Supplementary Tables

Supplementary Table 1 | 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 | 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 | 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%
Coco peat 30%
Fertilizer
Yates Flowtrace® (Yates, Padstow, NSW, Australia) 1 kg m^{-3}
Iron sulphate heptahydrate 1 kg m^{-3}
Superphosphate 0.4 kg m^{-3}
Copper sulphate 0.03 kg m^{-3}
Gypsum 1 kg m^{-3}

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

Component	**Measure**
Medium Grade Peat	40%
Sterilised Soil	40%
Horticultural Grit	20%
Fertilizer	
PG Mix™ 14-16-18 + Trace Elements (TE) Base Fertiliser	1.3 kg/m^3
Osmocote® Exact Mini 16-8-11+ 2MgO + TE 0.02% Boron	1.0 kg/m^3
H2Gro® **(**Wetting Agent) from ICL Specialty Fertilizers (Ipswich, UK)	
Maglime	3.0 kg/m^3
Insecticide	
Exemptor® from ICL Specialty Fertilizers (Ipswich, UK)	300 g/m^3

Supplementary Table 6 | JIC peat and sand mix supplied by Petersfield Growing (Leicester, UK).

Component	**Measure**
Fine peat	85%
Grit	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	4.0 kg/m^3

Supplementary Table 7 | 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 8 | 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 9 | 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 10 | 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 11 | 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 12 | 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 13 | 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 14 | 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 15 | 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 16 | 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 17 | 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 18 | 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 19 | 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 20 | 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 21 | 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 22 | 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 23 | 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 24 | 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 25 | 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 26 | 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 27 | 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 28 | 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 29 | 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 30 | 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 31 | 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 32 | 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 33 | 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 34 | 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 35 | 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 36 | 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 37 | 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 38 | 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 39 | 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 40 | 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 41 | 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 42 | 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 43 | 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		**accession QQ-74**	
	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 44 | 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 45 | 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 46 | 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 47 | 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 48 | 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