SEED SETTING AND FILLING PROBLEM IN SUNFLOWER AND ITS MANAGEMENT

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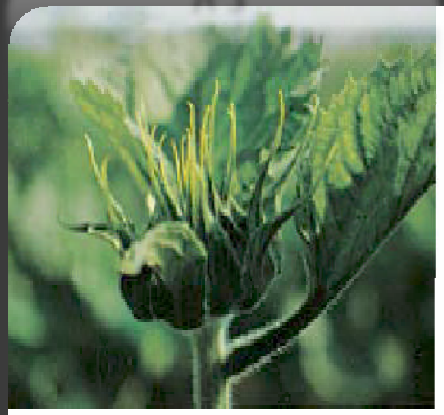
V-E

V-2

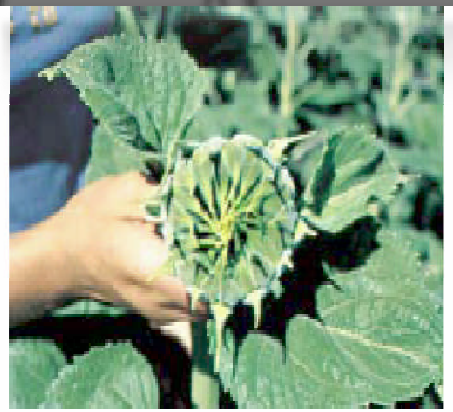
V-4

R-1

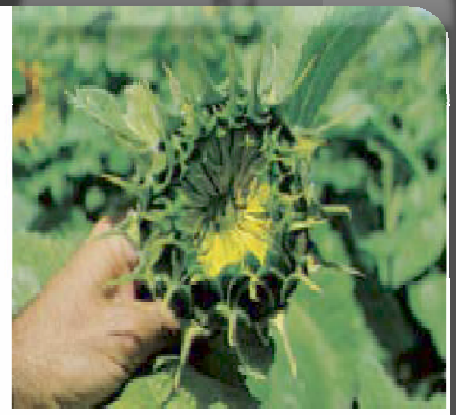
R-2



R-3

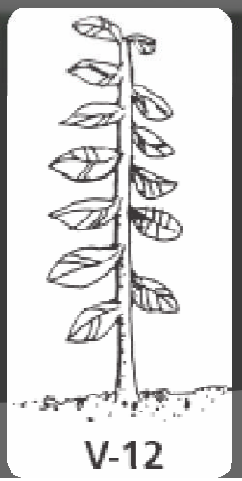


R-3 Top View

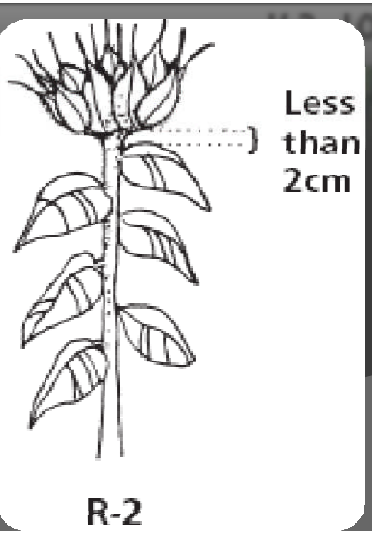


R-4 Top View

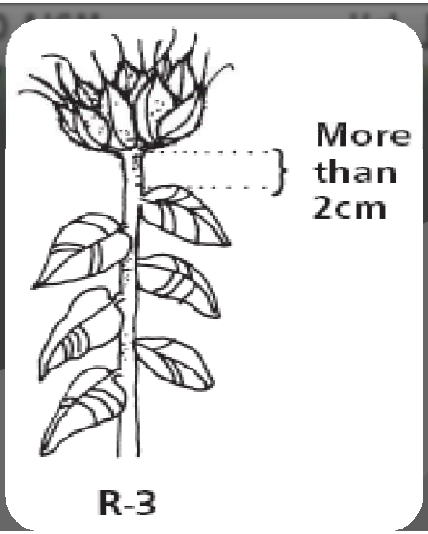
True leaf — 4 cm



V-12



R-2



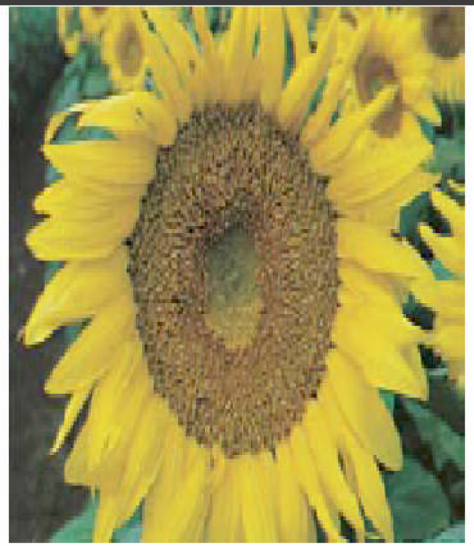
R-3

Growth stages

Schneiter and Miller, 1981.

R-5.1

R-5.5



R-5.9

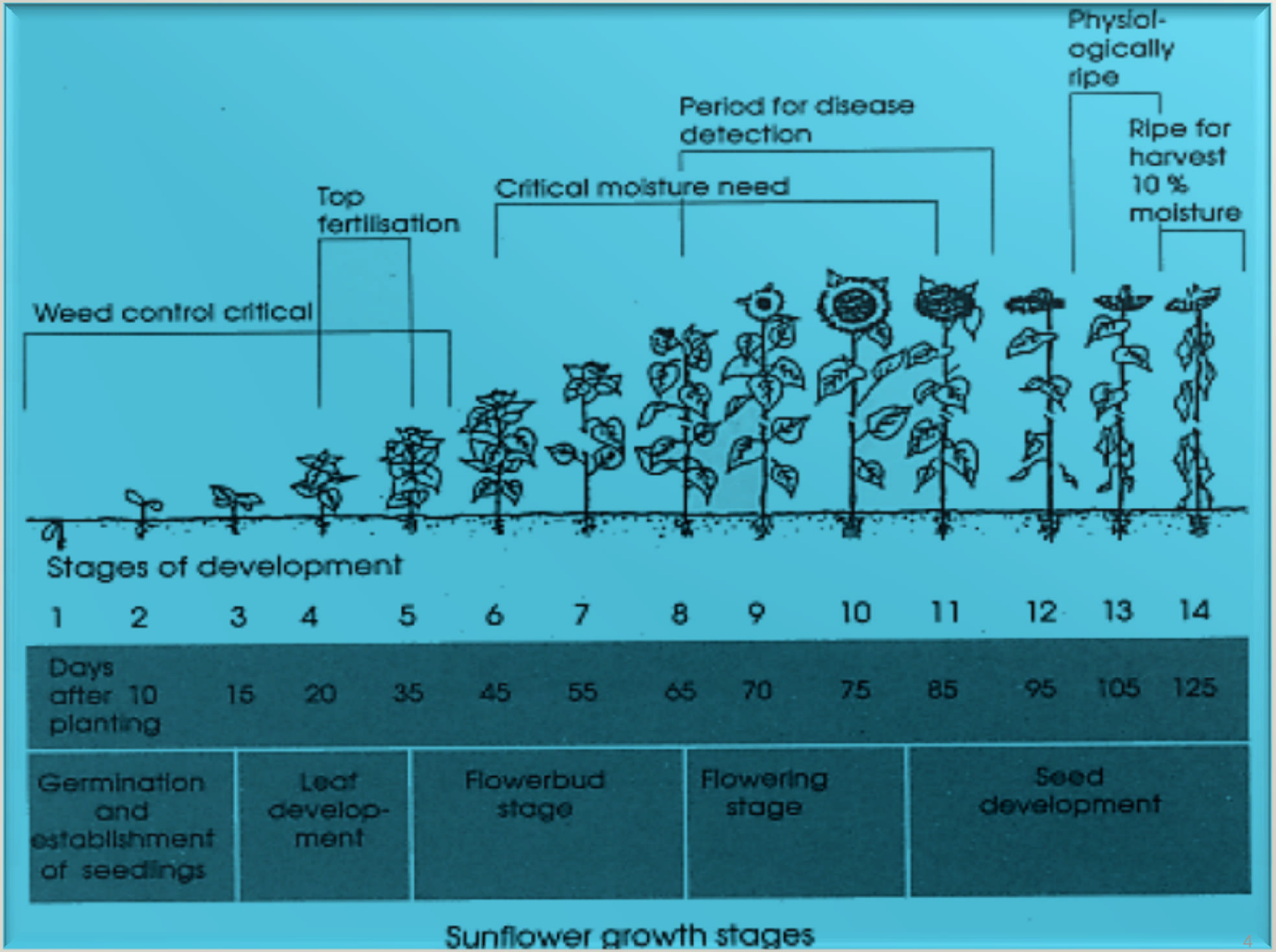
R-6

R-7

R-8

R-9

Schneiter and Miller, 1981.


Physiol-
ogically
ripe
Period for disease
detection
Ripe for
harvest
10 %
moisture
Critical moisture need
Top
fertilisation
Weed control critical
Stages of development
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Days
after 10 15 20 35 45 55 65 70 75 85 95 105 125
planting
Germination
and
establishment
of seedlings
Leaf
develop-
ment
Flowerbud
stage
Flowering
stage
Seed
development
Sunflower growth stages

Factors affecting seed setting and filling in sunflower

(A) GENETIC

- Low autogamy (Protandrous nature)
- Self-incompatibility (Combining ability)

$$\text{Autogamy \%} = \frac{\text{\% seed set under autogamous pollination}}{\text{\% seed set under open pollination}} \times 100$$

(Autogamous pollination is pollination under just covering the head).

$$\text{Self incompatibility \%} = \frac{\text{\% seed set under assisted self pollination}}{\text{\% seed set under open pollination}} \times 100$$

(B) PHYSIOLOGICAL

- Poor vascularization
- Uneven distribution of photoassimilates
- Decreased translocation of photosynthates to sink
- Role of growth regulators

(C) ENVIRONMENTAL

- Season
- Abiotic stresses

(D) AGRONOMIC MANAGEMENT

(E) PHYSICAL AVAILABILITIES OF POLLINATORS

Genetic factors and management

Autogamy studies of sunflower genotypes under bagged and open conditions

Genotypes	% of filled seed set under bagged condition		% seed set under open pollination		Autogamy percentage	
	1998-99	1999-2000	1998-99	1999-2000	1998-99	1999-2000
PKVSH-40	54.45	52.15	84.16	80.07	64.82	65.09
336-B	40.08	37.65	78.86	75.07	50.86	51.87
270-R	45.61	40.23	79.00	75.20	57.72	53.65
PKVSH-41	54.56	51.2	85.02	81.15	64.16	59.64
IB-60-B	40.70	41.26	84.00	80.16	48.46	51.59
IBK-196/2R	36.95	40.64	79.94	76.32	46.23	53.65
PKVSH-27	59.30	59.00	88.93	84.90	66.67	69.76
CMS-2B	42.99	41.86	70.90	77.07	53.08	54.39
AK-1R	46.10	42.63	78.93	75.01	58.35	57.11
CD at 5%	8.432	5.457	2.866	-	10.483	-

Rathod *et al*., 2002

Specific combining ability for seed yield attributes

Cross	No. of filled seeds	100 seed weight (g)	Seed yield per plant (g)
DCMS-18 x DSI-204	174.25	0.28	10.78
DCMS-18 x DSI-216	213.25	0.91	16.43
DCMS-23 x DSI-180	49.57	0.08	2.48
DCMS-23 x DSI-208	62.57	-0.10	2.31
DCMS-14 x DSI-220	377.64	0.29	17.45
DCMS-14 x DSI-225	191.81	0.52	13.51
SE±	23.50	0.10	0.83

Prasad *et al*., 2006

Correlation coefficients (P&G) between yield and yield contributing characters in sunflower

Character		Head diameter (cm)	100-seeds weight (g)	Total dry matter per plant (g)	Filled seeds per plant	Unfilled seeds per plant	Seed set (%)	Seed yield per plant (g)
Plant height (cm)	P	0.39	0.26	0.34	0.19	0.09	0.12	0.37
	G	0.40	0.27	0.35	0.20	0.12	0.12	0.38
Head diameter (cm)	P	1.00	0.10	0.25	0.57	-0.14	0.46	0.59
	G	1.00	0.11	0.25	0.60	-0.25	0.54	0.61
100-seeds weight (g)	P		1.00	0.39	-0.04	-0.06	0.10	0.45
	G		1.00	0.41	-0.05	-0.13	-0.05	0.47
Total dry matter/plant (g)	P			1.00	0.20	0.16	0.15	0.44
	G			1.00	0.21	0.24	0.07	0.45
Filled seeds/plant	P				1.00	-0.21	0.65	0.81
	G				1.00	-0.30	0.70	0.82
Unfilled seeds/plant	P					1.00	-0.45	-0.15
	G					1.00	-0.77	-0.24
Seed set (%)	P						1.00	0.53
	G						1.00	0.55

Ravi *et al*., 2006

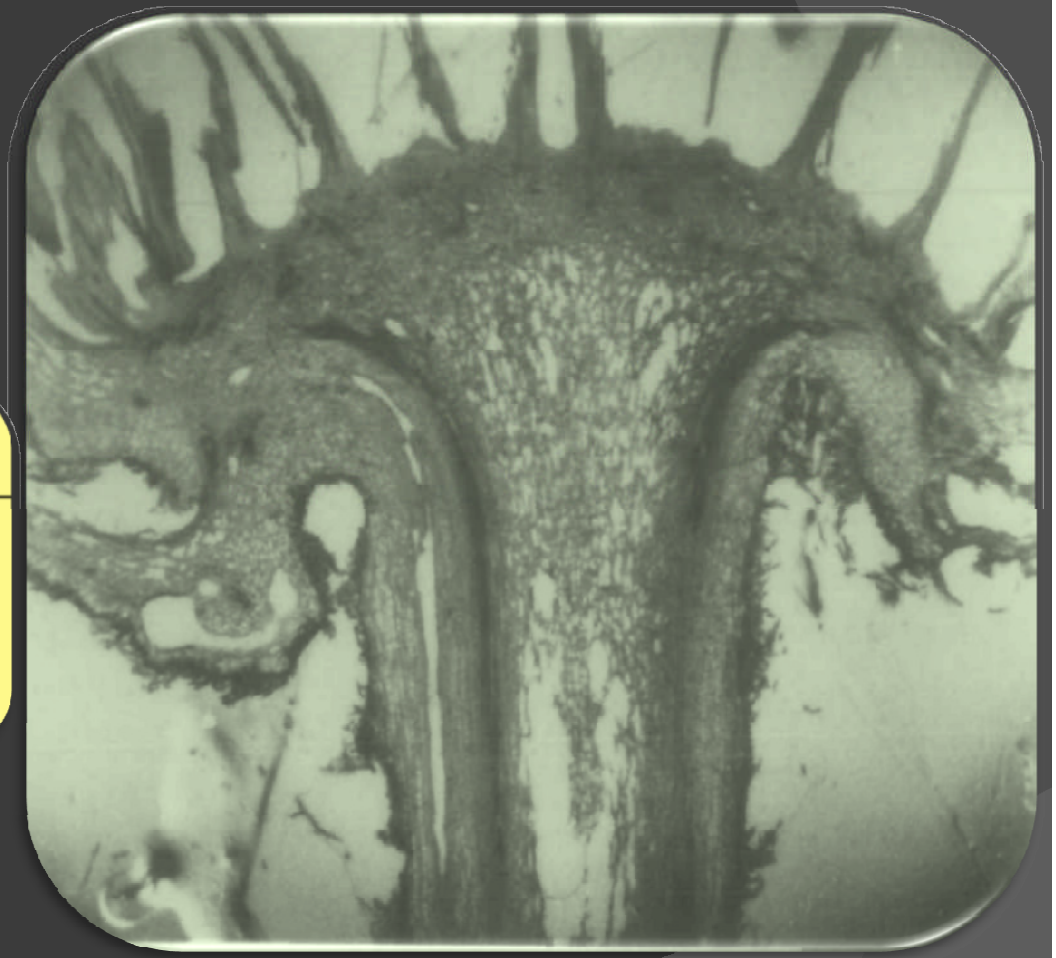
Physiological factors and management

Vascularization and seed filling

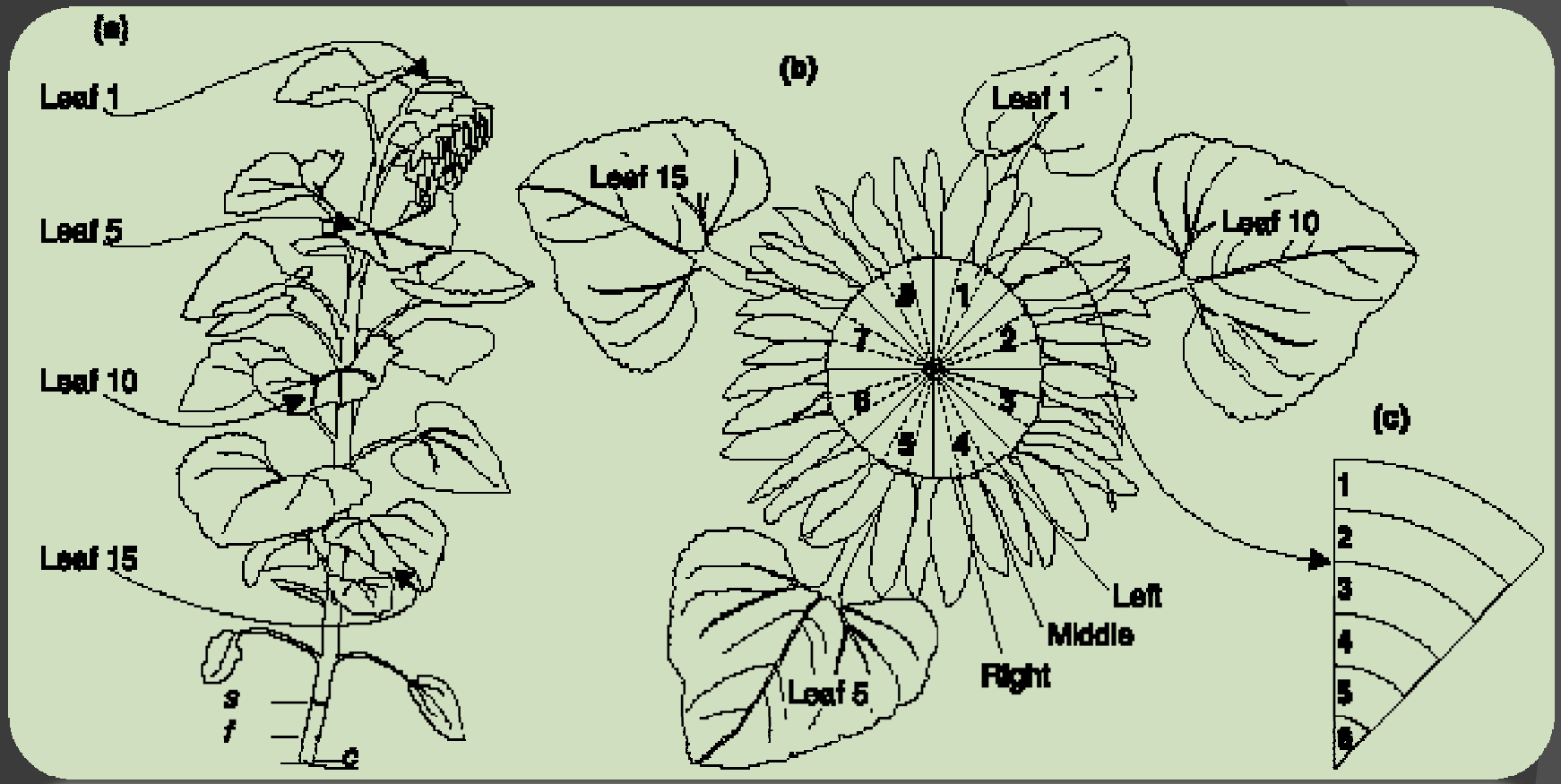
^{14}C lipid/^{14}C protein in peripheral, intermediary and central seeds during the grain-filling period

WAF	P	I	C
2	2·2	1·1	1·0
3	11·5	4·4	0·9
4	18·6	26·5	22·0
5	8·0	12·7	17·1

WAF=Weeks after flowering



Goffner *et al.*, 1988

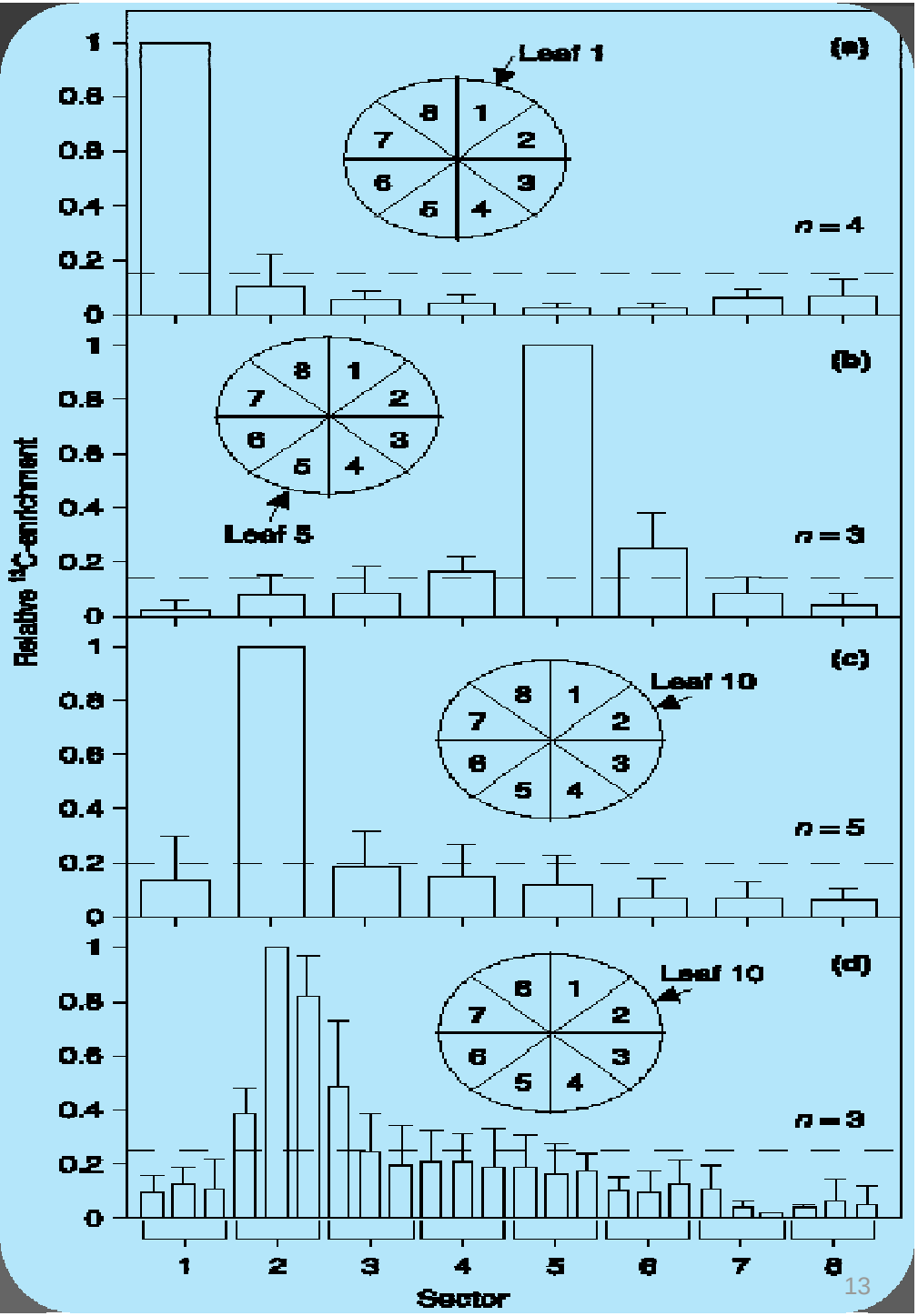


Nomenclature in $^{13}/^{14}$C-photoassimilate transport experiments. (a) Typical sunflower plant used, total number of leaves ranged from 22 to 27 per plant; *c*, *f* and s, remnants of cotyledons, first and second pair of true leaves, respectively. Leaf positions were numbered basipetally; leaf 1 is the most apical true leaf clearly different from involucral bracts. A single leaf between 1 and 15 was exposed either to $^{13}CO2$ or $^{14}CO2$. (b) For ^{13}C-analysis the capitulum was divided into eight main sectors (1–8), corresponding to the 3/8 phyllotaxy. The orientations of leaves 1, 5, 10 and 15 are shown in relation to the sectors. Each main sector was further divided into three subsectors (left, middle and right). (c) Sectorswere divided into six zones (1–6).

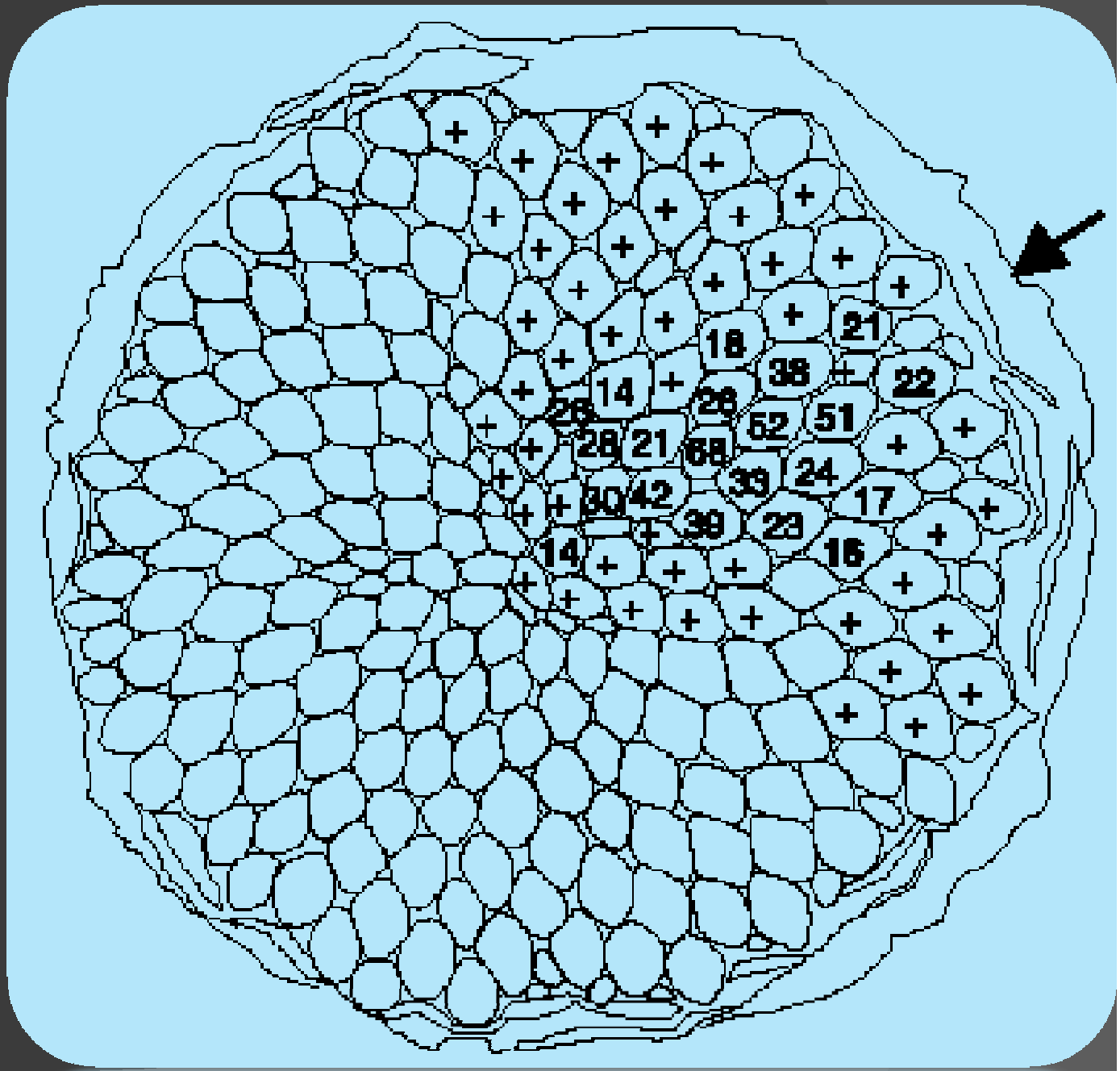
Alkio *et al.*, 2002

Transport of photoassimilates into the sunflower capitulum following $^{13}CO_2$-application to leaf 1, 5 and 10 at different stages of seed filling. The leaf chamber for $^{13}CO_2$-exposure was fixed to the centre of the leaf blade. After a chase period of 24 h samples were taken from the capitulum and analysed for $d^{13}C$ using a mass spectrometer. (For sampling and orientation of the exposed leaves, see previous slide). Data for the zones of maximum ^{13}C-import are displayed for the middle subsectors (a–c) or for each subsector (d). Background (dashed lines) = 2 [‰-points]/$Dd^{13}Cmax$ [‰-points]; $Dd^{13}Cmax$ is the highest ^{13}C-enrichment measured in the given capitulum.

Alkio *et al.*,2002

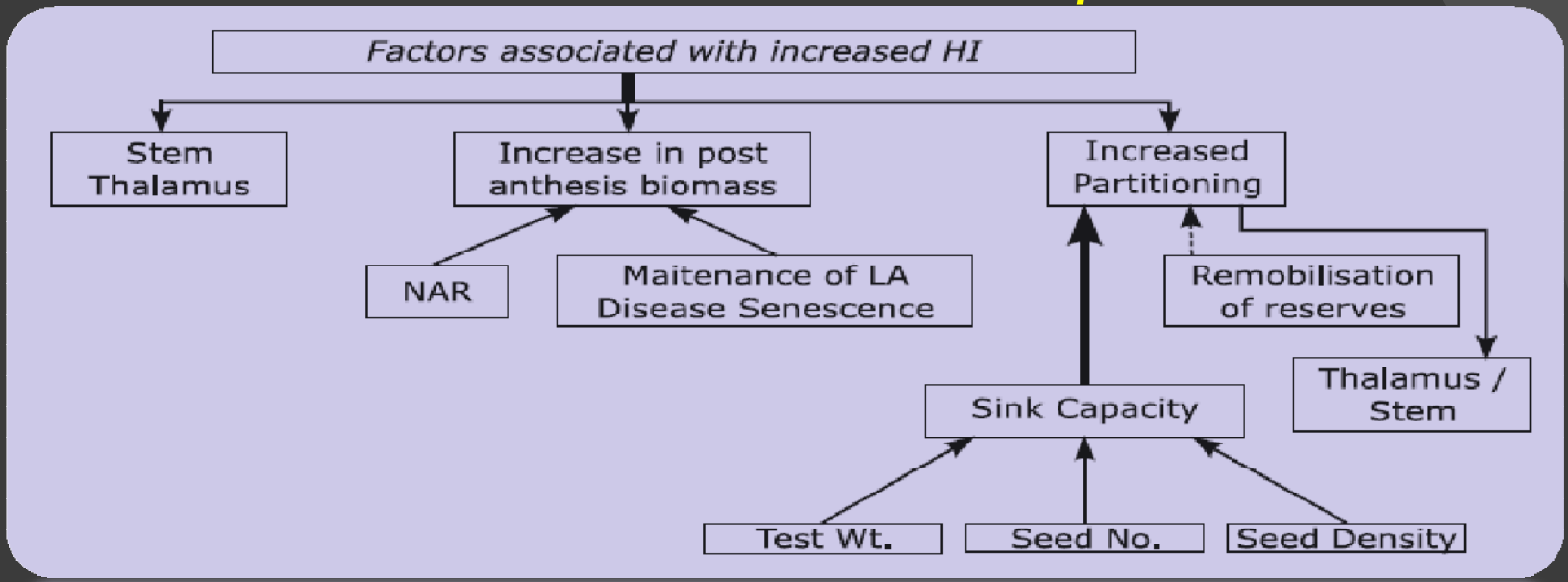


Transport of photoassimilates into the sunflower capitulum following $^{14}CO_2$-application to leaf 6 during seed filling. The leaf chamber for $^{14}CO_2$-exposure was fixed to the centre of the leaf blade. The arrow indicates the orientation of the insertion site of the exposed leaf. After a chase period of 3 h every single achene was taken from the capitulum and analysed for radioactivity using a phosphorimager. The distribution pattern shown was obtained from one plant; altogether, nine plants were investigated, with similar results. Achenes without symbol, radioactivity < 1 PSL mm^{-1}; achenes with crosses, 1 PSL mm^{-1} < radioactivity < 14 PSL mm^{-1}; achenes with figures, radioactivity in PSL mm^{-1}; PSL = quantity of photostimulated luminescence.

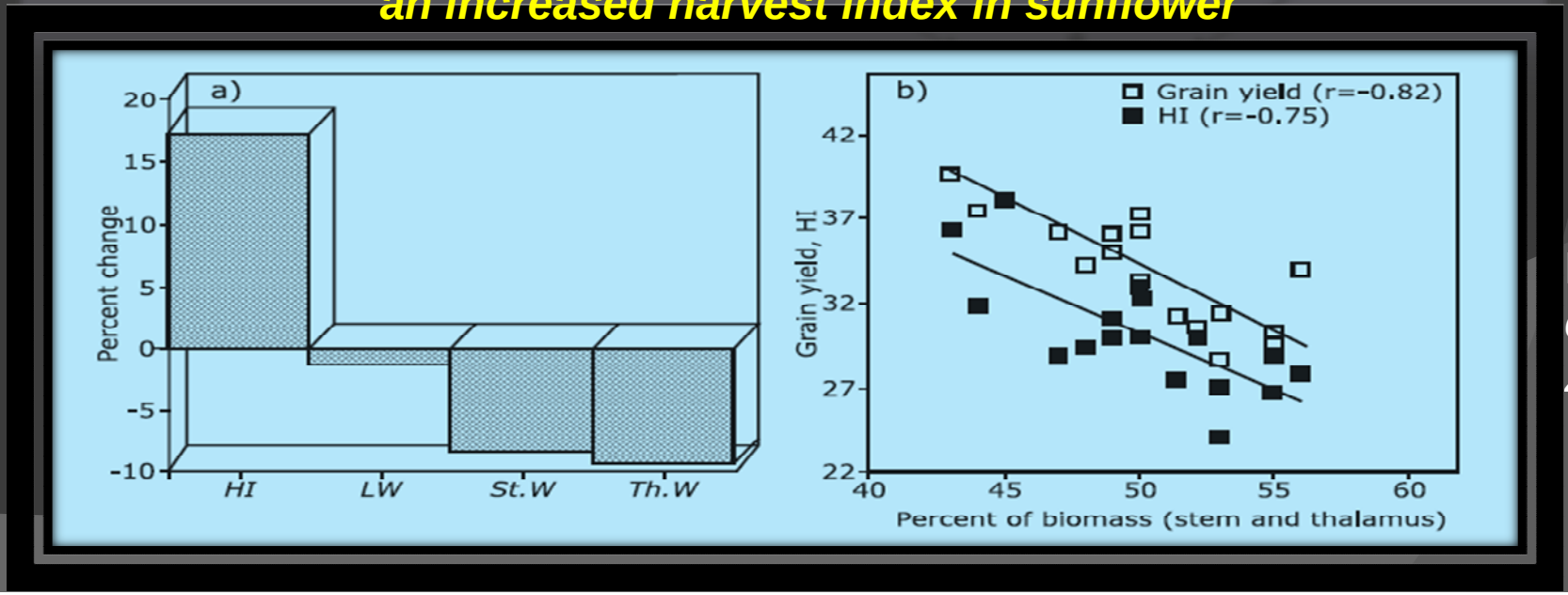


Alkio *et al.*,2002

Schematic representation showing the factors associated with an increased harvest index in sunflower

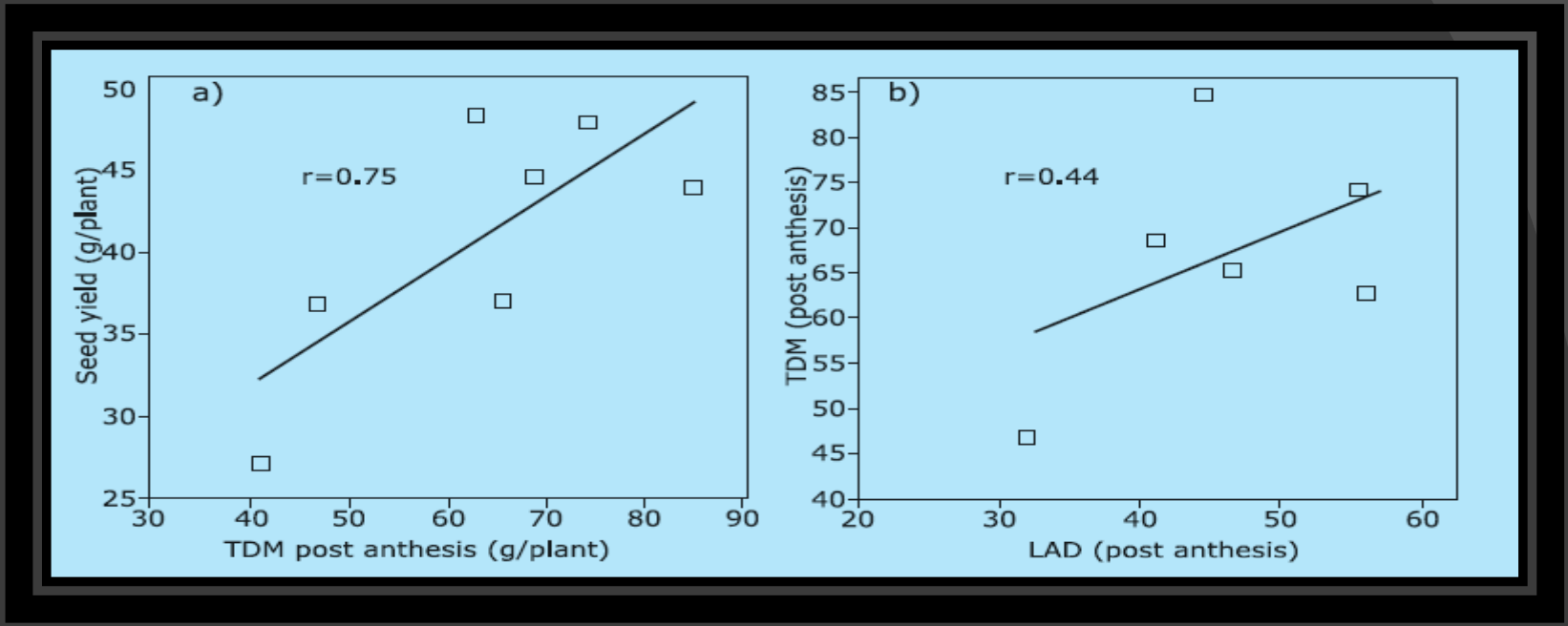


Comparative partition showing the factors associated with an increased harvest index in sunflower



Reddy *et al., 2003*

Relationship between post-anthesis biomass production and seed yield (a) and post-anthesis LAD and post-anthesis dry matter production in sunflower (b)



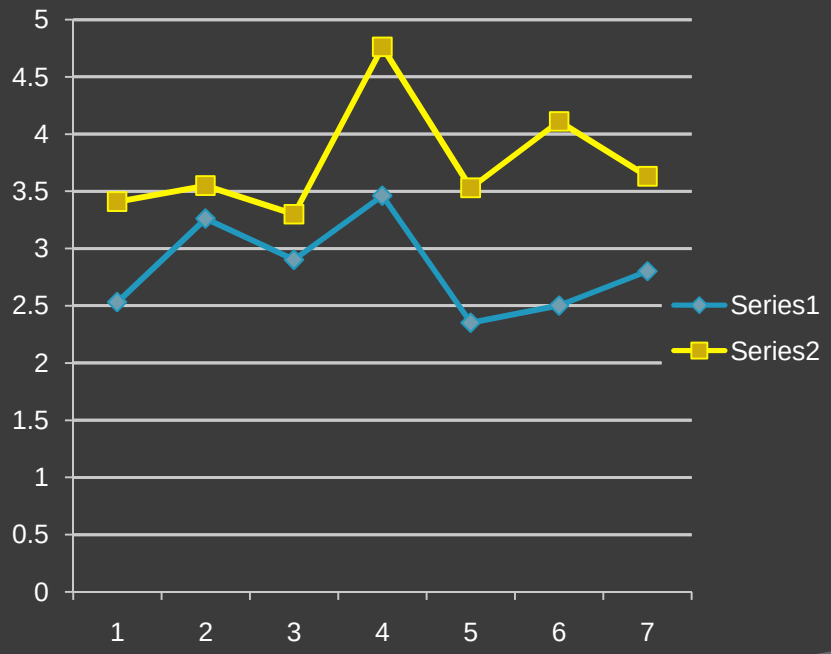
Effect of TIBA and NAA application on sink characters and seed yield of sunflower (cv. Morden) at constant source size

Treatment	Head diameter (cm)	Filled seed no./head	Weight of filled seed (g)	1000-seed weight (g)	Seed yield (kg ha^{-1})
Control	15.0	624	31.2	49.9	968
TIBA (240 ppm)	16.8	701	48.8	60.7	1246
TIBA (240 ppm) + NAA (50 ppm)	18.3	764	52.6	68.8	1295
CD (P<0.05)	2.1	84	6.3	3.3	44

Reddy *et al., 2003*

Glycolate content at various stages of growth and development (values are mean of three observations and expressed as mg per gram fresh weight of leaf)

Variety	Days after sowing						
	15	30	45	60	75	90	105
Orange Red	2.53±0.05	3.26±0.02	2.90±0	3.46±0.02	2.35±0.07	2.50±0	2.80±0.04
EC 68413	3.41±0.02	3.55±0.04	3.30±0	4.76±0.02	3.53±0.05	4.11±0.10	3.63±0.02

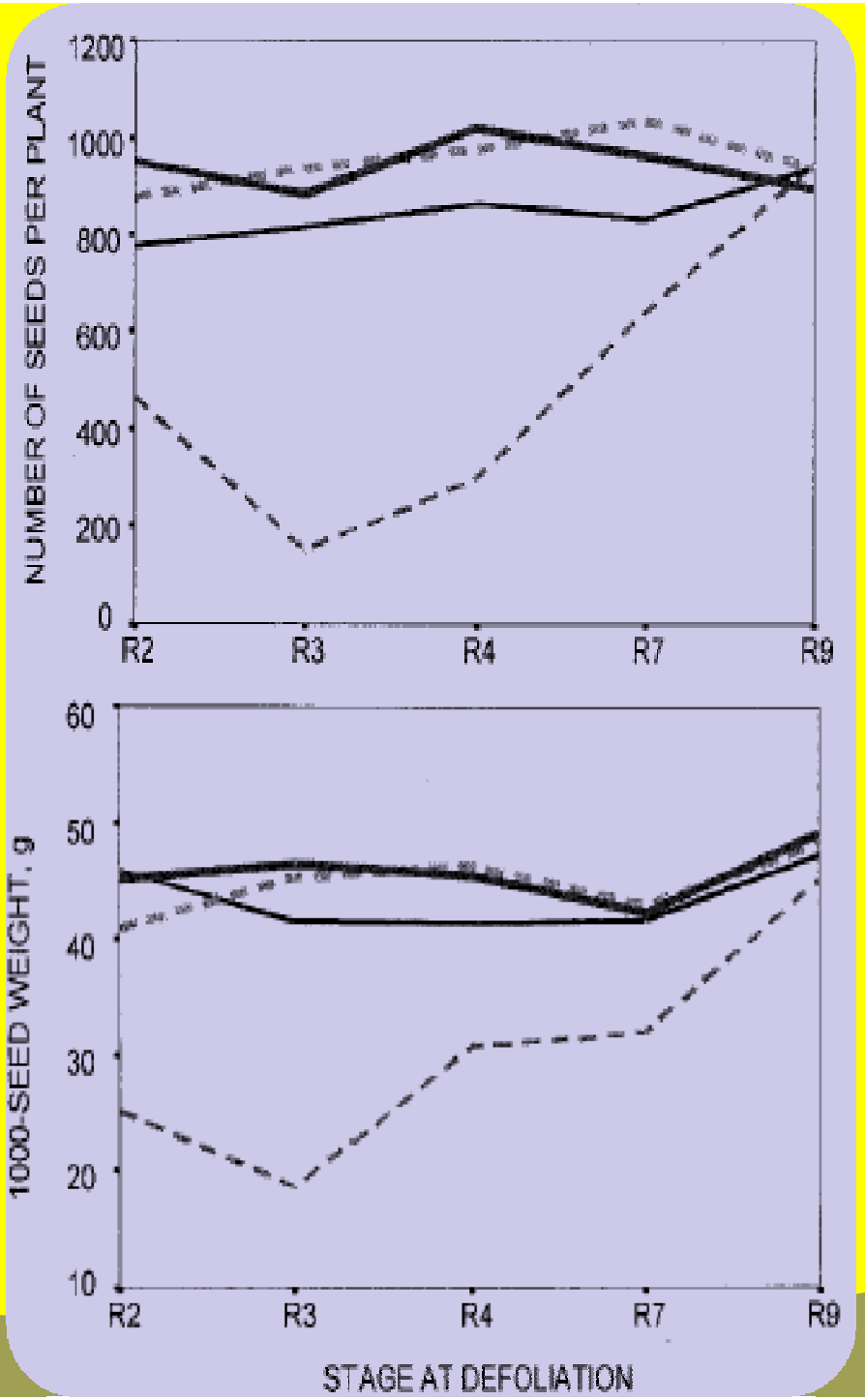


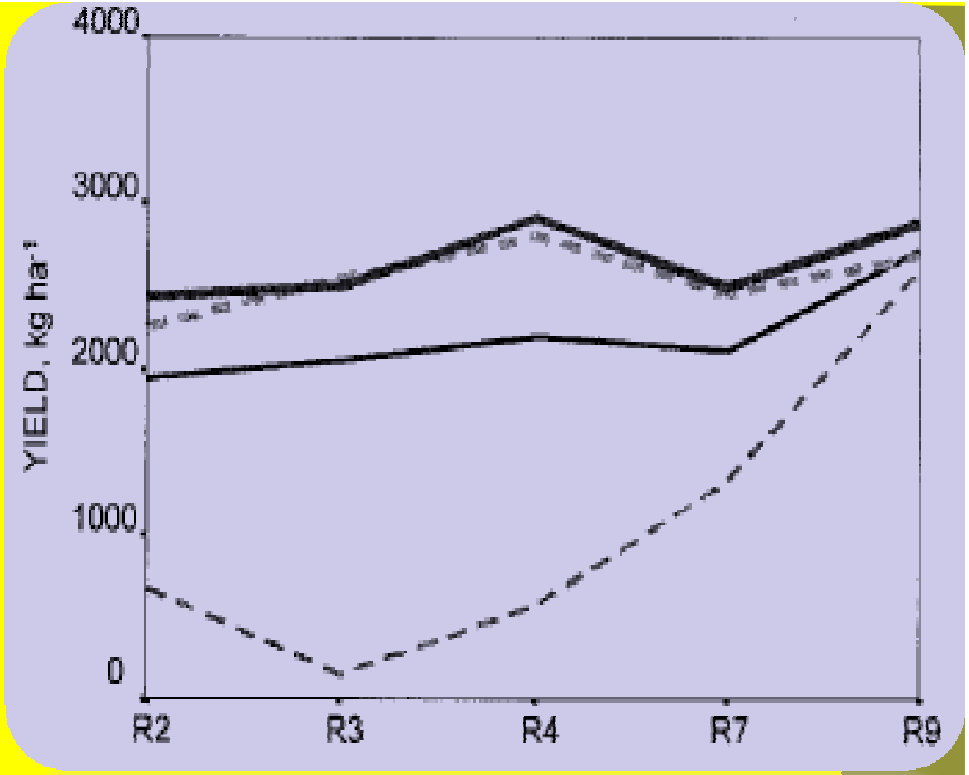
Series 1 =EC 68413
Series 2 =Orange Red

1=15
2=30
3=45
4=60
5=75
6=90
7=105

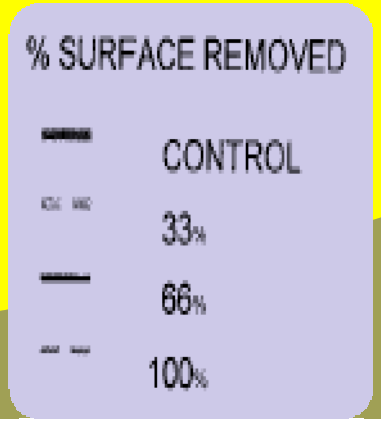
Days after sowing

Sairam and Srivastava, 1984



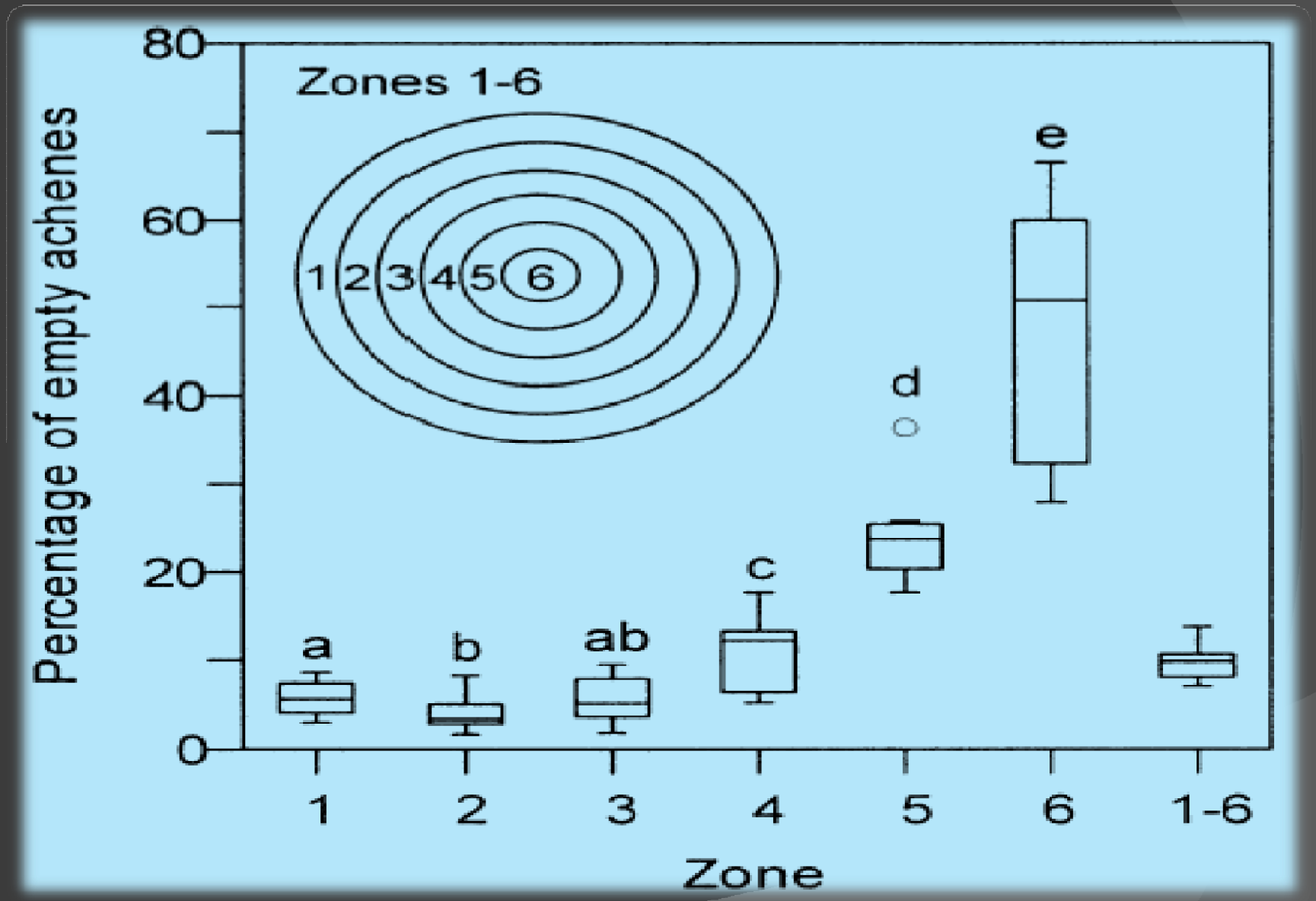


Defoliation effect



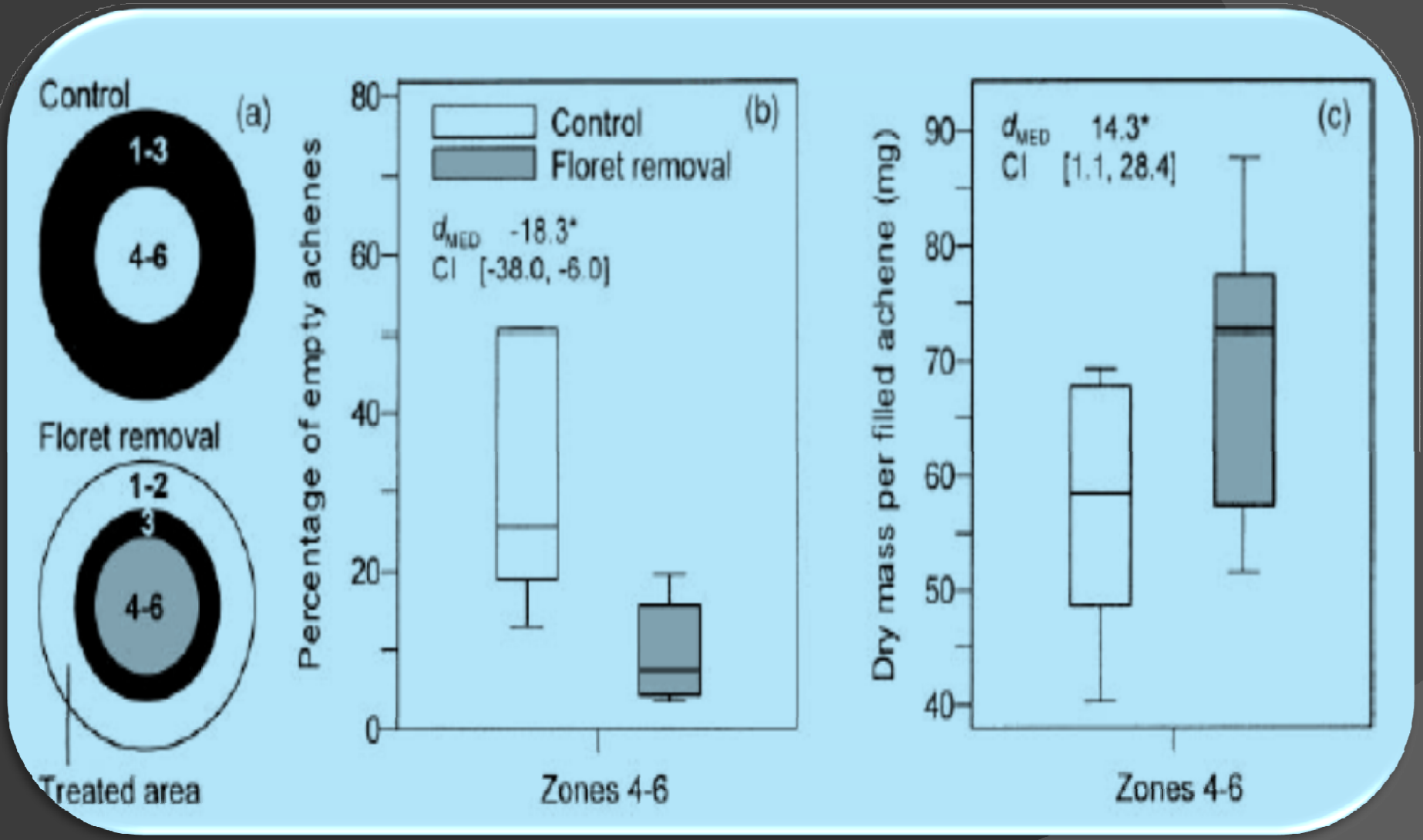
Muro *et al.*, 2001

Source–sink ratio and seed development in sunflower



Alkio *et al.*, 2003

Effect of floret removal on seed filling



Alkio *et al.*, 2003

Effect of nipping of auxillary buds on seed yield

Treatment	Capitulum diameter (cm)	Filled seed Number/ Capitulum	Seed set (%)	Seed wt/plant (g)
kharif 1997-98				
N0- control	9.04	306.1	61.68	9.79
N1-once nipping	1235	350.7	70.28	20.57
N2- continuous nipping	13.56	396.7	79.71	24.72
CD (P=0.05)	0.41	8.8	1.79	0.97
Spring 1997-98				
N0-control	9.06	310.2	62.14	6.53
N1-once nipping	11.51	363.9	73.20	17.31
N2-continuous nipping	13.81	423.8	84.51	21.9
CD (P=0.05)	0.27	9.7	1.34	0.53

Nipping stage – 50 DAS

vyakaranahal *et al.*, 2002

Effect of moisture stress on yield attributes

Treatment/character	DAS	T1	T2	T3	T4	T5	CD (P=0.05)
LAI	65	3.2	2.4	2.5	2.3	3.1	0.07
	87	2.4	1.7	1.9	1.7	2.1	0.06
Head Diameter (cm)	-	10.9	15.7	15.7	13.5	14.3	0.21
Seed filling (%)	-	85	80	80	75	76	0.8
100 seed weight (g)	-	4.0	3.6	3.8	3.6	3.6	0.7
Seed yield per plant	-	27.5	22.9	24.3	21.4	22.2	0.6

T1= No stress
T2= Stress at vegetative stage
T3= Stress at bud initiation stage
T4= Stress at flowering stage
T5= stress at seed filling stage

Reddy *et al*., 2003

Characteristics of the capitulum after foliar application of BA and GA to hybrid SPS 894

Treatments	Inner portion of the Capitulum			1000 achene weight (inner)
	Empty achenes (%)	Achene weight (g)	Achene number	
control	30a	6.5a	220a	29.5a
20 days after emergence				
GA 150	26a	6.4a	223a	28.7a
GA + BA 150	26a	7.5a	235a	31.2ab
BA 150	27a	8.3b	203a	40.1c
BA 250	24ab	9.2c	237a	38.8c
40 days after emergence				
GA 150	27a	6.2a	243a	25.5a
GA + BA 150	13c	8.0b	250b	32.1ab
BA 150	17b	7.0b	233a	33.2b
BA 250	21b	7.7b	251b	27.9a
60 days after emergence				
GA 150	28a	7.1b	240a	29.6a
GA + BA 150	29a	7.1b	245ab	22.6a
BA 150	20b	8.4c	269c	31.2ab

Averages followed by the same letter, in the same column are not significantly different (P=0.05)

Beltrano *et al.*, 1994

Effect of fertilizer (N) levels and Brassinolide(S) on seed filling percentage of sunflower

Treatments	Summer97						South west monsoon 97					
	N_1	N_2	N_3	N_4	N_5	S mean	N_1	N_2	N_3	N_4	N_5	S mean
S_1	**74.3**	**76.4**	**78.2**	**79.8**	**80.5**	**77.8**	**73.5**	**75.8**	**77.7**	**79.4**	**80.2**	**77.3**
S_2	**81.7**	**83.8**	**85.8**	**87.7**	**88.6**	**85.5**	**81.1**	**83.3**	**85.4**	**87.4**	**88.5**	**85.2**
S_3	**86.3**	**89.9**	**91.8**	**93.9**	**94.4**	**91.3**	**85.6**	**89.3**	**91.3**	**93.5**	**94.2**	**90.7**
S_4	**83.8**	**86.3**	**88.6**	**90.4**	**90.8**	**87.9**	**83.2**	**85.8**	**88.2**	**90.1**	**90.7**	**87.6**
N mean	**81.5**	**84.1**	**86.1**	**87.9**	**88.6**		**80.5**	**83.5**	**85.7**	**87.6**	**88.5**	
			CD								**CD**	
N mean			**0.40**								**0.08**	
S mean			**0.37**								**0.14**	
N at S			**0.83**								**0.30**	
S at N			**0.84**								**0.33**	

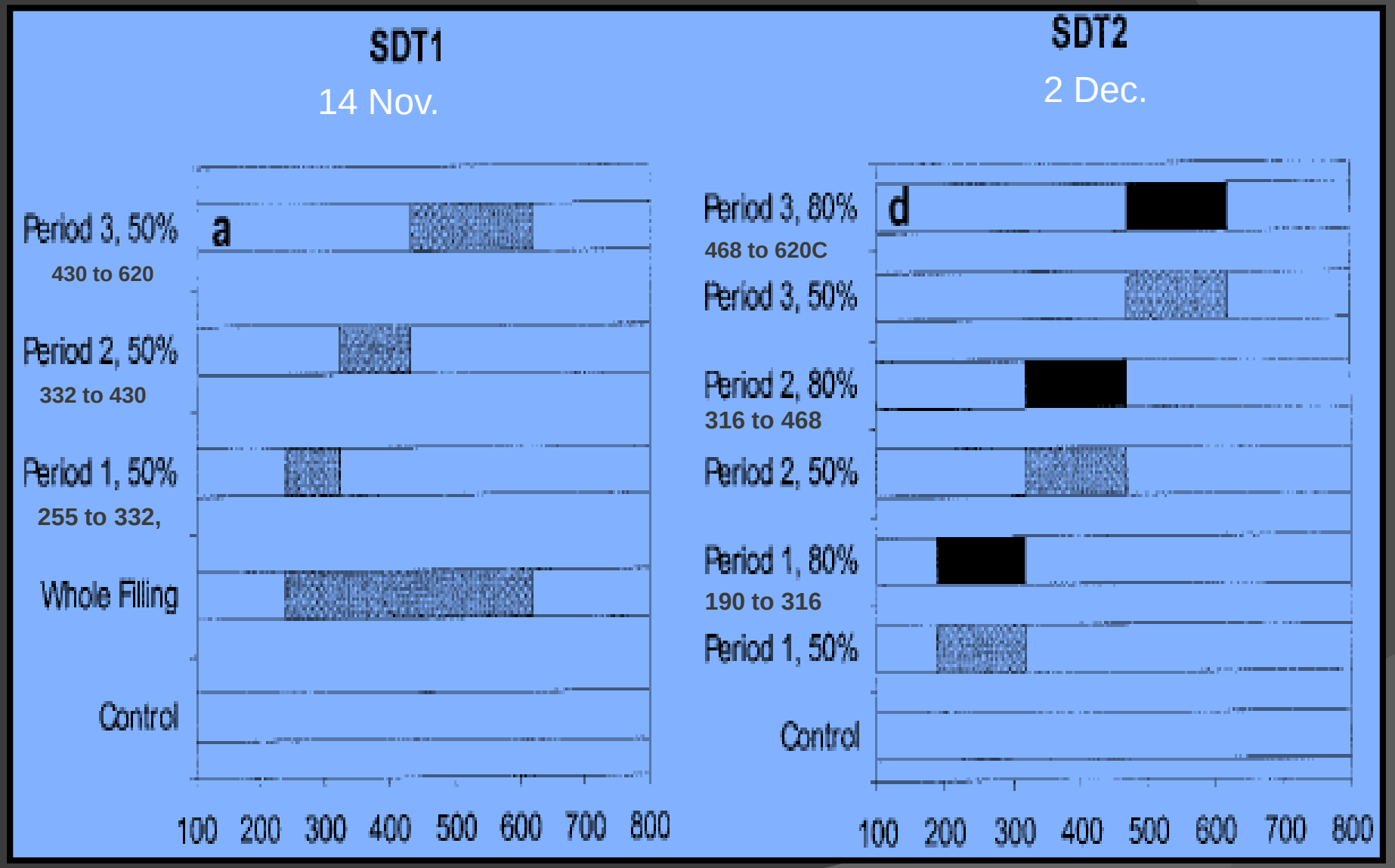
N_1 – N:P:K: :40:20:20 kg/ha
N_2 – N:P:K: :50:25:25 kg/ha
N_3 – N:P:K: :60:30:30 kg/ha
N_4 – N:P:K: :70:35:35 kg/ha
N_5 – N:P:K: :80:40:40 kg/ha

S_1 - Control
S_2 – Hand pollination
S_3 – Spraying 1 ppm Brassinolide
S_4 – 0.2% borax + 2% DAP at ray floret opening stage

Chinnamuthu *et al.*, 2000

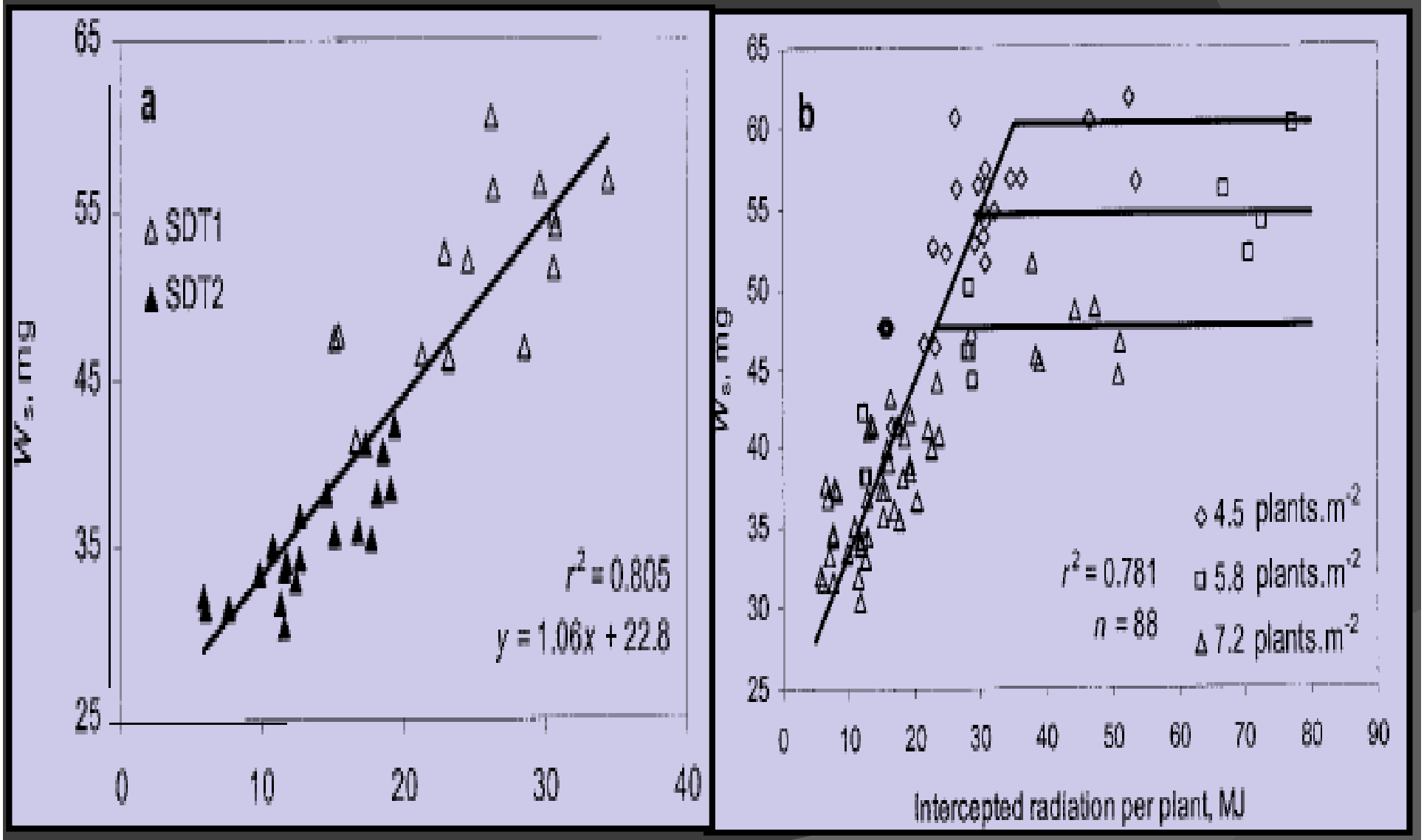
Environmental factors and management

Radiation treatments



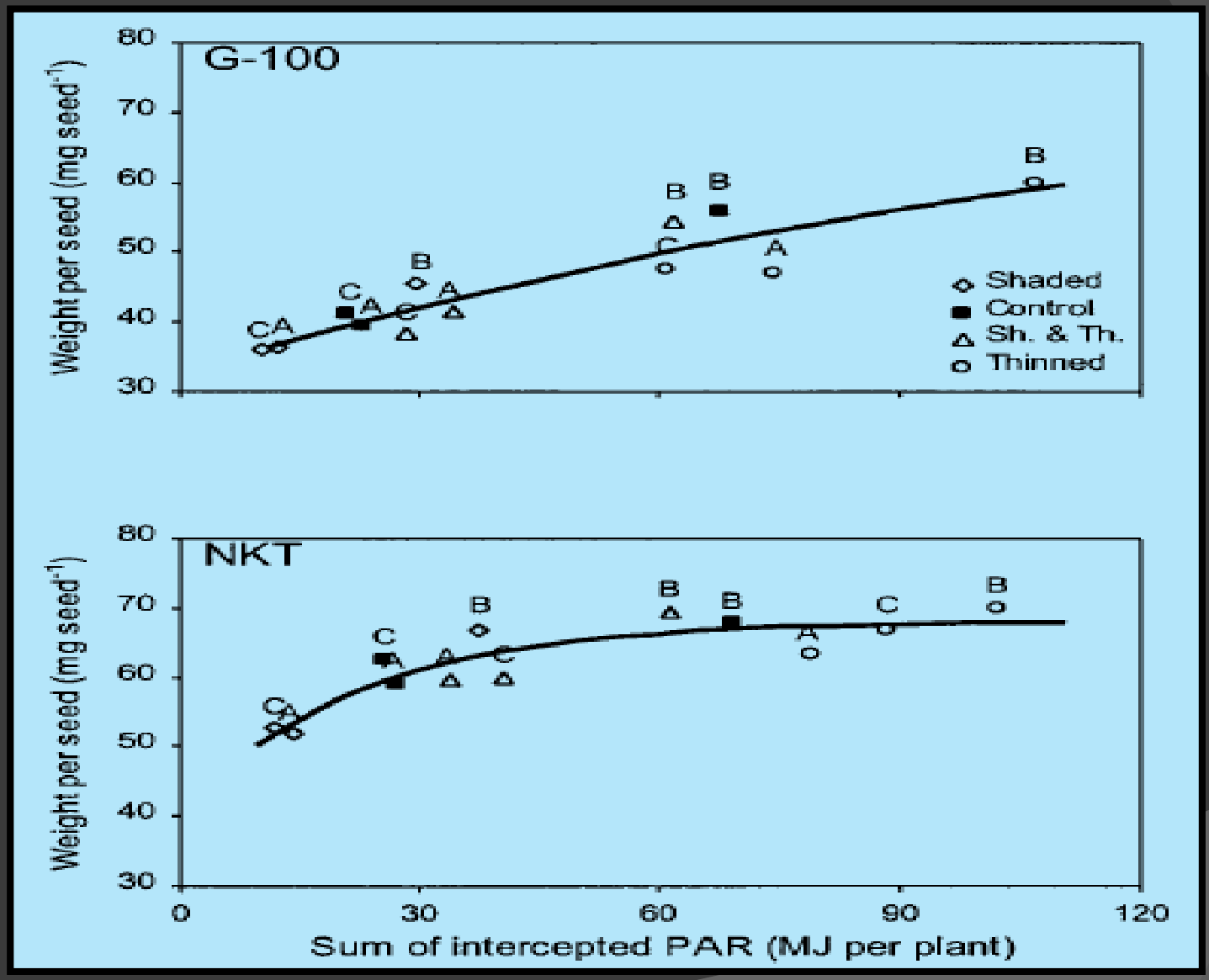
Thermal time after flowering ^{0}C days Luis, *et al.*, 2003

Final weight per seed and PAR



Luis, *et al.*, 2003

Solar radiation and seed filling



Guillermo *et al.*,2000

Number of filled seeds per capitulum as influenced by location, planting season and staggered sowing

Treatments	Location (L)		Season (P)		Mean (S)
	L_1	L_2	P_1	P_2	
Female					
S_0	150.80	153.77	145.57	159.00	152.28
S_1	266.80	268.77	276.28	259.30	267.79
S_2	411.89	488.43	430.53	469.78	450.16
S_3	313.02	342.34	318.85	336.51	327.68
S_4	179.22	176.17	173.48	181.90	177.69
S_5	351.85	438.94	384.98	405.81	395.39
S_6	332.15	419.14	342.43	408.86	375.64
S_7	320.86	322.95	321.05	322.75	320.90
Mean	290.82	326.31	299.15	317.99	308.57
	L	L´S	P	P´S	S
S.Em±	2.88	8.16	2.88	8.16	5.77
CD at 5%	8.15	23.04	8.15	23.04	16.29

L_1 - Dharwad P_1 - Kharif
L_2 - Bagalkot P_2 - Rabi
S_0 - Simultaneous sowing of female and male parent
S_1 - Sowing of male parent four days early to the female parent
S_2 - Sowing of male parent seven days early to the female parent
S_3 - Sowing of male parent ten days early to the female parent
S_4 - S_0 + spraying of urea (2%) at button formation stage to male parent
S_5 - S_1 + spraying of urea (2%) at button formation stage to male parent
S_6 - S_2 + spraying of urea (2%) at button formation stage to male parent
S_7 - S_3 + spraying of urea (2%) at button formation stage to male parent

Umesh *et al.*, 2007

Number of seed set per capitulum as influenced by location, planting season and staggered sowing

Treatments	Location (L)		Season (P)		Mean (S)
	L_1	L_2	P_1	P_2	
S_0	28.68	29.11	27.93	29.86	28.89
S_1	44.98	45.46	46.53	43.91	45.22
S_2	65.98	76.94	68.65	74.28	71.46
S_3	51.82	56.05	52.65	55.21	53.93
S_4	32.72	32.24	31.90	33.05	32.48
S_5	57.40	69.85	62.14	65.11	63.62
S_6	55.97	68.40	57.49	66.88	62.18
S_7	52.98	53.25	53.00	53.22	53.11
Mean	48.82	53.91	50.03	52.69	51.36
	L	LxS	P	PxS	S
S.Em±	0.25	0.70	0.25	0.70	0.49
CD at 5%	0.70	1.97	0.70	1.97	1.39

L_1 - Dharwad P_1 - Kharif
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S_7 - S_3 + spraying of urea (2%) at button formation stage to male parent

Umesh *et al.*, 2007

Mean seed yield of sunflower genotypes under different pollination methods over seasons

Season/treatment	Hybrid	Inbreds	Morden	Mean
Rainy				
Cloth bag	**22.58**	**7.22**	**11.50**	**10.21**
Cloth bag + assisted pollination	**29.19**	**11.33**	**14.74**	**14.74**
Cloth bag + bulk pollen pollination	**35.68**	**14.62**	**18.96**	**18.96**
Open pollination	**54.39**	**20.41**	**27.14**	**27.14**
Mean	**35.46**	**13.39**	**17.76**	**17.78**
Summer				
Cloth bag	**30.44**	**15.87**	**18.35**	**18.35**
Cloth bag + assisted pollination	**37.91**	**18.70**	**22.57**	**22.57**
Cloth bag + bulk pollen pollination	**43.82**	**20.38**	**21.60**	**24.70**
Open pollination	**49.62**	**23.55**	**31.57**	**28.50**
Mean	**40.44**	**19.28**	**21.94**	**23.48**
CD at 5%	Between 2 means	Between 2 sub means	Between 2 submeans at same main mean	Between 2 mainmeans at same or different submeans
Rainy	**2.12**	**0.79**	**3.71**	**3.82**
Summer	**2.60**	**1.06**	**4.93**	**4.98**

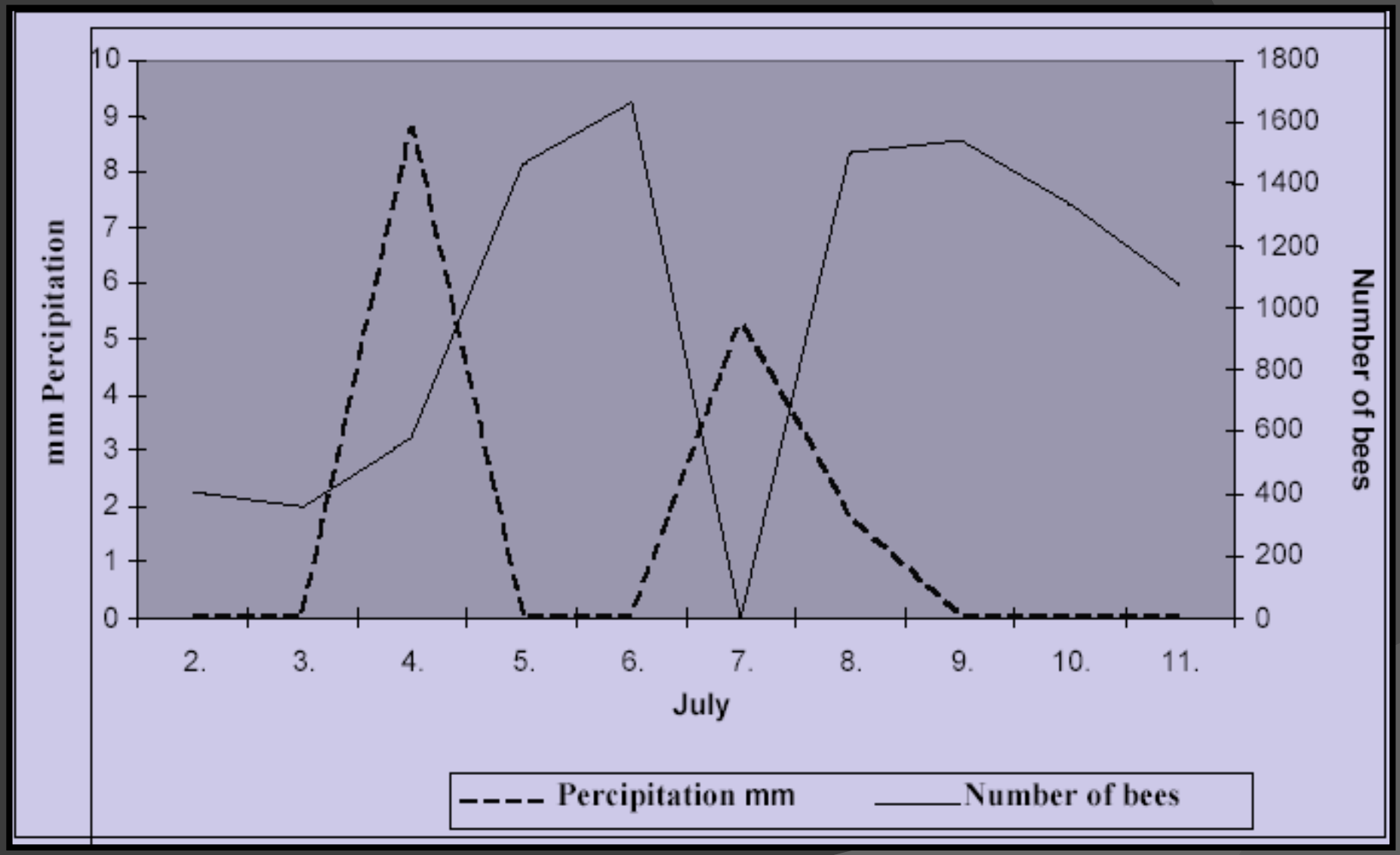
Sumangala and Giriraj, 2003

Percent seed filling under self and open pollination during *kharif*, *rabi*, and spring seasons in sunflower

Genotype	Self pollination			Open pollination		
	Kharif	Rabi	Spring	Kharif	Rabi	Spring
Peredovik	12.3	**29.6**	3.8	**84.2**	70.2	73.7
Arrowhead	12.9	1.3	**23.3**	81.6	77.6	**85.2**
Smena	**25.2**	11.5	13.6	82.5	67.7	**83.0**
White Africa	0.3	**11.2**	0.7	84.4	57.3	**87.6**
Krasnodar	2.7	**5.8**	1.9	86.4	75.0	79.6
K 989	0.0	**33.4**	2.0	81.5	77.2	80.9
K 2128	0.0	**34.7**	8.8	87.1	**87.2**	60.7
EC99231B	0.4	58.3	**61.8**	87.6	45.4	67.5
EC102318	29.6	2.0	**42.2**	80.8	77.1	**87.6**
EC113790	16.7	26.6	**77.0**	71.2	66.8	69.8
Mean	12.1	**20.6**	19.6	**83.7**	71.3	78.4
CD (0.05)	3.3	7	5.2	10.3	7.7	7

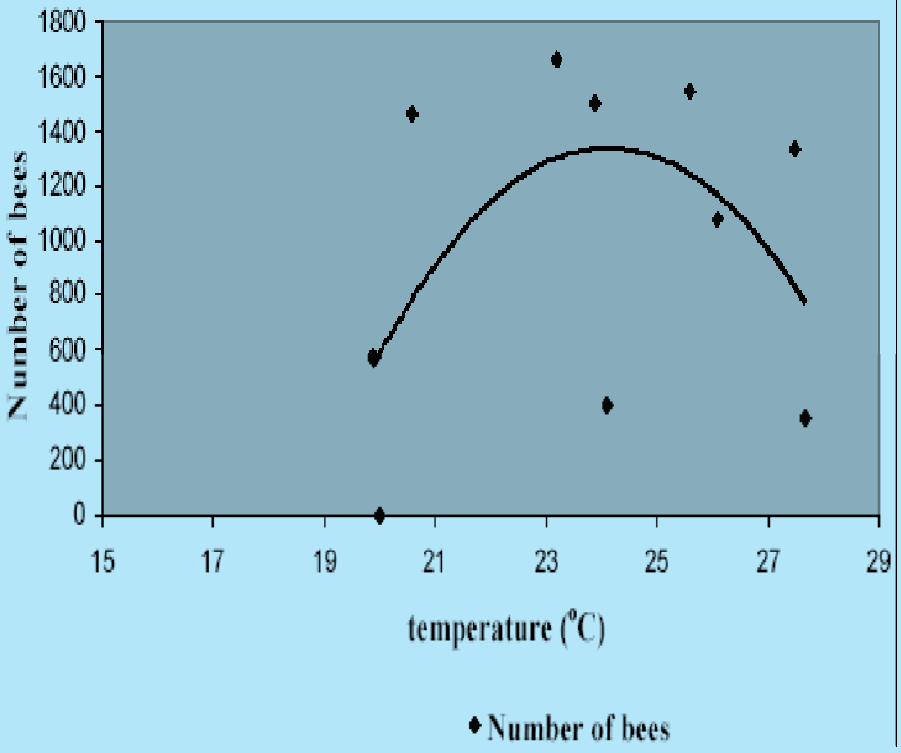
Choudhary and Anand, 1989

Precipitation and number of bees

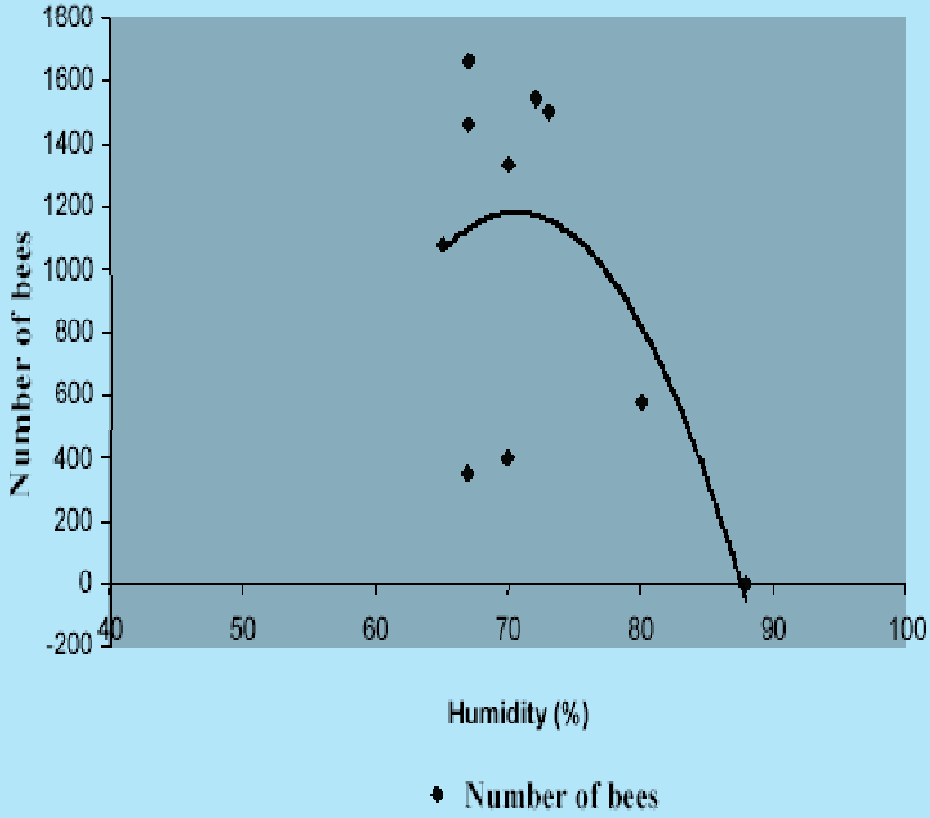


Puskadija, *et al*., 2007

Temperature and bees



Humidity and bees



Puskadija, *et al*., 2007

Agronomic management

Effect of pre sowing treatments (cv Morden)

Treatment	Disc size(cm^2)	Number of filled seeds	Number of unfilled seeds	100 seed weight (g)	Seed yield (kg/ha)
Control	**318**	**481**	**106**	**4.1**	**1276**
Kcl	**325**	**301**	**103**	**4.2**	**1484**
$MnSO_4$	**324**	**492**	**101**	**4.3**	**1578**
KNO_3	**321**	**487**	**104**	**4.1**	**1378**
Thiourea	**301**	**440**	**97**	**4.1**	**527**
GA_3	**324**	**494**	**110**	**4.2**	**1460**
Kinetin	**335**	**493**	**106**	**4.1**	**1407**
Hydration	**322**	**490**	**102**	**4.1**	**1410**
Hydration + Thiram	**330**	**490**	**102**	**4.2**	**1461**
Thiram	**367**	**504**	**106**	**4.2**	**1527**
Trichoderm herzianum	**368**	**515**	**105**	**4.1**	**1657**
CD (P=0.05)	**6.8**	**17.8**	**7.4**	**0.06**	**56.59**

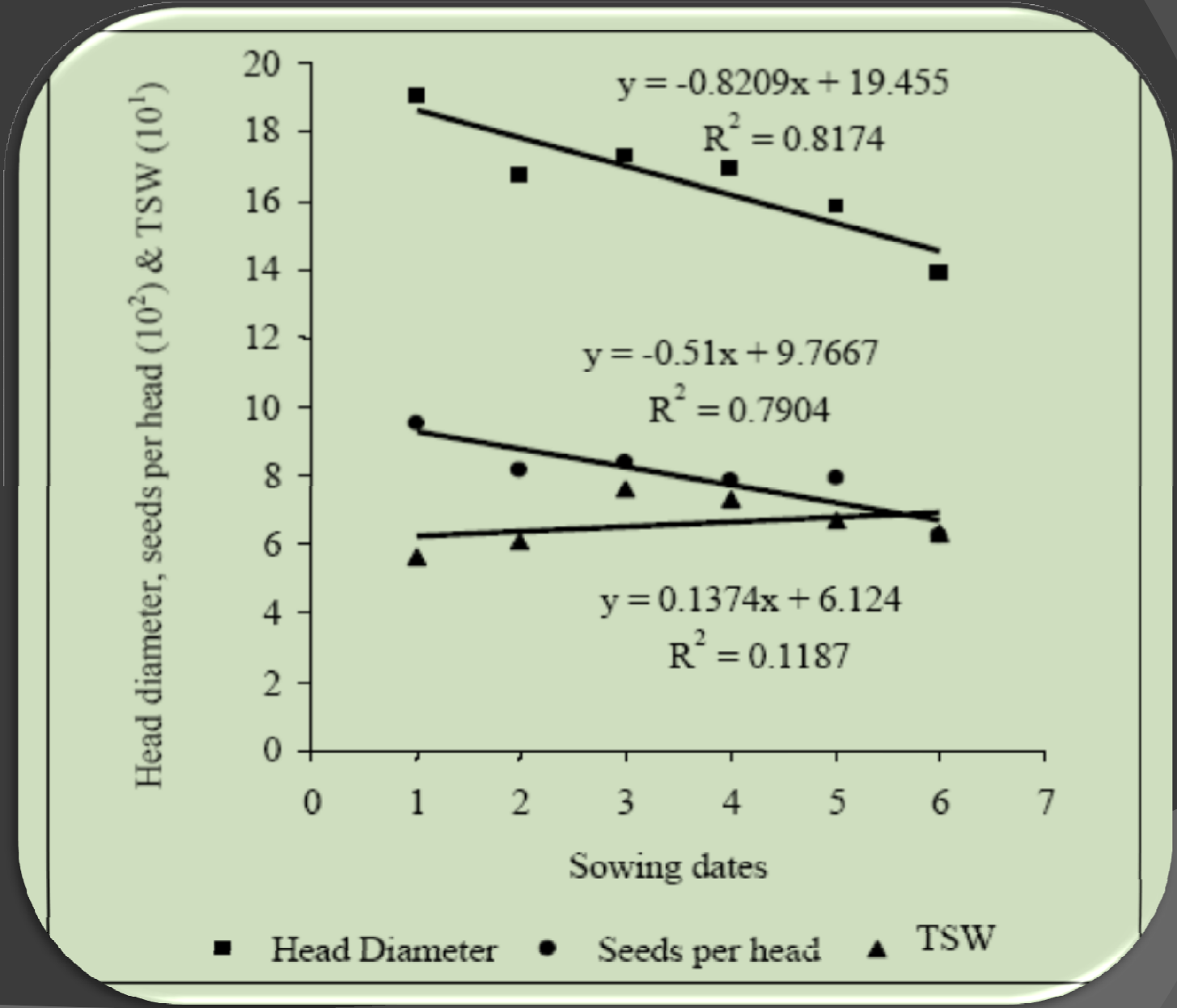
Shivanker *et al*., 2003

Effect of planting date on seed yield

Date of planting (D)	Capitulum diameter (cm)	Filled seed Number/ Capitulum	Seed set (%)	Seed wt/plant (g)
kharif 1997-98				
D1- July	13.03	381.2	76.36	21.16
D2- August	10.27	321.0	64.75	15.56
CD (P=0.05)	0.61	10.6	3.85	3.56
Spring 1997-98				
D1- Dec.	12.27	383.4	76.33	17.86
D2- Jan.	10.63	348.5	70.24	12.63
CD (P=0.05)	0.33	34.2	5.43	1.00

vyakaranahal *et al.*, 2002

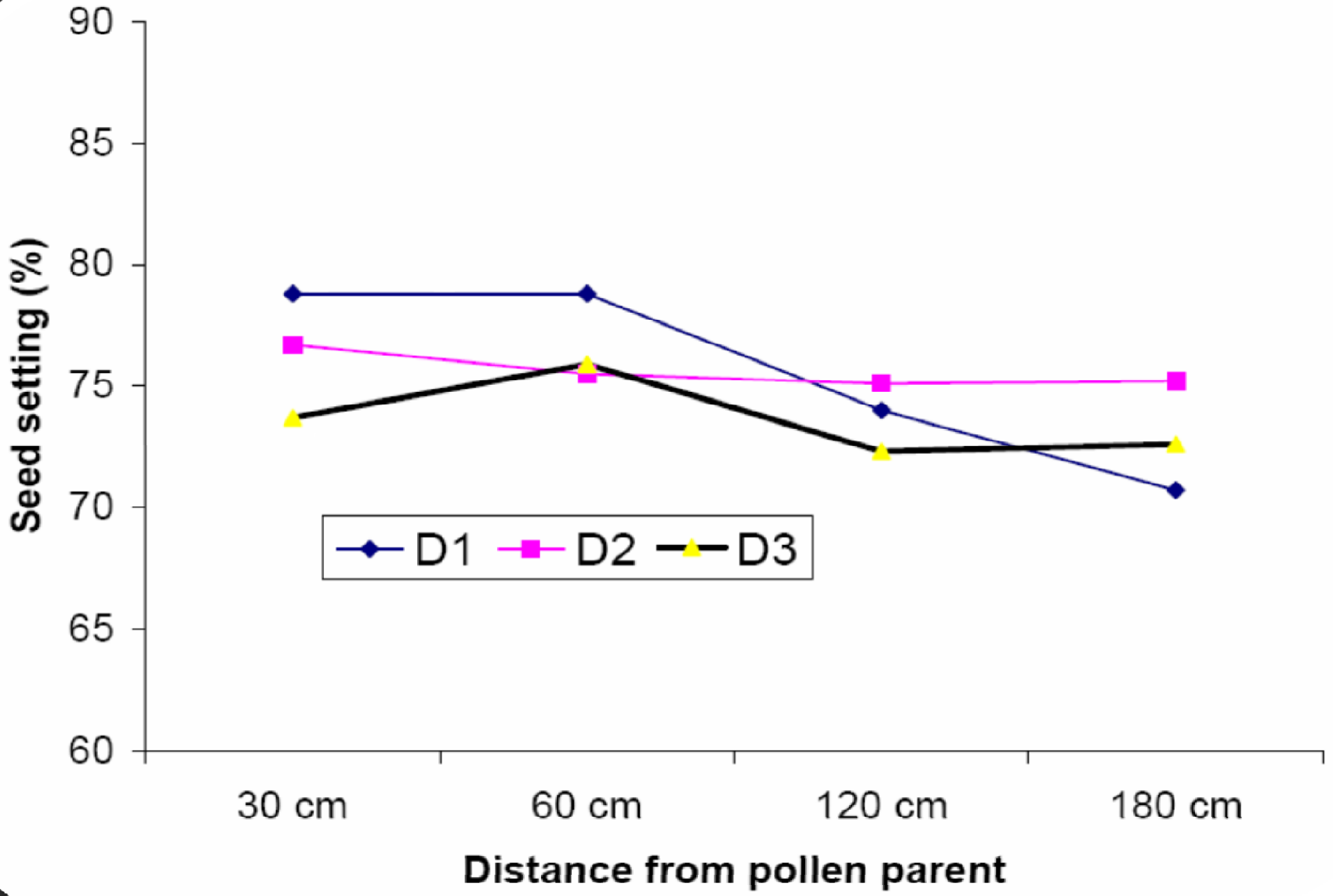
Relationship among sowing dates, head diameter, seeds/head and TSW.



22june, 4july, 14july, 30 july, 10 agust, 21 agust

Ahmad *et al*., 2005

Seed Setting at various distances from pollen parent: Effect of plant design



Separate rows (D1) Mixed planting (D2) Blocks (D3)

YADAV *et al*., 2006

Effect of crop geometry and phosphorus levels

Treatment	Head diameter (cm)	Filled seeds/head	Seed weight /head (g)
Crop geometry			
40 X 30 cm	**10**	**537**	**24**
50 X 20 cm	**11**	**550**	**27**
60 X 20 cm	**11**	**590**	**28**
CD (P=0.05)	**0.6**	**33**	**2.1**
P_2O_5 (kg/ha)			
40	**11**	**547**	**25**
60	**11**	**559**	**26**
80	**11**	**572**	**27**
CD (P=0.05)	**NS**	**11**	**0.9**

Soil –low P

Patel and Thakur, 2003

Seed yield (g/plant) as affected by different levels of P and genotype

Genotype	P levels (P_2O_5)			Mean seed yield (g/plant)	Response (%)
	0	45	90		
Sungene-85	0.62	1.04	1.72	1.12	109
DSH-1	0.47	0.94	1.75	1.05	180
KBSH-1	0.45	1.94	3.08	1.82	457
PAC-36	1.91	2.23	3.70	2.61	55
Mean	0.86	1.54	2.56		202
C.D. (P<0.01)	P level: 0.44 genotype: 0.51 P x genotype				

PAC-36 < Sungene-85 < DSH-1 < KBSH-1.

Dharudu *et al.*, 2003

Interaction effect of plant spacing and fertilizer on the yield of sunflower.

Plant spacing x N-P fertilizer treatment	Number of seeds per head			100 seed weight (g)			Seed yield (t/ha)		
	20 cm	25cm	30cm	20 cm	25cm	30cm	20 cm	25cm	30cm
Control	265.2 e			4.99 f			1.91 c		
$N_1 P_1$	329.1 ab	318.2 b	281.1 cd	5.58 b	5.58 b	5.22 de	2.16 bc	2.32 ab	1.95 c
$N_1 P_2$	339.1 a	318.1 b	279.9 cd	5.78 b	5.57 b	5.07 ef	2.16 bc	2.30 ab	1.97 c
$N_1 P_3$	328.1 ab	317.9 b	279.9 cd	5.67 b	5.63 b	5.59 b	2.38 ab	2.17 bc	2.19 bc
$N_2 P_1$	317.7 b	328.0 ab	277.4 cd	5.67 b	5.69 b	5.58 b	2.32 ab	2.16 bc	2.18 bc
$N_2 P_2$	329.6 ab	329.5 ab	271.7 de	5.68 b	5.67 b	5.67 b	2.40 ab	2.39 ab	2.15 bc
$N_2 P_3$	317.8 b	317.5 b	28.2 c	5.74 ab	5.68 b	5.58 b	2.30 ab	2.18 ab	2.17 bc
$N_3 P_1$	340.1 a	317.6 b	287.1 c	5.66 b	5.78 a	5.39 cd	2.41 ab	2.32 ab	2.17 bc
$N_3 P_2$	340.9* a	314.8 b	288.4 c	5.67 b	5.80* a	5.38 cd	2.50 a	2.32 ab	2.15 bc
$N_3 P_3$	329.4 ab	317.3 b	285.2 c	5.63 b	5.59 b	5.59 b	2.55* a	2.37 ab	2.16 bc

N1 -80 kg N/ha, N2 -100 kg N/ha , N3-120kg N/ha.
P1 -45 kg P_2O_5/ha, P2-60 kg P_2O_5/ha, P3-75 kg P_2O_5/ha.

Jahangir *et al*., 2006

Effect of N, P and K fertilization on yield attributes

Quantity of nutrients (kg ha^{-1})			Head diameter (cm)	Head weight (g plant^{-1})	Seed weight (g plant^{-1})	1000-seed weight (g)	Seed yield (kg ha^{-1})
N	P_2O_5	K_2O					
0	0	60	13.04 c*	59.34 c	33.87 c	36.10 e	1949 e*
60	75	60	16.68 b	82.39 b	52.80 b	44.16 c	2800 d
60	90	60	16.93 b	82.49 b	53.67 b	47.87 b	2761 d
90	75	60	18.03 b	87.60 b	53.92 b	44.45 c	3009 cd
90	90	60	18.07 b	87.40 b	54.90 b	47.96 b	2875 d
120	60	60	20.73 a	94.11 a	62.46 a	40.98 d	3188 bc
120*	75	60	20.69 a	94.80 a	62.61 a	44.61 c	3397 ab
120	90	60	20.76 a	95.44 a	62.67 a	47.88 b	3220 bc
120*	120	60	20.91 a	95.84 a	66.66 a	51.56 a	3554 a
Mean			18.43	86.60	55.95	45.06	

•In a column mean values followed by the same letter do not differ significantly at P=0.05

Thavaprakash *et al*., 2002

Effect of boron foliar application on head dry mass

B conc. in spray (mM)	4% B-loaded resin* in solution	12% B-loaded resin in solution	32% B-loaded resin in solution
0	0.0	0.0	3.7
28	2.9	15.3	27.1
65	7.1	18.5	30.2
120	9.0	25.3	34.9
1200	13.8	29.3	34.9
Control	37.4	37.4	37.4
LSD (P≤ 0.05)	2.5	3.8	4.1

*Amberlite IRA-743 = 2.16 mg/g of B resin wet

Asad *et al.*, 2003

Effect of boron application on seed yield of sunflower (Hybrid KBSH-1

Treatment	Seed yield
Control	10.0
Borax (2kg/ha)	
At button stage	14.3
At ray floret opening stage	15.3
CD (P≤0.05)	1.2

Reddy *et al*., 2003

Yield of sunflower as influenced by sulphur levels

Sulphur levels	Seed yield
0	10.08
20	11.18
40	12.35
CD (P=0.05)	1.00

Bhagat *et al*., 2005

Yield attributes of sunflower as influenced by irrigation schedule and N-management (mean data of 2 years) (sandy loam AP)

Treatment	Head diameter (cm)	Seeds/head	Filled seeds/head	1000 seed weight (g)
Irrigation schedule				
I_1 –IW:CPE=0.6	12.8	496	382	38.8
I_2 -IW:CPE=0.8	13.6	592	466	42.6
I_3 - IW:CPE=1.0	14.5	662	541	44.7
CD (P=0.05)	0.7	38	24	1.2
N –management practice				
N_0 -control	9.9	351	251	38.1
N_1 -100% fert.	15.5	684	562	45.2
N_2 -75% fert.+25% FYM	15	653	536	44.1
N_3 -50% fert. + 50 % FYM	14.4	646	498	42.5
N_4 -100% FYM	13.5	589	453	40.1
CD (P=0.05)	0.9	50	40	1.5

Sumathi and Rao,2007

Effect of INM on yield attributes of sunflower

Treatment	Head diameter (cm)	Seeds/ head	100 seed weigh t (g)	Seed yield (kg/ha)
T_{-1}=Control	15.41	418.22	4.41	432.12
T_{-2}=40:20:20 (NPK kg/ha)	17.92	521.68	4.46	501.66
T_{-3}= T_{-2}+FYM @ 12.5 t/ha	18.14	540.14	4.61	543.12
T_{-4}= T_{-2}+ Vermicompost @ 5 t/ha	18.91	572.12	4.69	574.61
T_{-5}= T_{-3}+ Azospirillum @ 2kg/ha (soil application)	19.12	610.89	4.71	662.68
T_{-6}= T_{-4}+ Azospirillum @ 2kg/ha	20.11	673.12	4.84	793.14
T_{-7}= T_{-5}+ $ZnSo_4$ @ 25 kg/ha	20.82	706.49	4.85	841.28
T_{-8}= T_{-6}+ $ZnSo_4$ @ 25 kg/ha (soil application)	22.96	743.31	4.86	926.12
T_{-9}= T_{-7}+ Foliar spray of 1% KH_2Po_4 at ray floret stage	23.11	791.21	5.92	1085.31
T_{-10}= T_{-8}+ Foliar spray of 1% KH_2Po_4 at ray floret stage	24.86	820.16	6.01	1243.21
SEd	0.90	17.15	0.06	39.08
CD (P=0.05)	0.18	35.21	0.12	78.56

Kalaiyarasan and Vaiyapuri, 2007

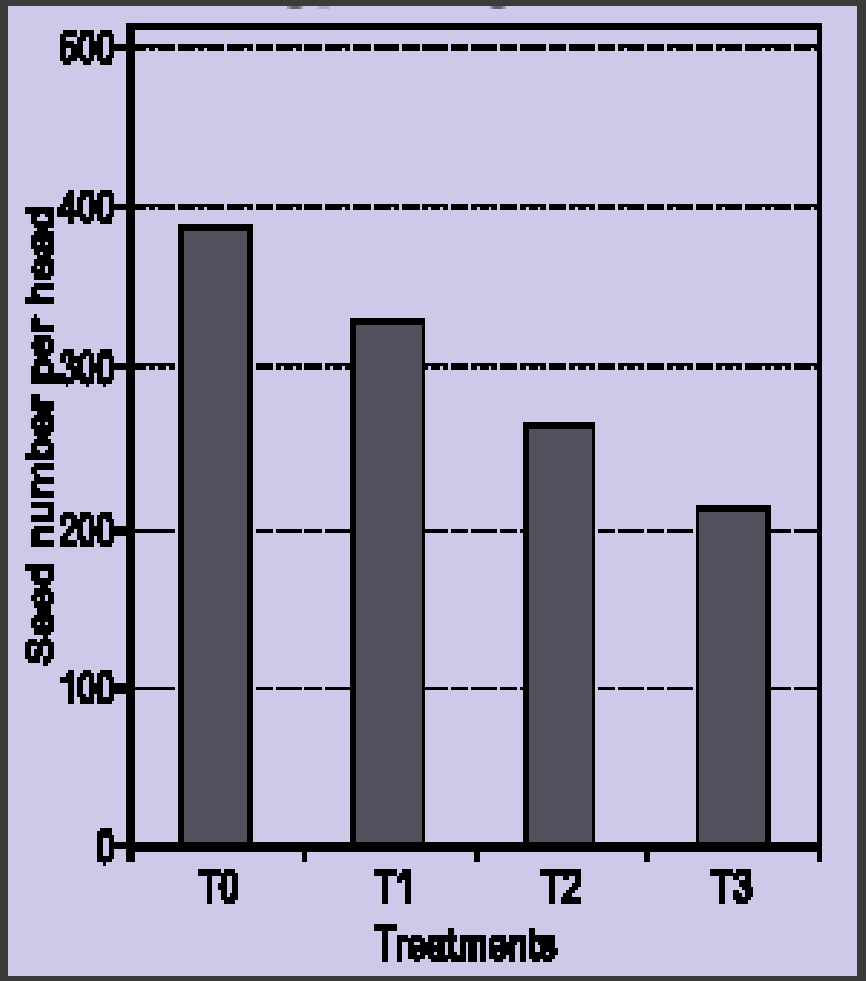
Pollination management

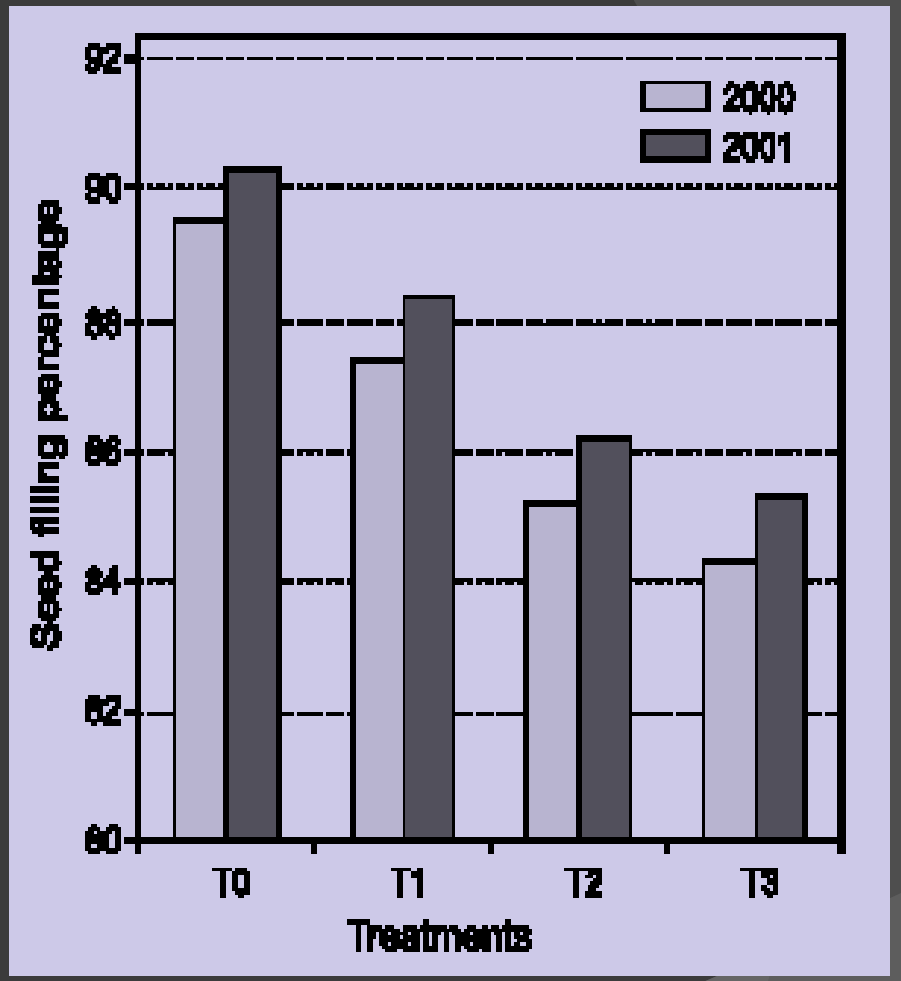
Effect of different treatments of pollen use efficiency on seed yield and quality parameters of sunflower hybrid DSH-1

TREATMENT	Head diameter (cm)	Seed set (%)	100 seed weight (g)	Seed yield per plant (g)
T_{1-}hand pollination (100% pollen)	14.5	83.8	4.23	29.1
T_{2-} hand pollination (75%pollen + 25% borax)	14.0	81.0	4.10	27.4
T_{3-} hand pollination (50%pollen + 50% borax)	13.6	78.9	3.99	25.5
T_{4-} T_1 + sugar (5%) spray	15.0	86.2	4.68	32.5
T_{5-} T_2+ sugar (5%) spray	14.3	83.0	4.25	29.2
T_{6-} T_3+ sugar (5%) spray	14.1	80.1	4.11	26.2
T_{7-} T_1 +Bee-Q spray (12.5g/l)	15.5	88.2	5.10	33.1
T_{8-} T_2+Bee-Q spray (12.5g/l)	14.9	85.5	4.52	30.3
T_{9-} T_3+Bee-Q spray (12.5g/l)	14.2	83.4	4.25	27.3
C D (P=0.05)	0.63	4.8	0.28	3.60

Prabhu *et al*., 2004

Effect of filler materials on seed number and filling percentage





T_0 - 100% pollen,
T_1- 75% pollen plus 25% borax as filler material
T_2 - 50% pollen plus 50% borax as filler material
T_3 - 50% pollen with 50% finger millet (*Eleusine corocana* L.) flour

Sumathi *et al.*, 2005

Conclusion

- Breeding for the for the self fertile lines and characters directly associated with seed setting and filling can improve the yield in sunflower.
- Reducing the source-sink or sink-sink competition by physiological manipulation such as reduction in thalamus weight, increasing post anthesis dry matter accumulation and clipping of old leaves.
- Directed application of TIBA to head has resulted in increased filling and test weight by way of increased translocation of photosynthates to sink.
- Maintain optimum plant stands recommended for the region. Very less plant population per unit area produced large sized flowers and caused poor seed setting in the centre of the flower.
- Decide optimum seeding period in such a way that the flowering should not coincide with extremes of temperature, heavy rainfall and fog.
- Follow only recommended fertilizer schedule. Sunflower responds profitably to the use of secondary and micronutrient B.
- Boron application at ray floret opening stage improved seed set and filling percentage.
- Avoid moisture stress at bud formation, flowering and milking stages.
- Providing supplemental pollination, either by hand pollination or through increasing pollinators (bees) activity has increased the seed set percent or filling.
- Environmental factors greatly influence the seed setting and filling in sunflower. Continuous rains and cloudy weather or high temperature affects seed set and yield.
- *Rabi*/summer season recorded higher seed set percent than *kharif* season in inbreds, hybrids and populations.


THANK
YOU
VERY
MUCH