Plant Light Management.
What Do The Terms DLI, µMole and Mole Mean For Plant Lighting?

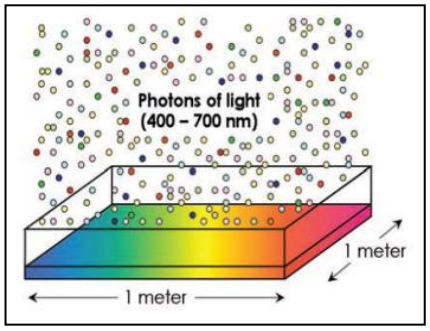
When you see **µMole**, pronounced micromole, is used as a unit of measuring the net energy in plant lighting and represents the large number of photons that fall within the PAR regions of 400-700nm spectrums over a fixed area. To be precise when you see µMole it is being used as an abbreviation for **µMol/M^{2}S** that is the unit of measure for PPFD. The µ symbol derives from the ancient Greek alphabet, letter Mµ and is used in modern mathematics to represent the term micro or 1/1,000,000th, therefore a µMole is 1/1,000,000th of a Mole.

The term **Mole** is a unit less large number (number value only) often used in physics and chemistry, it is also known as Avogadro's number, 6.022 x 10^{23}. The Mole is based on the quantity of elemental atoms or molecules, such that the net weight of that quantity equals the Atomic Weight or the Molecular Weight in Grams. If you had 6.022 x 10^{23} atoms of a particular element, its weight in grams would be equal to its atomic weight from the periodic table. A µMole is a millionth of a Mole or 6.022 x 10^{17}.

Using Moles/Day to target crop specific Daily Lighting Integral needs

Plants need a minimum amount of sunlight each day to meet their basic biological needs which will vary based on species. For flowering and fruiting plants increases in sunlight energy, beyond the minimum amounts of light can show significant increases in both the quality and quantity of flowering and fruiting production. To determine how much light is available to our plants as a **daily accumulation of that light** is referred to as the plants **Daily Light Integral or DLI** for that particular plant species as a **Moles/Day** value.

The advantage of using Moles/Day as a daily accumulation of light over that of an instantaneous µMole reading can be demonstrated with an analogy; To determine how much rain fell during the course of a day, you would place a bucket outdoors and record the volume of water collected over that day. Whereas, recording the intensity of rainfall at one instant, e.g., the raindrops per second, would be of little value.



For indoor plant lighting applications where light intensities will be constant over the photoperiod the formula to convert µMole to Moles is:

µMol/M^{2}S x 3600 s/hr x photoperiod(hrs/day) ÷ 1,000,000 µMole/Mole = Mol/M^{2}Day

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This chart was developed as a reference to show how instantaneous µMole readings, when held constant or as an average µMole levels over the hours/day would accumulate as a Moles/Day value.

Moles per Day

(per Square Meter)

Hours/day	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
uMol/M^2-S																	
200	**6**	**6**	**7**	**8**	**9**	**9**	**10**	**11**	**12**	**12**	**13**	**14**	**14**	**15**	**16**	**17**	**17**
300	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**21**	**22**	**23**	**24**	**25**	**26**
400	**12**	**13**	**14**	**16**	**17**	**19**	**20**	**22**	**23**	**24**	**26**	**27**	**29**	**30**	**32**	**33**	**35**
500	**14**	**16**	**18**	**20**	**22**	**23**	**25**	**27**	**29**	**31**	**32**	**34**	36	38	40	41	43
600	**17**	**19**	**22**	**24**	**26**	**28**	**30**	**32**	**35**	37	39	41	43	45	48	50	52
700	**20**	**23**	**25**	**28**	**30**	**33**	**35**	38	40	43	45	48	50	53	55	58	60
800	**23**	**26**	**29**	**32**	**35**	37	40	43	46	49	52	55	58	60	63	66	69
900	**26**	**29**	**32**	36	39	42	45	49	52	55	58	62	65	68	71	75	78
1000	**29**	**32**	36	40	43	47	50	54	58	61	65	68	72	76	79	83	86
1100	**32**	36	40	44	48	51	55	59	63	67	71	75	79	83	87	91	95
1200	**35**	39	43	48	52	56	60	65	69	73	78	82	86	91	95	99	104
1300	37	42	47	51	56	61	66	70	75	80	84	89	94	98	103	108	112
1400	40	45	50	55	60	66	71	76	81	86	91	96	101	106	111	116	121
1500	43	49	54	59	65	70	76	81	86	92	97	103	108	113	119	124	130

Bolded values represent typical target DLI amounts

500 uMole represents a typical desireable light intensity for indoor growing.

1000 uMole is a high level intensity for both indoor and greenhouse supplemental lighting may likely result in diminishing returns.

1500 uMoles is a typical plant saturation level for high DLI crops light is of no or very little benefit.

2000 uMole is a typical maximum natural sun output on a clear day at astronomical noon.

Moles/Day Values Relative to Plant Specific Daily Light Integrals

As we look to maintain the optimum levels of light for repeatable crop production we need to identify that those daily values are being met **by knowing that species minimum - maximum levels** of light DLI as shown in the following chart.

By knowing **plant specific DLI values** it gives the crop production manager more options when factoring **Return on Investment** whereby they can meet targeted DLI values with strategies that might employ fewer lights and longer photoperiods or perhaps to extend photoperiods and utilize more lights to meet higher intensities as a way to decrease harvest times and increase crop quality.

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Minimum	Good	High	Average Daily Light Integral (Moles/Day)													
SPECIES			2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Ferns (Pteris Adiantum)																	
Maranta																	
Phalaenopsis (Orchid)																	
Saintpaulia																	
Spathiphyllum																	
Forced Hyacinth																	
Forced Narcissus																	
Forced Tulip																	
Aglaonema																	
Bromeliads																	
Caladium																	
Dracaena																	
Nephrolepsis																	
Streptocarpus																	
Hosta																	
Hedera (English Ivy)																	
Begonia (Heimalis)																	
Sinningia																	
Schlumbergera																	
Cyclamen																	
Exacum																	
Heuchera																	
Coleus (Shade)																	
Impatiens, New Guinea																	
Iris, Dutch (Cut Flowers)																	
Kalanchoe																	
Lobelia																	
Primula																	
Impatiens																	
Pelargonium Peltatum (Ivy Geranium)																	
Begonia (Fibrous)																	
Senecia (Dusty Miller)																	
Fuchsia																	
Euphorbia (Poinsettia)																	
Lilium (Asiatic and Oriental)																	
Lilium Longiflorum (Easter Lily)																	
Antirrhinum																	
Chrysanthemum (Potted)																	
Dianthus																	

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Minimum	Good	High	Average Daily Light Integral (Moles/Day)														
SPECIES	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Gazania															
Gerbera															
Hibiscus Rosa-Siniensis															
Lobularia															
Pelargonium Hororum (Zonal Gera-Nium)															
Rose (Miniature Potted)															
Salvia Splendens															
Schefflera															
Angelonia															
Aster															
Salvia Farinacea															
Iberis															
Catharanthus (Vinca)															
Celosia															
Chrysanthemum (Garden)															
Dahlia															
Echinacea															
Ficus Bejaminia															
Gaura															
Hemerocallis															
Lantana															
Lavendula (Lavender)															
Tagetes (Marigold)															
Petunia															
Phlox (Creeping)															
Rudbeckia															
Sedum															
Thymus															
Verbena															
Viola (Pansy)															
Zinnia															
Alstroemeria (Cut Flower)															
Capsicum (Pepper)															
Chrysanthemum (Cut Flower)															
Dianthus (Carnation)															
Gladiolus (Cut Flower)															
Lycopersicon (Tomato)															
Rose (Cut Flower)															

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