheat (*T. durum* cv. Kronos) and bread wheat (*T. aestivum* cvs. Paragon and Cadenza) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were germinated for 5 days before pricking out on 3 November 2017 into 100 mL of JIC Peat and Sand Mix. The seedlings were then grown under a 16 h photoperiod for three weeks after which they were transferred to 1 L pots of JIC Cereal Compost Mix and kept under the respective photoperiod treatments. Values indicated are mean ± standard deviation based on six replicates.

	Kronos		**Paragon**		**Cadenza**	
Variable	**22 h**	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Days to GS31[1]	30.0 ± 1.2	37.0 ± 0.6	31.0 ± 0.6	39.0 ± 0.7	34.7 ± 1.2	42.0 ± 0.9
Days to GS55	46.0 ± 1.9	53.7 ± 1.0	48.2 ± 0.4	61.8 ± 0.8	50.5 ± 0.6	62.8 ± 0.8
Early harvest	64.0 ± 0.0	72.0 ± 0.0	66.0 ± 0.0	80.0 ± 0.0	69.0 ± 0.0	81.0 ± 0.0
Days to GS90 (late harvest)	94.0 ± 0.0	112.0 ± 0.0	94.0 ± 0.0	112.0 ± 0.0	98.0 ± 0.0	116.0 ± 0.0
Height	68.0 ± 4.4	68.9 ± 1.9	85.1 ± 3.2	86.4 ± 2.6	82.6 ± 2.2	83.9 ± 3.0
Tiller No.	5.8 ± 1.9	6.8 ± 1.0	5.5 ± 0.6	4.6 ± 0.6	5.0 ± 0.6	4.8 ± 0.8

[1]Days calculated from the time seeds were put into germination.

Supplementary Table 21 | **Spike characteristics of harvested spring durum (cv. Kronos) and bread wheat (cvs. Paragon and Cadenza) grown in the LED-supplemented glasshouse setup at JIC.**

Measurement of key characteristics of spikes harvested early (Spike_1) and at maturity (Spike_2) of spring growth habit durum wheat (*T. durum* cv. Kronos) and bread wheat (*T. aestivum* cvs. Paragon and Cadenza) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were germinated for 5 days before being pricked out on 3 November 2017 into 100 mL of JIC Peat and Sand Mix. The seedlings were then grown under a 16 h photoperiod for three weeks after which they were transferred to 1 L pots of JIC Cereal Compost Mix and kept under the respective photoperiod treatments. Values indicated are mean ± standard deviation based on six replicates.

	Kronos		**Paragon**		**Cadenza**	
Variable[1]	**22 h**	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Seeds per Spike_1	27.8 ± 7.9	29.8 ± 4.3	63.7 ± 7.8	63.8 ± 4.2	64.0 ± 2.7	65.5 ± 10.0
Seeds per Spike_2	30.4 ± 4.5	33.8 ± 5.9	59.0 ± 7.6	63.8 ± 6.8	58.0 ± 6.8	68.3 ± 7.8
Yield per Spike_1 (g)	0.4 ± 0.2	0.3 ± 0.1	1.4 ± 0.2	1.1 ± 0.1	1.0 ± 0.2	0.6 ± 0.2
Yield per Spike_2 (g)	1.9 ± 0.3	2.1 ± 0.4	2.9 ± 0.4	3.3 ± 0.5	3.0 ± 0.3	3.6 ± 0.6
TGW_1[2] **(g)**	12.6 ± 5.5	8.3 ± 2.1	21.4 ± 1.7	16.5 ± 2.2	15.2 ± 2.2	8.8 ± 2.1
TGW_2 (g)	62.2 ± 5.0	62.9 ± 3.1	49.1 ± 3.6	51.2 ± 2.9	51.9 ± 4.4	52.2 ± 3.4

[1] The suffixes "_1" and "_2" indicate early and late harvest (GS90), respectively.

[2] TGW – Thousand Grain Weight.

Supplementary Table 22 | **Seed germination rates of harvested spring durum (cv. Kronos) and bread wheat (cvs. Paragon and Cadenza) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of 20 seeds harvested at 18 days post-heading (Early Harvest) and at maturity (Late Harvest) from spring growth habit durum wheat (*Triticum durum* cv. Kronos*)* and bread wheat *(Triticum aestivum* cvs*.* Cadenza, Paragon,) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Values indicated are percentage mean ± standard deviation based on 4 replicates of 20 seeds under each photoperiod condition. All seeds were sown at 4°C for 3 days and scored for germination after a further 3 days at room temperature.

Cultivar	**Early Harvest (germination %)**		**Late Harvest (germination %)**	
	16 h	**22 h**	**16 h**	**22 h**
Kronos	88.8 ± 0.1	97.5 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
Paragon	98.8 ± 0.0	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0
Cadenza	98.8 ± 0.0	97.5 ± 0.1	100.0 ± 0.0	100.0 ± 0.0

Supplementary Table 23 | **Growth rate of spring durum (cv. Kronos) and bread wheat (cv. Cadenza) in SSD trays in the LED-supplemented glasshouse setup at JIC.** Days to key growth stages and measurement of key growth parameters of spring growth habit tetraploid wheat (*Triticum durum* cv. Kronos) and hexaploid wheat (*Triticum aestivum* cv. Cadenza) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK in 96-well trays (SSD system). Seeds were germinated for 5 days before transferring on 7 November 2017 into 96-well trays (each cell containing 75 mL of JIC Cereal Compost Mix). The seedlings were grown under a 16-hour photoperiod for 10 days after which the trays were transferred to the respective photoperiod treatments. Values indicated for the growth stages are a visual mean value across the tray. When indicated as mean ± standard deviation, values are based on 25 sampled spikes across the tray (excluding edge plants).

	SSD Cadenza		**SSD Kronos**	
	22 h	**16 h**	**22 h**	**16 h**
Days to GS31	32.0	40.0	28.0	34.0
Days to GS55	45.0	58.0	42.0	50.0
Harvest at 14 PA	63.0	76.0	60.0	68.0
Days to GS90	90.0	112.0	79.0	97.0
Seeds per Spike_1[1]	32.1 ± 3.4	27.5 ± 6.1	18.4 ± 4.5	15.4 ± 5.01
Seeds per Spike_2	30.8 ± 3.8	30.7 ± 5.1	18.8 ± 5.3	17.4 ± 3.9
Yield per Spike_1 (g)	0.44 ± 0.1	0.3 ± 0.1	0.3 ± 0.1	0.1 ± 0.1
Yield per Spike_2 (g)	1.4 ± 0.2	1.7 ± 0.4	0.9 ± 0.2	1.0 ± 0.2
TGW_1[2] **(g)**	13.5 ± 1.8	9.0 ± 2.9	13.6 ± 2.6	8.9 ± 1.3
TGW_2 (g)	45.3 ± 4.7	54.0 ± 8.1	50.2 ± 7.4	58.7 ± 5.2

[1] The suffixes "_1" and "_2" indicate early and late harvest (GS90), respectively.

[2] TGW – Thousand Grain Weight.

Supplementary Table 24 | **Seed germination rates of harvested spring durum (cv. Kronos) and bread wheat (cv. Cadenza) grown in SSD trays in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of 20 seeds harvested at 18 days post-heading (Early Harvest) and at maturity (Late Harvest) from durum wheat (*Triticum durum* cv. Kronos*)* and bread wheat *(Triticum aestivum* cv. Cadenza) grown as SSD under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Values indicated are mean ± standard deviation based on 5 replicates of 20 seeds under each photoperiod condition. All seeds were sown at 4°C for 3 days and scored for germination after a further 3 days at room temperature.

T. aestivum **cultivar**	**Early Harvest (%)**		**Late Harvest (%)**	
	16 h	**22 h**	**16 h**	**22 h**
Kronos	100.0 ± 0.0	97.6 ± 0.1	100.0 ± 0.0	100.0 ± 0.0
Cadenza	93.1 ± 0.1	100.0 ± 0.0	100.0 ± 0.0	100.0 ± 0.0

Supplementary Table 25 | **Growth rate of winter bread wheat (cvs. Crusoe and KWS Trinity) in the LED-supplemented glasshouse setup at JIC.** Days to key growth stages and measurement of key growth parameters of winter growth habit bread wheat (*T. aestivum* cvs. Crusoe and KWS Trinity) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were germinated for five days before being pricked out on 20 September, 2017 into 100 mL of JIC Peat and Sand Mix. The seedlings were grown under a 16-hour photoperiod for 12 days after which they were vernalised for 8 weeks (8-hour photoperiod, 6 °C). Seedlings were then transferred to 1 L pots of JIC Cereal Compost Mix and kept under the respective photoperiod treatments. Values indicated are mean ± standard deviation based on six replicates.

	Crusoe		**KWS Trinity**	
Variable	**22 h**	**16 h**	**22 h**	**16 h**
Days to GS31[1,2]	90.2 ± 0.5	94.0 ± 0.0	87.2 ± 0.8	92.3 ± 0.8
Days to GS55	106.6 ± 1.5	114.0 ± 0.7	104.2 ± 0.8	116.7 ± 0.8
Height	58.5 ± 4.3	57.1 ± 2.1	68.1 ± 3.4	55.5 ± 2.3
Tiller No.	6.2 ± 0.5	6.6 ± 0.6	4.7 ± 0.5	5.2 ± 0.4
Days to GS90	159.0 ± 0.0	168.0 ± 0.0	154.0 ± 0.0	170.0 ± 0.0

[1] Days were counted from the time germinated seeds were sown. Germination took five days (including three days of cold stratification at 4 °C to break dormancy).

[2] All measurements are made with respect to the first tiller, and in accordance with the Zadoks scale (Zadoks et al., 1974).

Supplementary Table 26 | Spike characteristics of harvested winter bread wheat (cvs. Crusoe and KWS Trinity) grown in the LED-supplemented glasshouse setup at JIC. Measurement of key characteristics of spikes harvested early (Spike_1) and at maturity (Spike_2) from winter growth habit bread wheat (*T. aestivum* cvs. Crusoe and KWS Trinity) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were germinated for five days before being pricked out on 20 September, 2017 into 100 mL of JIC Peat and Sand Mix. Seedlings were then grown under a 16-hour photoperiod for 12 days after which they were vernalised for 8 weeks (8-hour photoperiod, 6 °C). Seedlings were then transferred to 1 L pots of JIC Cereal Compost Mix and kept under the respective photoperiod treatments. Values indicated are mean ± standard deviation based on six replicates.

	Crusoe		**KWS Trinity**	
Variable[1]	**22 h**	**16 h**	**22 h**	**16 h**
Seeds per Spike_1	52.2 ± 11.3	65.0 ± 2.4	72.5 ± 5.8	73.5 ± 6.9
Seeds per Spike_2	44.2 ± 3.8	54.2 ± 6.7	62.5 ± 3.9	62.3 ± 7.0
Yield per Spike_1 (g)	0.8 ± 0.2	0.8 ± 0.1	1.1 ± 0.2	0.8 ± 0.1
Yield per Spike_2 (g)	2.4 ± 0.1	2.5 ± 0.4	3.3 ± 0.2	3.3 ± 0.4
TGW_1[2] **(g)**	16.0 ± 3.8	11.6 ± 1.1	15.1 ± 2.4	10.3 ± 1.6
TGW_2 (g)	53.8 ± 4.5	46.1 ± 2.7	52.1 ± 3.8	52.8 ± 3.2

[1] The suffixes "_1" and "_2" indicate early and late harvest (GS90), respectively.

[2] TGW – Thousand Grain Weight.

Supplementary Table 27 | **Seed germination rates of harvested winter bread wheat (cvs. Crusoe and KWS Trinity) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of 20 seeds harvested at 18 days post-heading (Early Harvest) and at maturity (Late Harvest) from winter growth habit bread wheat *(Triticum aestivum* cvs. KWS Trinity and Crusoe) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Values indicated are percentage mean ± standard deviation based on 4 replicates of 20 seeds under each photoperiod condition. All seeds were sown at 4°C for 3 days and scored for germination after a further 3 days at room temperature.

Cultivar	**Early Harvest (germination %)**		**Late Harvest (germination %)**	
	16 h	**22 h**	**16 h**	**22 h**
Crusoe	97.5 ± 0.01	85.0 ± 0.1	100.0 ± 0.0	100.0 ± 0.0
KWS Trinity	87.5 ± 0.1	95.0 ± 0.1	100.0 ± 0.0	100.0 ± 0.0

Supplementary Table 28 | Growth rate of spring barley (cvs. Golden Promise, Manchuria, Nigrate and Baronesse) in the LED-supplemented glasshouse setup at JIC. Days to key growth stages of barley (*Hordeum vulgare* cvs. Golden Promise, Manchuria, Nigrate and Baronesse) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were directly sown on 25 October, 2017 in 1 L pots of JIC Cereal Compost Mix. Values indicated are mean days after sowing (DAS)[1] ± standard deviation based on five replicates.

Development stage[1]	***H. vulgare* cv. Golden Promise**		***H. vulgare* cv. Manchuria**		***H. vulgare* cv. Nigrate**		***H. vulgare* cv. Baronesse**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
1st leaf[2]	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0	5.0 ± 0.0
3rd leaf	12.0 ± 0.0	12.0 ± 0.0	12.0 ± 0.0	19.0 ± 0.0	12.0 ± 0.0	19.0 ± 0.0	12.0 ± 0.0	12.0 ± 0.0
1st node	20.0 ± 0.0	20.0 ± 0.0	17.0 ± 0.0	20.0 ± 0.0	20.0 ± 0.0	24.0 ± 0.0	20.0 ± 0.0	20.0 ± 0.0
Flag leaf	29.8 ± 3.8	38.0 ± 0.0	24.0 ± 0.0	34.0 ± 0.0	48.0 ± 4.2	59.8 ± 4.6	28.6 ± 0.9	39.2 ± 1.6
Emergence of awns	36.4 ± 2.2	42.8 ± 1.6	27.0 ± 0.0	38.0 ± 0.0	58.4± 10.1	64.4 ± 4.0	31.6 ± 0.9	41.0 ± 0.0
Grain milk	55.6 ± 2.2	63.8 ± 1.6	48.0 ± 0.0	59.0 ± 0.0	79.6 ± 11.8	84.0 ± 2.1	52.0 ± 2.2	63.8 ± 1.1
Early Harvest (viable seed collection)	ND[3]	70.8 ± 1.6	ND[3]	64.0 ± 0.0	ND[3]	84.0 ± 0.0	ND[3]	71.2 ± 1.6
Mature Seed Harvest	71.0 ± 0.0	82.0 ± 0.0	63.0 ± 0.0	77.0 ± 0.0	85.0 ± 0.0	97.0 ± 0.0	71.0 ± 0.0	82.0 ± 0.0

[1] DAS refers to the number of days (post seed sowing) to reach the indicated developmental growth stages. Seeds were sown directly in Cereal mix contained in 1 L pots.

[2] All measurements are with respect to the main tiller.

[3] Not determined.

Supplementary Table 29 | **Characteristics of harvested spring barley (cvs. Golden Promise, Manchuria, Nigrate and Baronesse) grown in the LED-supplemented glasshouse setup at JIC.** Number of spikes per plant, grains per spike, 100-grain weight per plant of spikes and seeds harvested at physiological maturity from barley (*Hordeum vulgare* cvs. Golden Promise, Manchuria, Nigrate and Baronesse) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 25 October 2017 directly into 1 L pots of JIC Cereal Compost Mix. Values indicated are mean ± standard deviation based on five replicates.

***H. vulgare* cultivar**	**Spikes per plant**		**Grain per spike**		**100-grain weight (g)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Golden Promise	14.6 ± 2.6	24.4 ± 3.6	22.2 ± 1.3	24.4 ± 1.5	4.5 ± 0.6	3.9 ± 0.4
Manchuria	8.0 ± 1.6	8.4 ± 1.8	32.6 ± 2.6	52.0 ± 2.6	4.1 ± 0.3	4.1 ± 0.6
Nigrate	12.8 ± 4.3	9.0 ± 2.1	53.6 ± 2.9	62.0 ± 4.7	2.5 ± 0.1	2.8 ± 0.1
Baronesse	14.4 ± 2.5	20.6 ± 5.3	19.4 ± 1.5	22.8 ± 0.8	5.2 ± 0.6	5.2 ± 0.5

Supplementary Table 30 | **Seed germination rates of harvested spring barley (cvs. Golden Promise, Manchuria, Nigrate and Baronesse) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of 60 seeds harvested early (14 days post anthesis) and at maturity from barley (*Hordeum vulgare* cvs. Golden Promise, Manchuria, Nigrate and Baronesse) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 25 October 2017 directly into 1 L pots of JIC Cereal Compost Mix. Values indicated are mean ± standard deviation based on five replicates.

***H. vulgare* cultivar**	**Germination percentage (%)**		
	16 h Early	**16 h Mature**	**22 h Mature**
Golden Promise	58.7 ± 21.5	86.0 ± 4.5	97.0 ± 1.8
Manchuria	85.0 ± 4.6	84.7 ± 8.9	88.3 ± 8.4
Nigrate	95.7 ± 2.3	96.9 ± 2.7	93.0 ± 7.4
Baronesse	95.7 ± 5.2	96.0 ± 3.4	90.0 ± 2.9

Supplementary Table 31 | **Growth rate of *Brassica rapa* (line R-0-18), *B. napus* (line RV31) and *B. olerecea* (line DH1012) in the LED-supplemented glasshouse setup at JIC.** Days to key growth stages and measurement of key growth parameters of *Brassica rapa* (line R-0-18), *B. napus* (line RV31) and *B. olerecea* (line DH1012) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 in 100 mL of Levington® Advance F2 Seed and Modular Compost (ICL Specialty Fertilizers) and grown in a 16-hour photoperiod for seven days, and thereafter transferred to 1 L pots of JIC Cereal Compost Mix and placed in the respective photoperiod conditions. Values indicated are mean ± standard deviation based on 12 replicates.

	***B. rapa* (R-0-18)**		***B. oleracea* (DH1012)**		***B. napus* (RV31)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Days till first flower opens	36.5 ± 2.5	41.0 ± 3.7	49.2 ± 1.8	61.2 ± 2.3	34.5 ± 0.7	45.0 ± 0.0
Flowering duration	20.5 ± 2.5	66.0 ± 3.7	41.8 ± 1.8	85.8 ± 2.3	22.5 ± 0.7	62.0 ± 0.0
Days till drying off, first pods on main raceme can be harvested[1]	91	112	128	169	91	109
Time to harvest[1]	112	120	155	189	113	123

[1] Batch treated.

Supplementary Table 32 | **Characteristics of harvested *Brassica rapa* (line R-0-18), *B. napus* (line RV31) and *B. olerecea* (line DH1012) grown in the LED-supplemented glasshouse setup at JIC.** Measurement of key parameters of mature plants of *B. rapa* (line R-0-18), *B. napus* (line RV31) and *B. oleracea* (line DH1012) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 in 100 mL of Levington® Advance F2 Seed and Modular Compost (ICL Specialty Fertilizers) and grown in a 16-hour photoperiod for seven days, and thereafter transferred to 1 L pots of JIC Cereal Compost Mix and placed in the respective photoperiod conditions. Values indicated are mean ± standard deviation based on 12 replicates.

	***B. rapa* (R-0-18)**		***B. oleracea* (1012)**		***B. napus* (RV31)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Number of branches bearing fertile pods	5.2 ± 1.2	3.8 ± 0.7	5.5 ± 0.8	6.0 ± 1.3	5.5 ± 0.8	6.0 ± 1.3
Number of later branches not producing fertile pods	1 ± 0.7	0.3 ± 0.9	0.8 ± 0.9	0.1 ± 0.3	0.8 ± 0.9	0.1 ± 0.3
Number of non-branching nodes	3.0 ± 1.0	5.8 ± 1.3	3.2 ± 0.7	6.3 ± 1.5	3.2 ± 0.7	6.3 ± 1.5
Plant height (m)	1.4 ± 0.1	1.4 ± 0.2	1.1 ± 0.2	1.6 ± 0.1	1.1 ± 0.2	1.6 ± 0.1

Supplementary Table 33 | **Characteristics of pods harvested from *Brassica rapa* (line R-0-18), *B. napus* (line RV31) and *B. olererecea* (line DH1012) grown in the LED-supplemented glasshouse setup at JIC.** Measurement of key post-harvest parameters of mature plants of *Brassica rapa* (line R-0-18), *Brassica napus* (line RV31) and *Brassica oleracea* (line DH1012) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 in 100 mL of Levington® Advance F2 Seed and Modular Compost (ICL Specialty Fertilizers) and grown in a 16-hour photoperiod for seven days, and thereafter transferred to 1 L pots of JIC Cereal Compost Mix and placed in the respective photoperiod conditions. Values indicated are mean ± standard deviation based on 12 replicates.

	***B. rapa* (R-0-18)**		***B. oleracea (1012)***		***B. napus* (RV31)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Length of beak (remains of stigma) (mm)	20.9 ± 5.0	34.0 ± 3.6	2.4 ± 0.6	2.9 ± 0.7	7.9 ± 1.8	11.7 ± 2.0
pod valve length (mm)	35.2 ± 7.8	47.8 ± 4.2	30.5 ± 5.8	42.6 ± 6.0	43.5 ± 12.7	59.7 ± 8.5
Total pod length (valve plus beak) (mm)	56.0 ± 11.4	81.8 ± 6.4	32.9 ± 6.0	45.5 ± 6.2	51.4 ± 13.7	71.4 ± 9.4

Supplementary Table 34 | **Seed characteristics of harvested *Brassica rapa* (line R-0-18), *B. napus* (line RV31) and *B. olerecea* (line DH1012) grown in the LED-supplemented glasshouse setup at JIC.** Measurement of key post-harvest seed parameters harvested from earliest set pods of mature plants of *B. rapa* (line R-0-18), *B. napus* (line RV31) and *B. oleracea* (line DH1012) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 in 100 mL of Levington® Advance F2 Seed and Modular Compost (ICL Specialty Fertilizers) and grown in a 16-hour photoperiod for seven days, and thereafter transferred to 1 L pots of JIC Cereal Compost Mix and placed in the respective photoperiod conditions. Values indicated are mean ± standard deviation based on 12 replicates.

	***B. rapa* (line R-0-18)**		***B. oleracea* (line DH1012)**		***B. napus* (line RV31)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Seeds per pod	10.3 ± 3.1	32.3 ± 3.5	3.9 ± 1.0	7.3 ± 2.0	8.3 ± 3.9	24.0 ± 2.9
Thousand grain weight (g)	3.0 ± 0.5	4.5 ± 0.4	2.7 ± 0.4	3.7 ± 0.2	3.9 ± 0.5	5.1 ± 0.7
Area (mm^2)	3.1 ± 0.2	3.5 ± 0.2	3.3 ± 0.2	3.8 ± 0.2	4.4 ± 0.3	4.8 ± 0.4

Supplementary Table 35 | **Seed germination rates of harvested *Brassica rapa* (line R-0-18), *B. napus* (line RV31) and *B. olerecea* (line DH1012) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of seed harvested at physiological maturity from earliest set pods of plants of *B. rapa* (line R-0-18), *B. napus* (line RV31) and *B. oleracea* (line DH1012) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 in 100 mL of Levington® Advance F2 Seed and Modular Compost (ICL Specialty Fertilizers) and grown in a 16-hour photoperiod for seven days, and thereafter transferred to 1 L pots of JIC Cereal Compost Mix and placed in the respective photoperiod conditions. Values indicated are mean ± standard deviation based on three replicates (10 seeds per replicate).

	***B. rapa* (R-0-18)**		***B. oleracea* (DH1012)**		***B. napus* (RV31)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Germination percentage (%)	100 ± 0.0	100 ± 0.0	96.7 ± 5.8	96.7 ± 5.8	100 ± 0.0	96.7 ± 5.8

Supplementary Table 36 | Growth rate of pea (accessions JI 2822 and cultivars Cameor and Princess) in the LED-supplemented glasshouse setup at JIC. Days to key growth stages, and measurement of key growth and development parameters for three genotypes of pea (*Pisum sativum* accession JI 2822, JI 3253 (cv. Cameor) and JI 2623 (cv. Princess)), grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were scarified and sown on 14 November 2017 in 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean ± standard deviation based on five replicates.

	JI 2822		JI 3253 (Cameor)		JI 2623 (Princess)	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
1st Flower bud node	6.4 ± 0.9	6.4 ± 0.6	9.6 ± 0.6	10.2 ± 0.8	17.0 ± 1.0	16.6 ± 0.9
1st open flower DAS[1]	28.4 ± 0.6	38.6 ± 1.1	30.0 ± 1.0	41.2 ± 1.6	38.2 ± 0.8	48.8 ± 1.3
No. pods	6.8 ± 1.1	10.4 ± 1.5	6.4 ± 1.3	8.0 ± 0.7	6.2 ± 2.2	10.0 ± 2.6
No. side shoots	3.6 ± 0.6	2.6 ± 0.9	3.6 ± 1.3	1.8 ± 0.8	1.8 ± 2.1	1.0 ± 1.2
Final node No.	11.8 ± 0.5	12.4 ± 0.9	14.8 ± 0.5	15.6 ± 0.9	21.2 ± 1.5	22.2 ± 1.1
Final height (mm)	276.0 ± 4.2	397.0 ± 28.0	561.0 ± 11.9	723.0 ± 67.0	845.0 ± 58.1	1120.0 ± 94.6
Seed harvest (DAS)[2]	61.0 ± 0.0	84.0 ± 0.0	61.0 ± 0.0	86.8 ± 3.8	68.0 ± 0.0	91.0 ± 0.0
No. of seeds	23.6 ± 2.7	36.4 ± 6.1	32.4 ± 8.5	40.4 ± 7.5	21.4 ± 3.1	41.8 ± 6.4

[1] DAS = Days After Sowing. Days counted from sowing date

[2] All plants were kept under water stress for 7 days before harvesting. Seeds were not harvested at physiological maturity (early harvest).

[3] All seeds were dried at 30°C for 7 days.

Supplementary Table 37 | **Seed germination rates of harvested pea (accessions JI 2822 and cultivars Cameor and Princess) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability tests by monitoring germination of seed harvested early from for three genotypes of pea (*Pisum sativum* accession JI 2822, JI 3253 (cv. Cameor) and JI 2623 (cv. Princess)), grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Plants were deprived of water for 7 days prior to harvesting of seed, and harvested pods were dried at 30°C in for 7 days. Values indicated are mean ± standard deviation based on five replicates.

	JI 2822		**JI 3253 (Cameor)**		**JI 2623 (Princess)**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Germination percentage (%)	95.0 ± 7.1	100.0 ± 0.0	98.0 ± 2.7	99.0 ± 2.2	94.0 ± 10.8	97.0 ± 4.5

Supplementary Table 38 | **Growth rate of grasspea (cv. Mahateora) in the LED-supplemented glasshouse setup at JIC.** Days to key growth stages and measurement of key growth parameters of grasspea (*Lathyrus sativus* cv. Mahateora) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 directly into 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean ± standard deviation based on 10 replicates.

	***L. sativus* cv. Mahateora**	
	22 h	**16 h**
First flower opening	31 days	Not determined
Early harvest[1,2]	80 days	129 days
Mature harvest[1]	173 days	173 days

[1] All replicates were treated as a batch for harvesting

[2] For early harvest, a few pods that were ready to be harvested were sampled from two replicates of each variety for each photoperiod treatment.

Supplementary Table 39 | **Seed characteristics of harvested grasspea (cv. Mahateora) grown in the LED-supplemented glasshouse setup at JIC.** Average weight of seeds per plant, harvested at physiological maturity, from grasspea (*L. sativus* cv. Mahateora) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November, 2017 directly into 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean ± standard deviation based on 10 replicates.

	***L. sativus* cv. Mahateora**	
	22 h	**16 h**
No. of seeds per plant	36.3 ± 16.9	49.3 ± 25.0
Seed weight per plant (g)	3.5 ± 1.7	3.8 ± 2.2

Supplementary Table 40 | **Seed germination rates of harvested grasspea (cv. Mahateora) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination tests of seed harvested early from relatively mature pods of grasspea (*L. sativus* cv. Mahateora) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 directly into 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Pods were sampled from plants kept under each photoperiod treatment.

	***L. sativus* cv. Mahateora**	
	22 h	**16 h**
No. of seeds from pods sampled early	19	18
No. of seeds sampled for germination tests	15	15
Germination percentage (%)	100.0 ± 0.0	100.0 ± 0.0

Supplementary Table 41 | **Growth rate of *Brachypodium distachyon* (accessions Bd21, Bd21-3 and Bd3-1) in the LED-supplemented glasshouse setup at JIC.** Measurement of key growth stages and growth and development parameters for *B. distachyon* (accessions Bd21, Bd21-3 and Bd3-1) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 15 November, 2017 directly into 100 mL of 50% JIC Cereal Mix/50% JIC Peat and Sand Compost, and seedlings were transferred to 600 mL pots of the same soil mix 23 days later. Values indicated are mean ± standard deviation based on 9-10 replicates.

***B. distachyon* accession**	**Mean days to heading[1]**		**Mean final plant height (cm)**		**Mean grain weight per plant (g)**		**Harvest window[1,2]**	
	22 h	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**	**22 h**	**16 h**
Bd21	27.0 ± 0.0	40.7 ± 0.9	30.1 ± 1.6	41.9 ± 2.4	1.1 ± 0.2	1.2 ± 0.3	83	98-119
Bd21-3	27.0 ± 0.0	42.0 ± 2.5	35.1 ± 4.1	54.7 ± 4.4	1.1 ± 0.2	1.2 ± 0.4	83	98-119
Bd3-1	29.4 ± 2.2	45.4 ± 2.6	47.7 ± 5.1	58.0 ± 4.0	ND	ND	83	98-119

[1]Days calculated from date of sowing.

[2]Material was harvested when the ears on individual plants were drying and most ears had turned brown. Plants were dried at 30°C for 7 days prior to weighing.

Supplementary Table 42 | **Seed germination rates of harvested *Brachypodium distachyon* (accessions Bd21 and Bd21-3) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of seed harvested at physiological maturity from for two accessions of *B. distachyon* grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. All plants were harvested when the ears on individual plants were drying and most ears had turned brown. Plants were dried at 30°C for 7 days post-harvest. Germination tests were conducted with five replicate Petri dishes with 18-23 seeds per dish. After wetting, seeds were kept for 24 hours at 4°C and then moved to 22°C. Germination was assessed after 72 hours at 22°C. Values indicated are mean ± standard deviation.

	Bd21		**Bd21-3**	
	22 h	**16 h**	**22 h**	**16 h**
Germination percentage (%)	96.0 ± 2.3	82.4 ± 4.9	81.8 ± 18.9	83.8 ± 8.1

Supplementary Table 43 | **Growth rate of *C. quinoa* (accession QQ-74 and cv. Titicaca) in the LED-supplemented glasshouse setup at JIC.** Days to key growth stages of quinoa (*Chenopodium quinoa* accession QQ-74 and cv. Titicaca) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were germinated for 4 days and then transferred directly into 1 L pots containing Peat and Sand Mix on 9 February 2018. Values indicated are mean days after transfer of germinated seedlings[1] ± standard deviation based on 3-5 replicates.

Development stage[2,3]	***C. quinoa* QQ-74**		***C. quinoa* Titicaca**	
	22 h	**16 h**	**22 h**	**16 h**
Inflorescence emergence	45.2 ± 4.4	57.0 ± 0.0	43.6 ± 3.6	43.6 ± 3.6
Anthesis[2]	55.0 ± 4.6	64.3 ± 6.1	54.2 ± 3.8	57.8 ± 1.1
Fruit development[2] **(early harvest point)**	78.6 ± 3.6	87.0 ± 3.5	78.6 ± 3.6	81.8 ± 4.4
Ripe/mature fruit[2]	106.5 ± 7.8	103.8 ± 5.5	104.8 ± 2.5	101.0 ± 0.0
Senescence	113.2 ± 8.3	123.7 ± 4.0	113.2 ± 8.3	124.6 ± 3.1

[1] Germination for all samples required 4 days. Seeds were germinated by application of GA_3.

[2] Three 16 h QQ-74 plants were followed due to pest-related death of two plants from weeks 7-8. All other measurements refer to 5 plants.

[3]All measurements are with respect to the primary inflorescence, using the BBCH Code System.

NOTE: Plants were phenotyped every 2-8 days. This may cause whatever differences there might be between replicates or varieties to even out at the time of measurement, causing a net zero standard deviation.

Supplementary Table 44 | Seed characteristics of harvested *C. quinoa* (accession QQ-74 and cv. Titicaca) grown in the LED-supplemented glasshouse setup at JIC. One-thousand seed weight (g) of quinoa (*Chenopodium quinoa* accession QQ-74 and cv. Titicaca) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK (sown on 9 February 2018). Early harvest was carried out at the fruit development grain stage (~25 days and ~26 days post-anthesis in 22 and 16 h rooms, respectively). Seed was later harvested at physiological maturity once at least half of the inflorescence had senesced (~61 and ~65 days post-anthesis in 22h and 16h rooms, respectively). Inflorescences were dried at 30°C for 3-5 days prior to weighing. Values are expressed as mean ± SD, based on three replicates.

	C. quinoa			
	accession QQ-74		**cv. Titicaca**	
	22 h	**16 h**	**22 h**	**16 h**
Early harvest (1000 grain weight, g)	1.9 ± 0.1[2]	3.1 ± 0.0[1,2]	2.1 ± 0.1[2]	2.8 ± 0.0[2]
Mature harvest (1000 grain weight, g)	2.4 ± 0.1[2,3]	3.7 ± 0.1[1,3]	1.6 ± 0.2[2,3]	2.7 ± 0.0[3]

[1] Based on two replicates as one replicate did not seem to have produced viable seed.

[2] Based on extrapolated 200-seed weights

[3] Based on extrapolated 100-seed weights

Supplementary Table 45 | **Seed germination rates of harvested *C. quinoa* (accession QQ-74 and cv. Titicaca) grown in the LED-supplemented glasshouse setup at JIC.** Germination percentage of 30 seeds of quinoa (*Chenopodium quinoa* accession QQ-74 and cv. Titicaca) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK (sown on 9 February 2018). Early harvest was carried out at the fruit development grain stage (80 and 87 days post-anthesis in 22 and 16 h rooms, respectively). Seed was later harvested at physiological maturity once at least half of the inflorescence had senesced (108-119 and 126 days post-anthesis in 22h and 16h rooms, respectively). Inflorescences were dried at 30°C for 3-5 days prior to weighing. Values are expressed as mean ± SD, based on three replicates.

	C. quinoa			
	accession QQ-74		**cv. Titicaca**	
	22 h	**16 h**	**22 h**	**16 h**
Early harvest (germination %)	98.8 ± 1.9	100.0 ± 0.0	82.2 ± 1.9	80.0 ± 6.2
Mature harvest (germination %)	100.0 ± 0.0	99.0 ± 0.6	100.0 ± 0.0	95.0 ± 0.6

Supplementary Table 46 | **Growth rate of *Avena Strigosa* (accession S75) grown in the LED-supplemented glasshouse setup at JIC.** Days to key growth stages, and measurement of key growth and development parameters for oat (*Avena strigosa* accession S75) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 directly into 100 mL of JIC Peat and Sand Mix and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean ± standard deviation based on seven replicates.

	22 h	**16 h**
Days to 2nd leaf emergence[1]	9.7 ± 0.8	15.0 ± 0.0
Days to flowering	52.0 ± 0.0	66.0 ± 0.0
Days to harvest	100.0 ± 0.0	114.0 ± 0.0
No. of tillers	12.6 ± 1.1	8.6 ± 1.4
Total seed weight (g)	8.9 ± 1.1	13.9 ± 3.1

[1] Days counted from sowing date.

[2] All plants were kept under water stress 14 days before harvesting.

[3] All seeds were dried at 25°C in the oven for 15 days.

Supplementary Table 47 | **Characteristics of mature plants of *Avena Strigosa* (accession S75) grown in the LED-supplemented glasshouse setup at JIC.** Plant height measured at different time points as an indicator of growth progress for oat (*Avena Strigosa* accession S75) grown under 22 and 16-hour photoperiods in LED-supplemented glasshouses at John Innes Centre, UK. Seeds were sown on 14 November 2017 directly into 100 mL of JIC Peat and Sand Mix
and seedlings were transferred to 1 L pots of JIC Cereal Compost Mix 23 days later. Values indicated are mean ± standard deviation based on seven replicates.

Plant Height	**22 h**	**16 h**
Plant Height: Day 8[1]	11.0 ± 1.0	5.0 ± 0.7
Plant Height: Day 10	17.1 ± 0.9	10.8 ± 0.9
Plant Height: Day 15	30.6 ± 0.9	17.5 ± 0.9
Plant Height: Day 22	46.6 ± 1.8	35.4 ± 2.0
Plant Height: Day 25	48.1 ± 2.3	38.4 ± 1.9
Plant Height: Day 30	56.0 ± 1.8	48.8 ± 1.5
Plant Height: Day 36	79.23 ± 4.8	60.0 ± 2.7
Plant Height: Day 52	127.4 ± 15.4	116.7 ± 10.6

[1] Days counted from sowing date.

Supplementary Table 48 | **Seed germination rates of harvested *Avena Strigosa* (accession S75) grown in the LED-supplemented glasshouse setup at JIC.** Seed viability demonstrated through germination percentages of 30 seeds harvested at physiological maturity from oat (*Avena Strigosa* accession S75) grown under 22 and 16-hour photoperiods in LED-Supplemented glasshouses at John Innes Centre, UK. Plants were not watered for 2 weeks prior to harvesting seed. Values indicated are mean ± standard deviation based on 3 replicates of 30 seeds under each photoperiod condition.

***A. strigosa* accession S75**	**22 h**	**16 h**
Germination percentage (%)	100.0 ± 0.0	100.0 ± 0.0

Supplementary Table 49 | **FP Media composition**

	Stock solution	**Volume to add for 1L of solution**
Calcium Chloride ($CaCl_2.2H_2O$)	40g/L	2.5mL
Magnesium Sulphate ($MgS0_4.7H20$)	40g/L	3.0mL
Potassium phosphate monobasic (KH_2PO_4)	30g/L	3.33mL
Di-sodium hydrogen phosphate dodecahydrate ($Na_2HPO_4.12H_2O$)	45g/L	3.33mL
Ferric Citrate	2.5g/L	2.0mL
Gibson's Trace *In 500 mL of distilled water, add:* *1.43g Boric acid (H_3BO_3),* *1.015g of Manganese Sulphate ($MnSO_4.4H_2O$),* *0.11g of Zinc Sulphate ($ZnSO_4.7H_2O$),* *0.04g of Copper Sulphate ($CuSO_4.5H_2O$), 0.04g of Molybdic acid (H_2MoO_4)*	-	1.0mL