Potential to include spike photosynthesis in breeding programs: *Genetic variation for spike photosynthesis and identification of molecular markers*

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TRIGO (Wheat) Yield Potential
WORKSHOP 2016

MasAgro

SAGARPA

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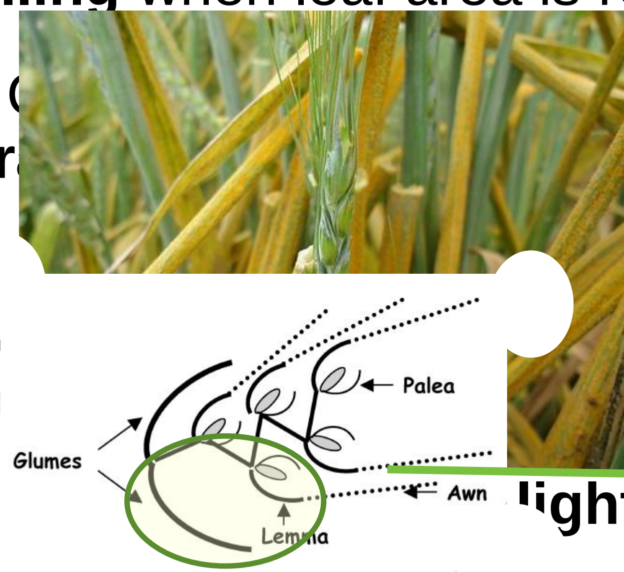
OUTLINE

- Introduction: importance of spike photosynthesis
- Tools developed at CIMMYT
- Application in a mapping population
- Conclusions

Introduction: Spike Photosynthesis

…could contribute from **10 to 80%** of the assimilates deposited in grains (Kriedemann 1966; Evans and Rawson 1970; Araus et al. 1993; Maydup et al. 2010; Sanchez-Bragado et al., 2014)

…**delayed chlorosis** (Abbad et al. 2004), ability to maintain a **better water status under drought** (Tambussi et al. 2005) and capacity to **safeguard seed-filling** when leaf area is reduced (Maydup et al. 2010).



…uses respiratory C grain respiration, increasing **transpir** al. 1993; Bort et al. 1996).

…high SP has be **rtant trait** in the model nd drought (Reynolds et al. sani & Rey

betwe **light during grain filling** da et al.,

…its contribution to grain yield shows **genetic variation** (…ero et al., 2014)

60-70% CO_2 refixed by green pericarp, lemma and glume (Knoppik *et al.*, 1986; Gebbing and Schnyder, 2001)

Introduction: Spike Photosynthesis

Morphological diversity of spikes

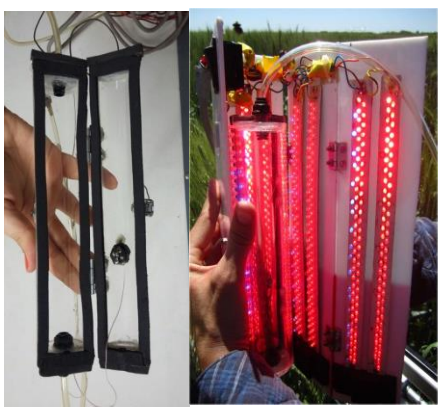
Spike diversity in BW panel

Tools developed at CIMMYT

Direct Measurements with…

- Spike illumination chamber

LI-6400XT



Spike Photosynthetic Rate

Indirect Measurements with …

- Photosynthesis inhibition treatments
    - Textile

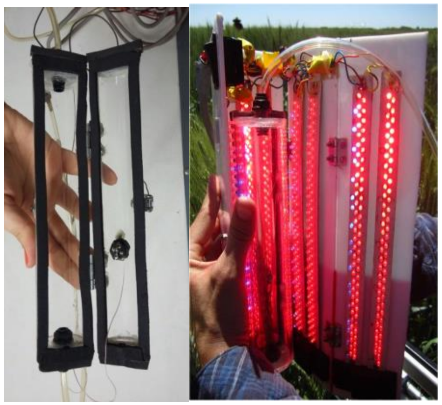
Spike Photosynthesis Contribution

Material and Methods: 4 Trials evaluated during 2 years

	Years*	Env	*n*	SPR	SPC
PADs POP	2012 & 2013	YP	12	12	12
CIMCOG I-Subset	2012 & 2013	YP	30	15	30
CIMCOG II	2014 & 2015	YP	60	16	60
RILs Atil/dicoccum-YP	2012 & 2014	YP	95	2 (parents)	95
RILs Atil/dicoccum-Heat	2013 & 2014	Heat	95	-	95

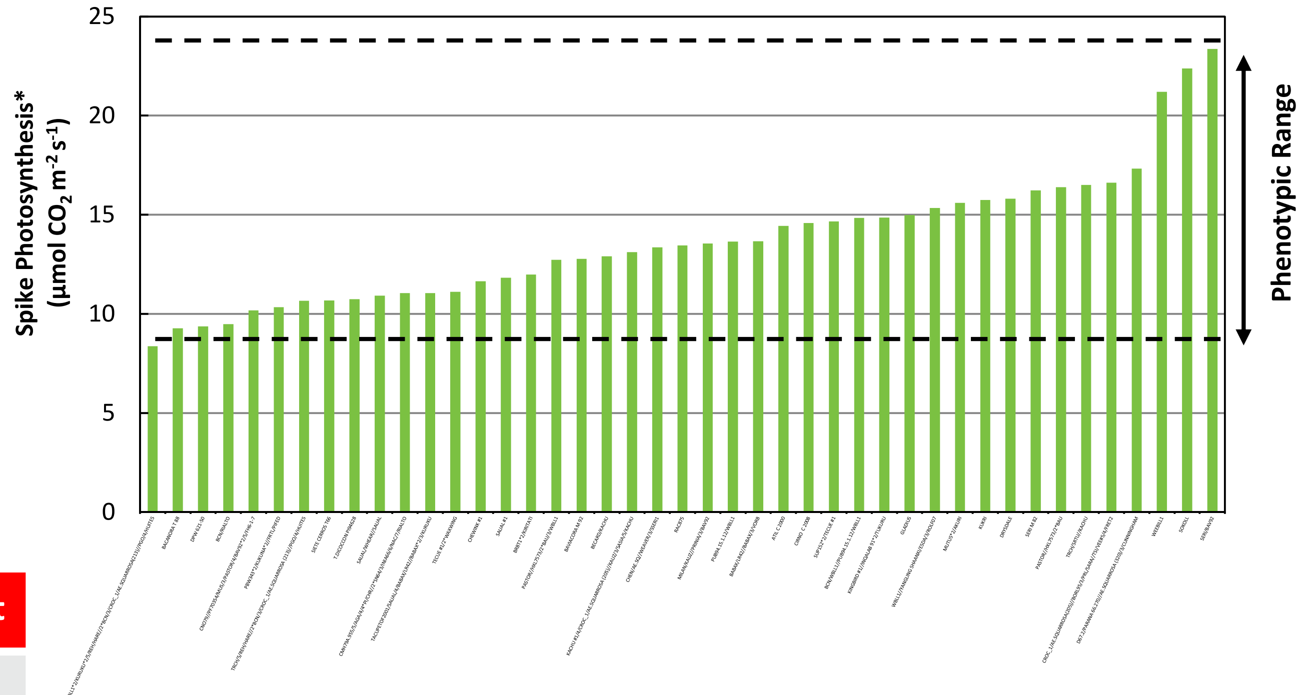
*2012, 2013, 2014 and 2015 refers to 2011-2012, 2012-2013, 2013-2014 and 2014-2015 growing cycles respectively

Results and Discussion: Genetic variation



PADs POP n=12

Treatments	Yield Potential	Heat
	CV (%)	
Textile	5.3	3.9



	Years*	n	SPC Mean	SPC Min	SPC Max
PADs POP	2012 & 2013	12	34.6	25.2	41.2
CIMCOG I-Subset	2012 & 2013	30	28.2	16.1	41.6
CIMCOG II	2014 & 2015	60	28.5	12	45.2
RILs Atil/dicoccum	2012 & 2014	95	26	10.1	41.8

*2012, 2013, 2014 and 2015 refers to 2011-2012, 2012-2013, 2013-2014 and 2014-2015 growing cycles respectively

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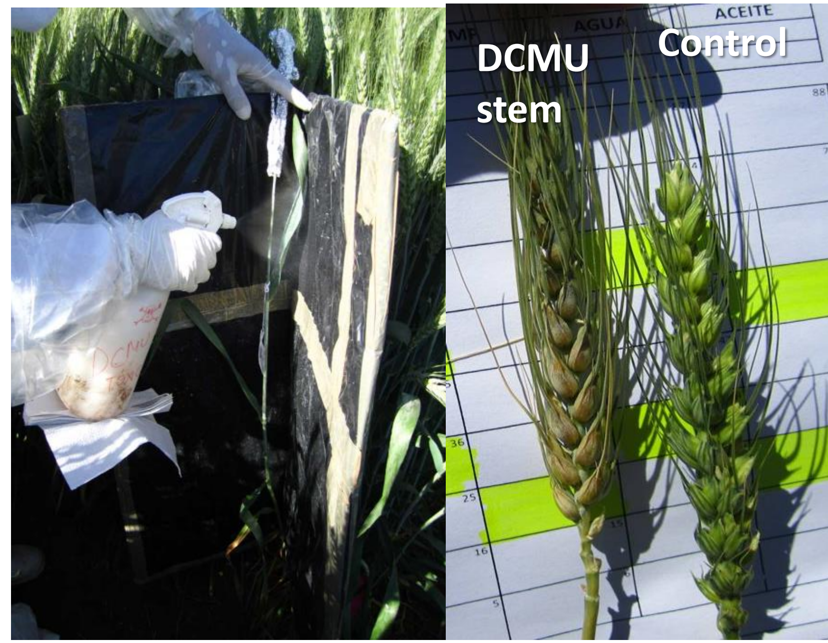
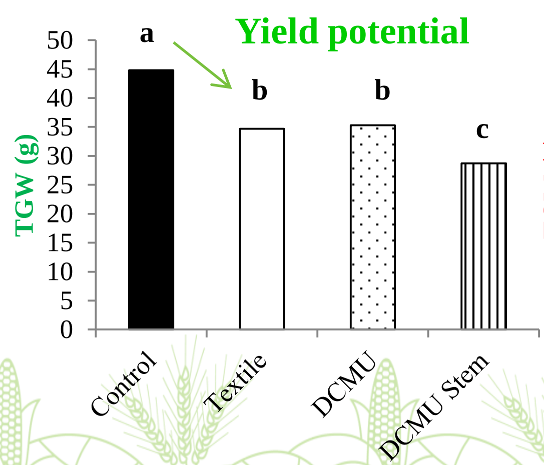
Tools developed at CIMMYT : Indirect Measurements using Inhibition treatments

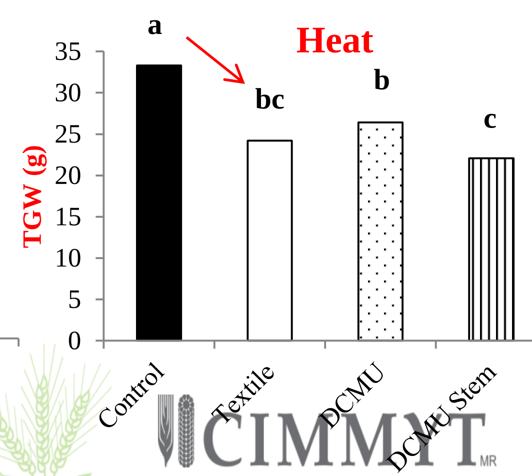
TEXTILE

DCMU

DCMU Stems



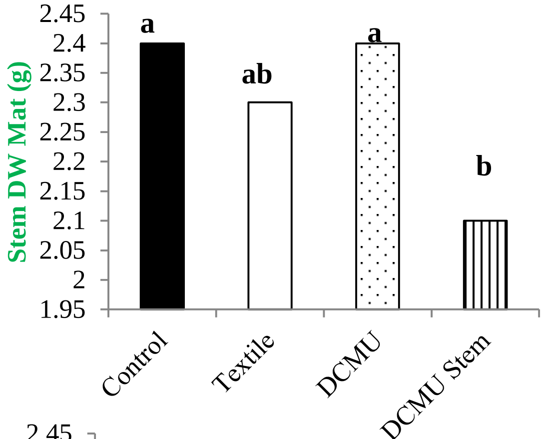


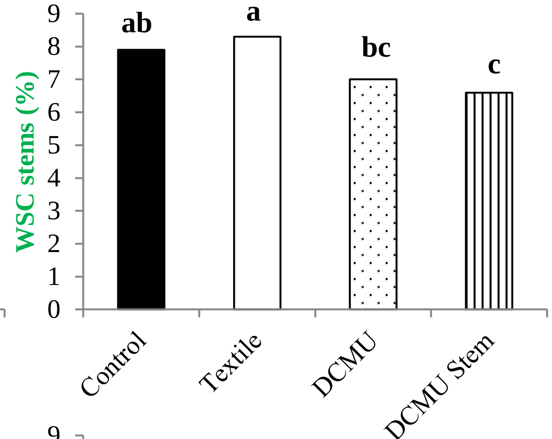


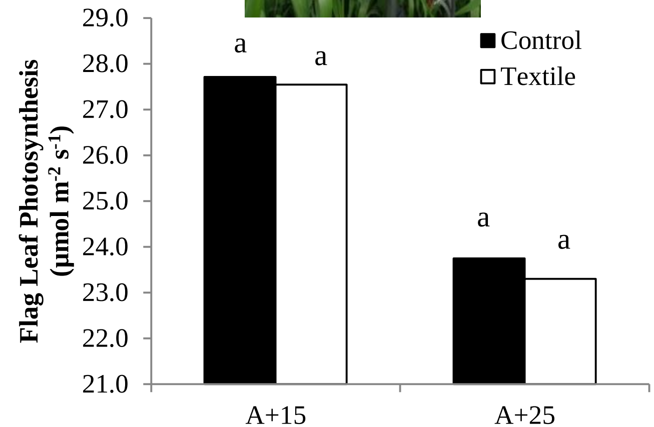
Tools developed at CIMMYT : Indirect Measurements using Inhibition treatments

PADs POP n=12, 2 years

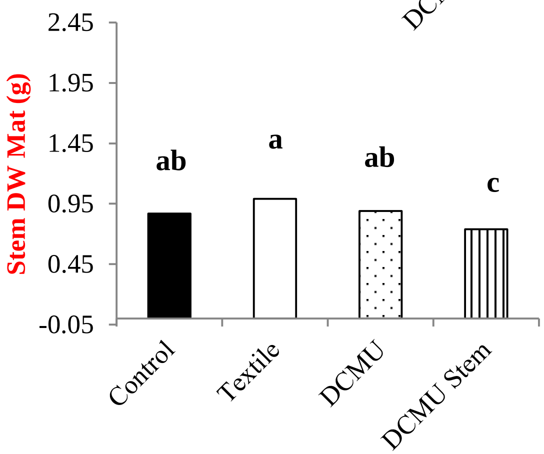
Yield potential

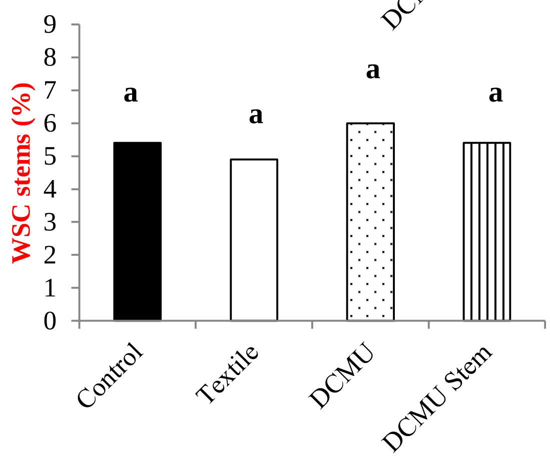


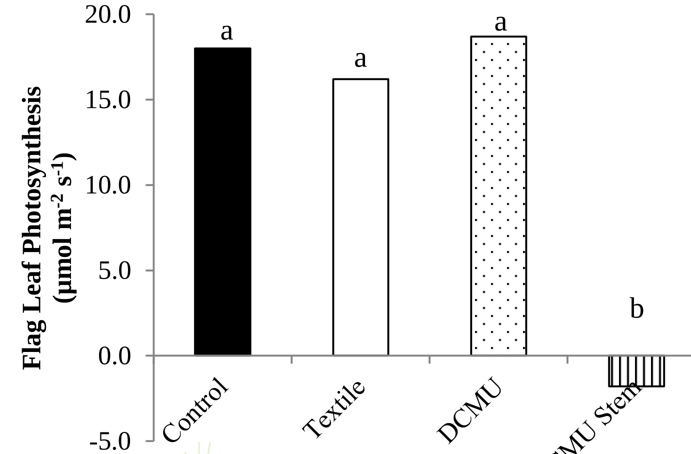




Heat







- ✓ **No compensation of Flag leaf photosynthesis, Pre-anthesis Contribution and WSC at physiological maturity**

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Results and Discussion: Application in a mapping population

95 RILs *T. turgidum* (*Atil*) x *T. dicoccum*

	Yield potential		Heat stress	
	2011-12	2013-14	2013	2014
Emergence date	2-Dec-11	8-Dec-13	8-Mar-13	5-Apr-14
TTA - TTH (°C days)	1460	1592	993	1275
TTM (°C days)	2152	2321	1738	1794
Temp (max/min °C)	25.4/6.3	26.8/8.6	30.8/11.6	34.8/15.0
Max Temp > 35 °C	0	2	14	40
Radiation (MJ m^{-2} day^{-1})	20.4	19.5	28.0	27.6
ETo (mm)	4.1	4.0	6.5	7.0
Rainfall (mm)	12.1	28.4	0.9	1.2
Water available (mm)	>500	>500	>500	>600

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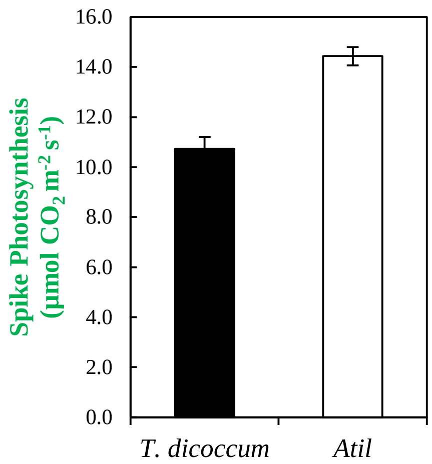
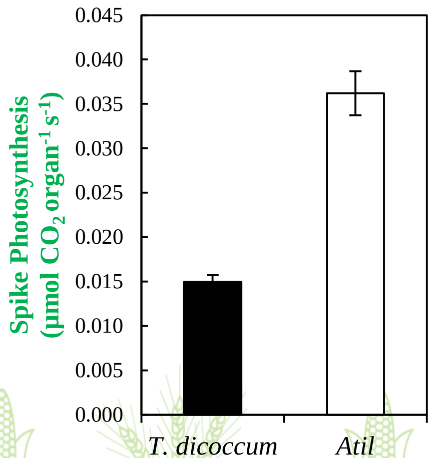
Application in a mapping population :

95 RILs *T. turgidum* (*Atil*) x *T. dicoccum*

Direct Measurements

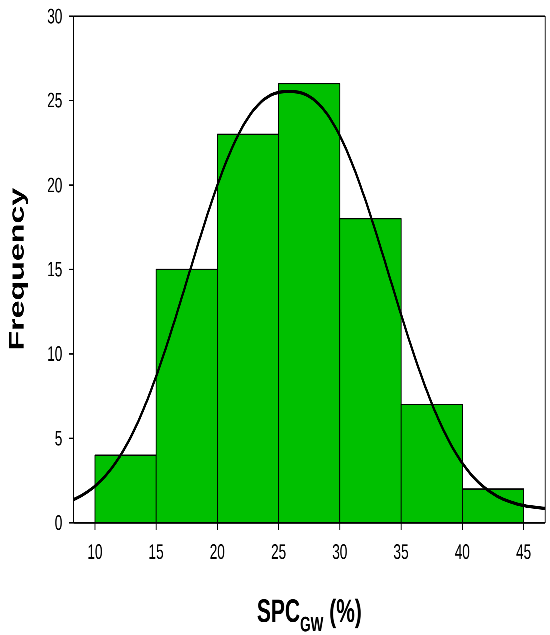




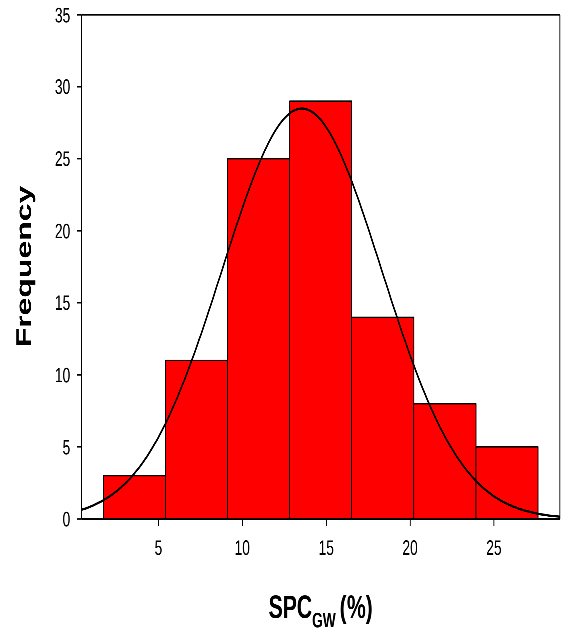
Indirect Measurements with Textile (inhibition treatment)

$$SPC_{GW} = \frac{(\text{GW of } control - \text{GW of treated } plants)}{\text{GW of } control} \times 100$$

Yield potential



Heat



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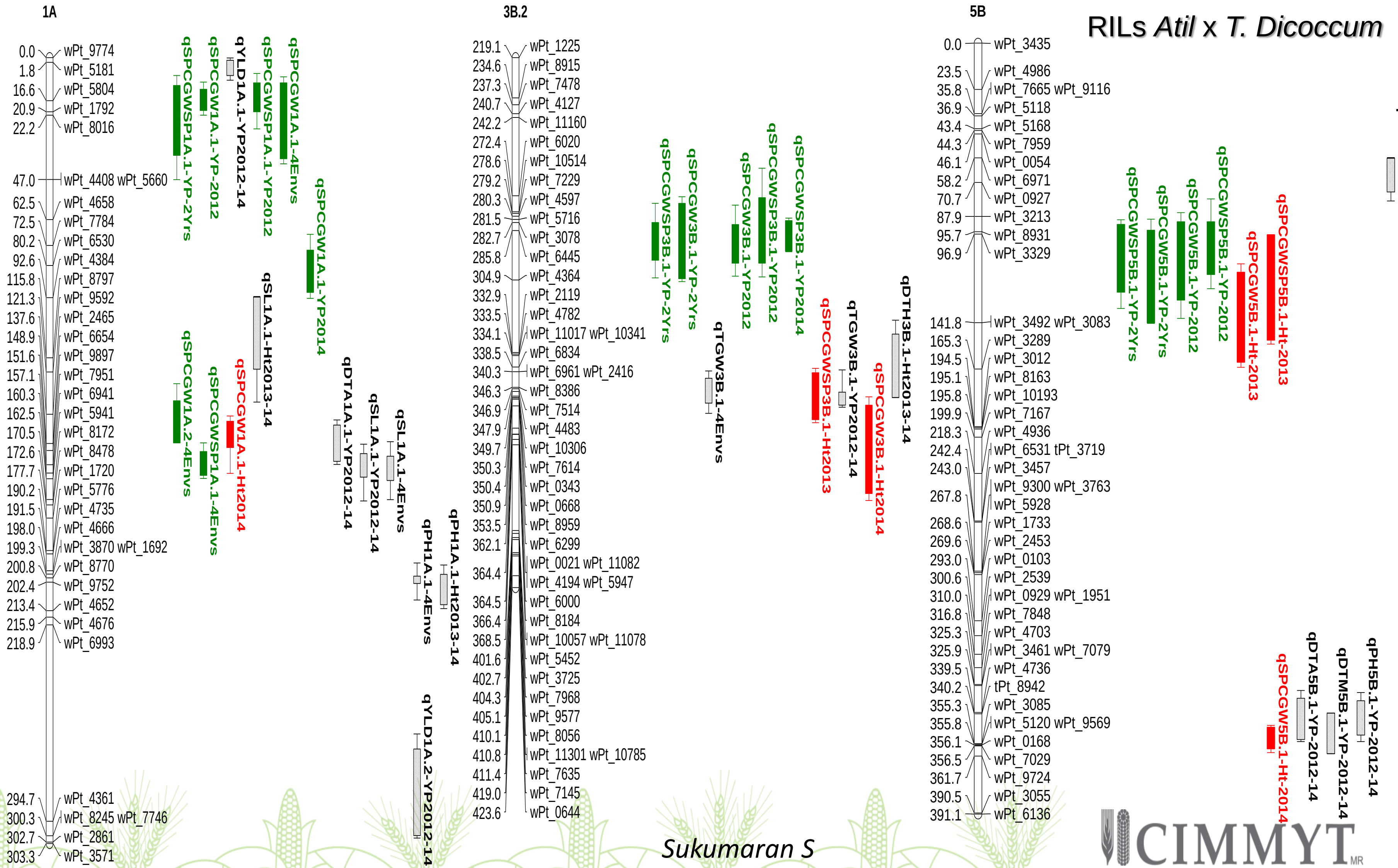
Results and Discussion: Identification of QTLs for Spike Photosynthesis Contribution under YP and Heat



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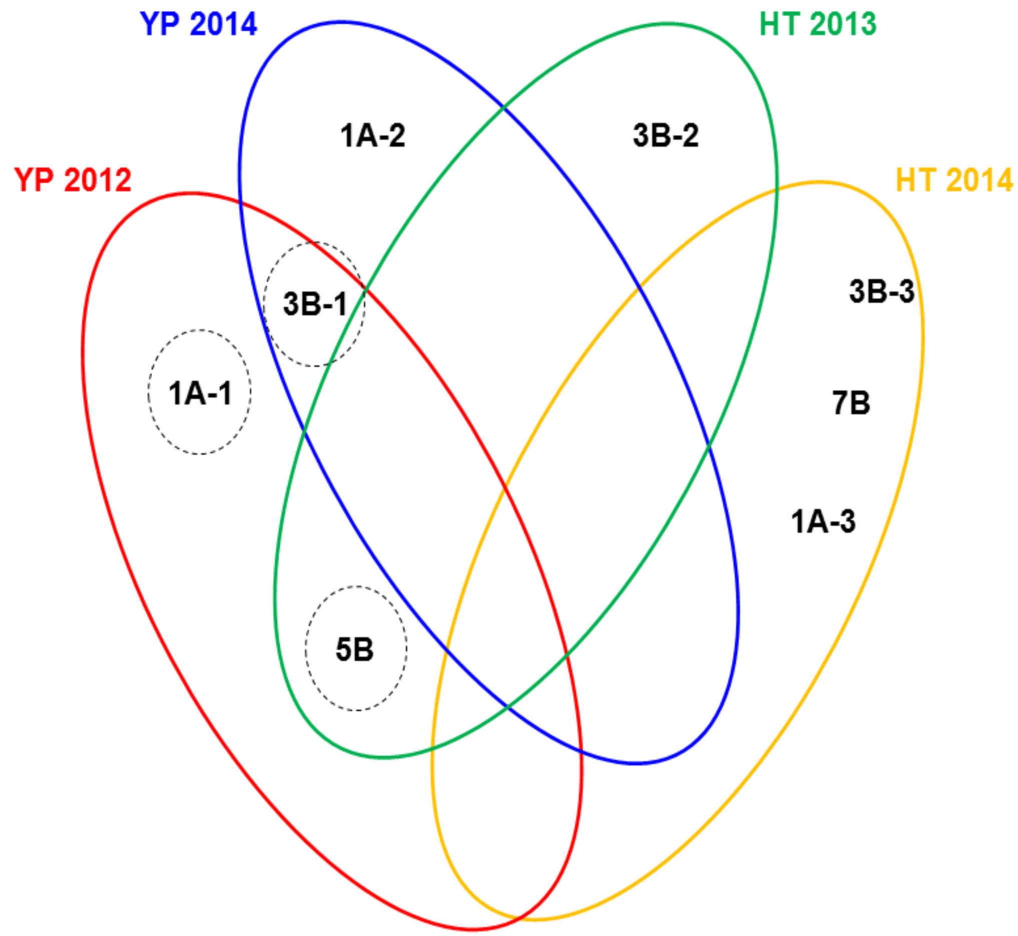
Results and Discussion: Identification of QTLs for Spike Photosynthesis Contribution under YP and Heat

Env	Trait	Chr	QTL	Flanking markers	CI (cM)	Peak Position	LOD	PVE (%)	Additive Effect
YP 12	SPC_{GWSP}	1A	qSPCGWSP1A.1-YP2012	wPt9774-wPt1792	10.2-20.1	16.8	4.4	14.0	0.05
		3B	qSPCGWSP3B.1-YP2012	wPt10514-wPt4364	275.3-296.3	281.7	3.9	12.7	-0.04
		5B	qSPCGWSP5B.1-YP2012	wPt3213-wPt3492	90.6-117.2	97.2	4.8	**30.2**	-0.06
YP 14	SPC_{GWSP}	3B	qSPCGWSP3B.1-YP2014	wPt6445-wPt4364	281.7-292.3	286.3	2.5	9.7	-0.04
YP†	SPC_{GWSP}	1A	qSPCGWSP1A.1-YP-2Yrs	wPt9774-wPt4408	10.7-37.7	18.6	3.1	3.3	0.04
		3B	qSPCGWSP3B.1-YP-2Yrs	wPt6445-wPt4364	282.7-297.3	287.9	4.8	14.4	-0.04
		5B	qSPCGWSP5B.1-YP-2Yrs	wPt3213-wPt3492	91.9-126.4	107.0	5.9	**29.2**	-0.07
HT 13	SPC_{GWSP}	3B	qSPCGWSP3B.1-Ht2013	wPt6834-wPt6299	341.1-353.9	350.7	2.7	9.5	2.22
		5B	qSPCGWSP5B.1-Ht2013	wPt8931-wPt3492	97.2-150.7	120.2	2.6	**21.7**	2.71
HT 14	SPC_{GWSP}	7B	qSPCGWSP7B.1-Ht2014	wPt0276-wPt5992	36.1-63.8	45.7	2.8	16.3	-4.35
Ht†	SPC_{GWSP}	3B	qSPCGWSP3B.1-Ht-2Yrs	wPt1162-wPt7961	49.4-54.4	53.3	2.6	11.7	0.28
4Envs±	SPC_{GWSP}	1A	qSPCGWSP1A.1-4Envs	wPt6654-wPt8172	151.2-161.4	157.4	3.8	15.0	-2.1
			SPCGW						
YP 2012	SPC_{GW}	1A	qSPCGW1A.1-YP2012	wPt9774-wPt1792	12.5-20.4	16.8	2.6	11.8	0.03
		3B	qSPCGW3B.1-YP2012	wPt10514-wPt4364	282.0-300.5	289.9	3.0	17.9	-0.03
		5B	qSPCGW5B.1-YP2012	wPt3213-wPt3492	94.6-117.2	96.5	7.4	**41.6**	-0.06
YP 2014	SPC_{GW}	1A	qSPCGW1A.1-YP2014	wPt4658-wPt4384	74.1-90.9	84.8	2.8	12.9	0.03
YP†	SPC_{GW}	3B	qSPCGW3B.1-YP-2Yrs	wPt6020-wPt4364	275.3-304.4	290.9	3.1	9.9	-0.02
		5B	qSPCGW5B.1-YP-2Yrs	wPt3213-wPt3492	94.9-141.9	121.5	3.2	**32.4**	-0.04
HT 2013	SPC_{GW}	5B	qSPCGW5B.1-Ht2013	wPt8931-wPt3289	116.2-161.9	134.3	2.9	31.4	2.27
HT 2014	SPC_{GW}	1A	qSPCGW1A.1-Ht2014	wPt2465-wPt6941	138.0-160.7	145.9	5.1	20.4	-4.20
		3B	qSPCGW3B.1-Ht2014	wPt0343-wPt5452	356.4-379.1	366.3	4.4	15.0	3.29
		5B	qSPCGW5B.1-Ht2014	wPt4736-wPt9724	347.4-358.9	355.6	3.0	11.2	2.81
4Envs±	SPC_{GW}	1A	qSPCGW1A.1-4Envs	wPt9774-wPt4408	7.1-37.2	26.5	5.9	17.6	2.8
		1A	qSPCGW1A.2-4Envs	wPt9592-wPt6654	127.3-148.2	144.1	3.2	12.9	-1.8

Results and Discussion: Consistent QTLs for YP and Heat



RILs *Atil* x *T. Dicoccum*

Sukumaran S

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Conclusions

- ✓ The present study highlights the importance of spike photosynthesis to final grain yield showing phenotypic variation for spike photosynthetic rate and spike photosynthesis contribution to grain yield.
- ✓ An average of 30% of the assimilated deposited in the grains is associated with spike photosynthesis in elite lines.
- ✓ Three QTLs on chromosomes 1A, 3B, and 5B where the QTL on chromosome 5B was detected under both yield potential and heat stress conditions and explained 21-41% variation in the trait.

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Acknowledgements

Matthew Reynolds
Sivakumar Sukumaran
Wheat Physiology team

JL Araus
Rut Sanchez-Bragado

Carolina Rivera-Amado


Thanks for your interest!

Spike Photosynthesis 50 years later:

New tools, New game

Gemma Molero, S. Sukumaran and MP Reynolds

9th International Wheat Conference,

September 23, 2015, Sydney

IWC2015
20-25 September 2015 / Sydney Australia

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SECRETARÍA DE AGRICULTURA, GANADERÍA, DESARROLLO RURAL, PESCA Y ALIMENTACIÓN

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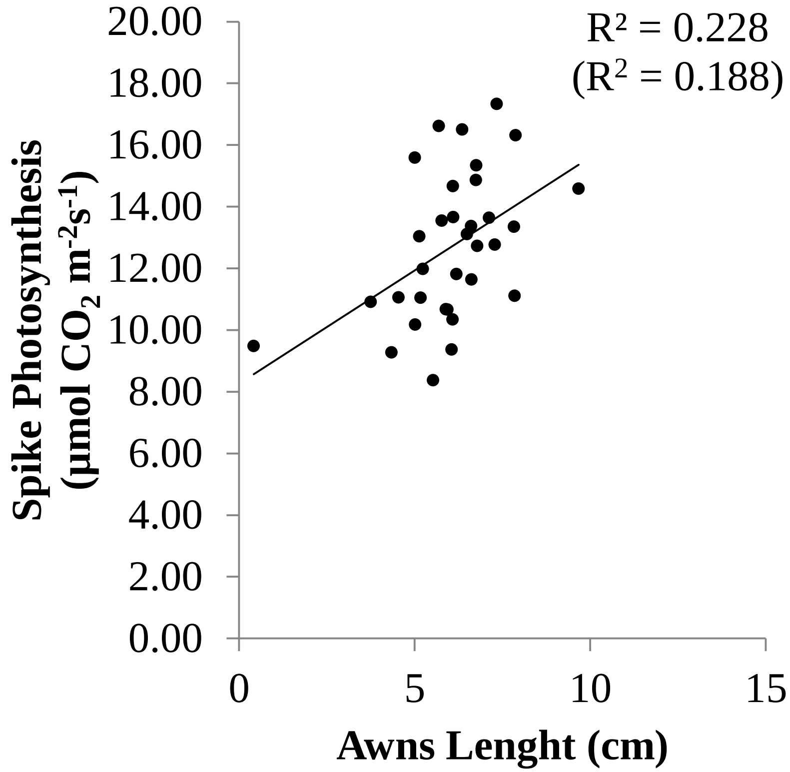
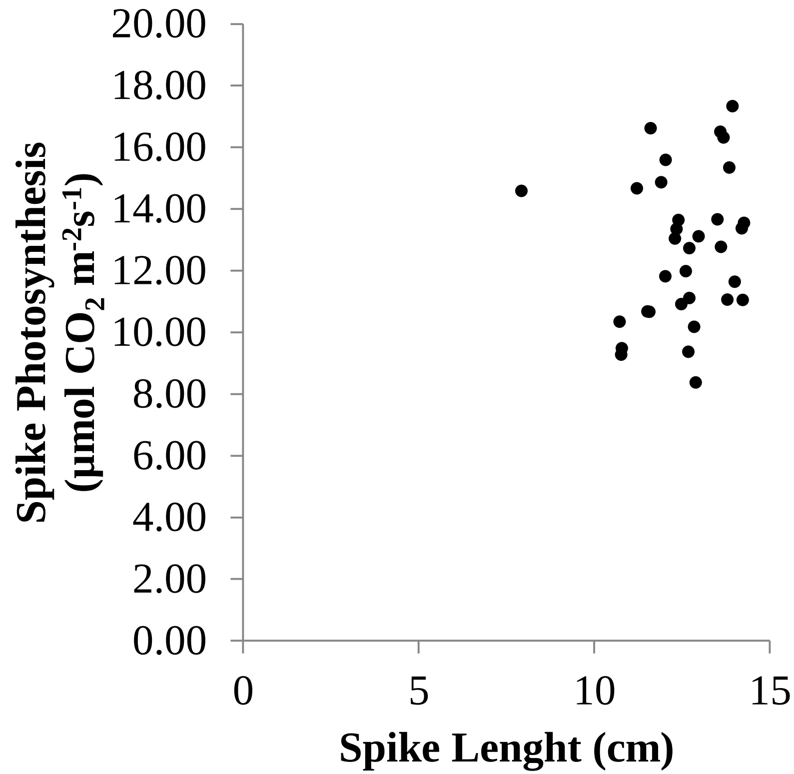
n = 33, Elite lines





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