# Winter wheat: Selection for weed competitiveness in organic and low-input cropping systems

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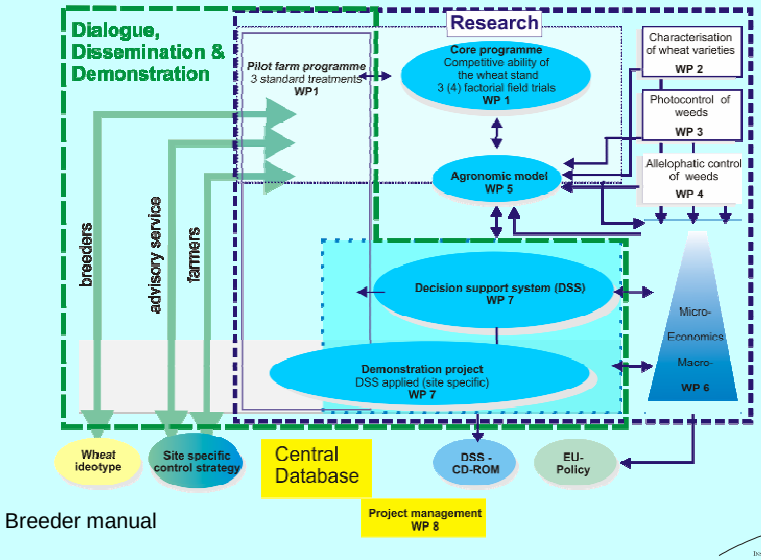
**www.iol.uni-bonn.de**



## WECOF -Strategies of weed control in Organic Farming
## Site specific strategies




Breeder manual

**Basic growth conditions (** compared with mainstream agriculture**):**

Limited soil-nutrient availability esp.nitrogen
No split - application of nitrogen
N :f ( precrop, rotation, retarded mineralisation )

- Retarded early development
- Limited tillering
- Limited LAI
- Limited LAD
- Limited crop ground cover
- Limited WUE
- Limited light interception
- Limited yield

Mechanical weed control

- Suboptimal spacing

Direct control of pathogens limited

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# Crop ideotypes for organic cereal cropping systems

**Main topics mentioned:**

Nutrient management / efficiency
Competitiveness against weeds
Pathogens
Product quality

➡ All related to morphological features

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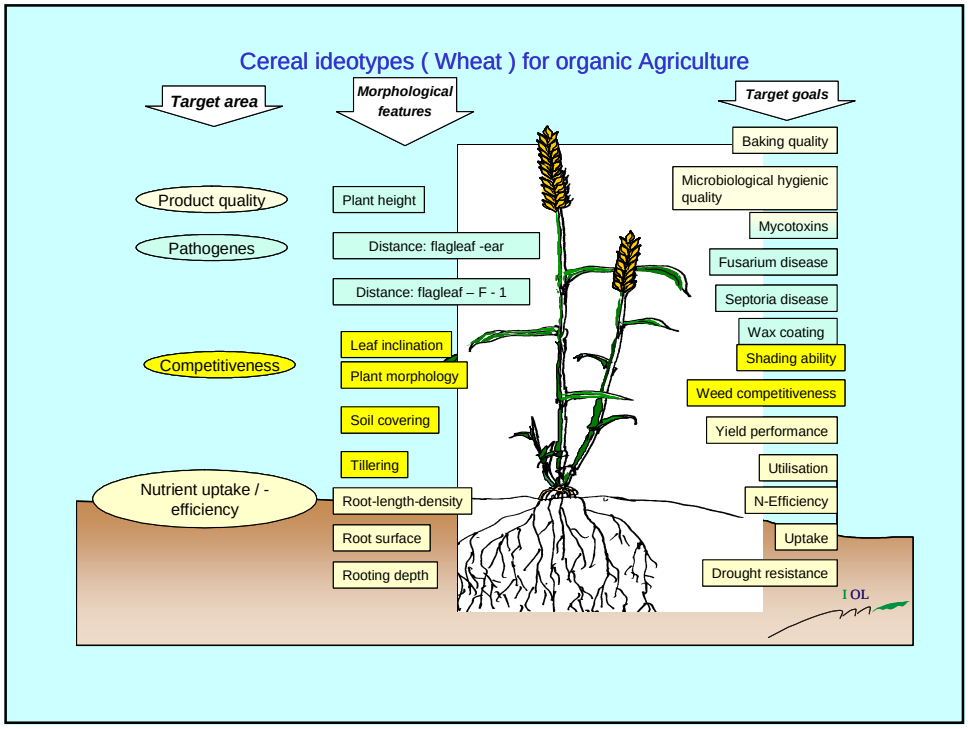




## *During phase of tillering (GS 25): Breeding targets*

Competition against weeds mainly based on shoot growth rate and speed of development.

- ➡ f (root growth)
- ➡ number of crown roots: f (tiller number*plant$^{-1}$) ➡ High tillering ability

**Rapid early development, high crop coverage:**

- ➡ Early prostrate growth beneficial under conditions of summer drought ( WUE increased )
- ➡ Early shaders are often also later shaders
- ➡ Allelopathic exudates may be beneficial

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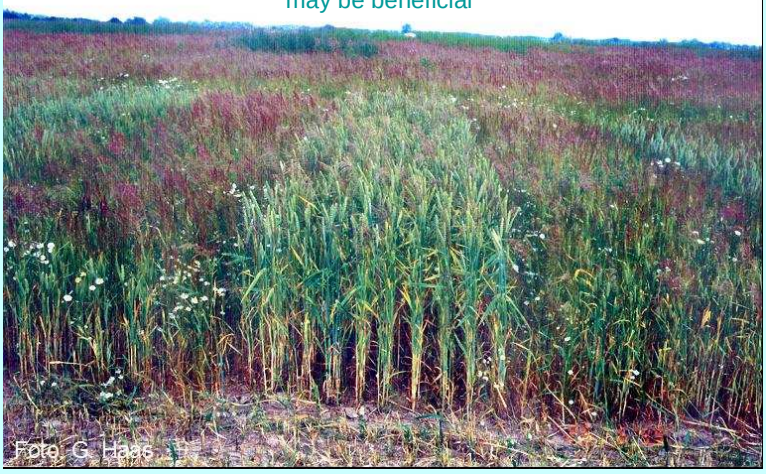
*Apera spica venti* as affected by winterwheat cultivars

Rapid early development, plant height and allelopathic exudates may be beneficial






**Controlling weeds - Cereals: normally not hoed !**
**Problem weeds need to be hoed**

Spacing suboptimal

➡ **Competitiveness against weeds limited**

Breeding target: Adapted morphology

➡ Optimized distribution of limited leaf area
➡ Planophile leaf inclination
➡ Taller crop /longer culms

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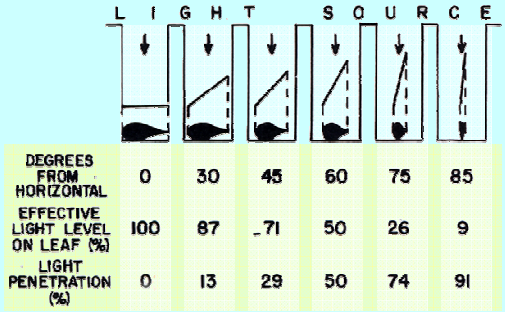
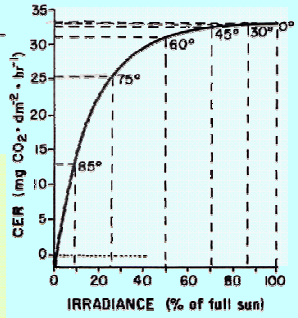
## Relationship among leaf angle, solar radiation at leaf surface and light response curve for a red clover leaf




| DEGREES FROM HORIZONTAL | 0 | 30 | 45 | 60 | 75 | 85 |
|---|---|---|---|---|---|---|
| EFFECTIVE LIGHT LEVEL ON LEAF (%) | 100 | 87 | 71 | 50 | 26 | 9 |
| LIGHT PENETRATION (%) | 0 | 13 | 29 | 50 | 74 | 91 |




Source: GARDNER, Franklin P.,*Physiology of crop plants'*

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## Relationship among leaf orientation, leaf photosynthesis, LAI and total plot photosynthesis

| ***Leaf angle*** *From Horizontal* | ***Leaf Photosynthetic Rate*** *(mg $CO_2$ * $dm^{-2}$ * $hr^{-1}$)* | ***LAI to Intercept Most Light*** [1] | ***Total Plot Photosynthesis*** *(mg $CO_2$ * $dm^{-2}$ Bodenfläche * $hr^{-1}$)* |
|---|---|---|---|
| 0 | 33 | 1 | 33 |
| 60 | 31 | 2 | 62 |
| 75 | 26 | 4 | 104 |
| 85 | 12 | 10 | 120 |

[1] Assuming perfect leaf placement – this would also correspond to critical LAI.

(GARDNER et al. 1985)

**Leaf inclination influencing rate of photosynthesis (GS 39-75)**

Erectophile: beneficial for LAI > 3.5
Planophile: beneficial for LAI < 3.0

(DE WIT 1965)

➡ Optimize leaf area distribution by using planophile types when LAI limited esp. when spacing suboptimal.

Selection criteria: Use *‚crop ground cover‘* in breeding program

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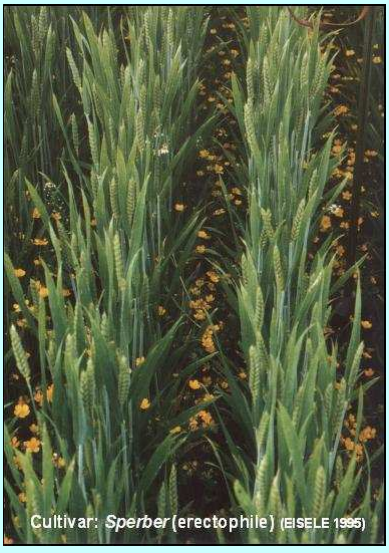


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Light measurement in a winter wheat plot with a *Line Quantum Sensor LI-191SA* and a *LI-190SA Sensor* (Reference)


EISELE 1992

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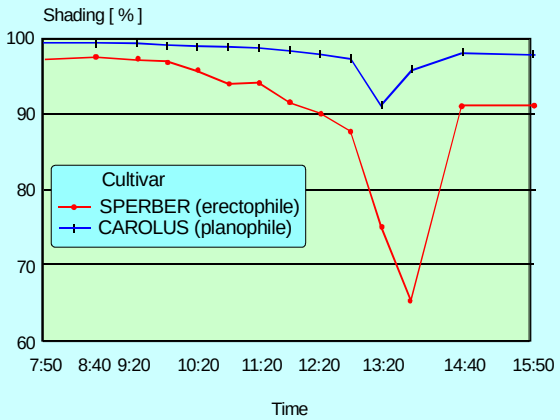
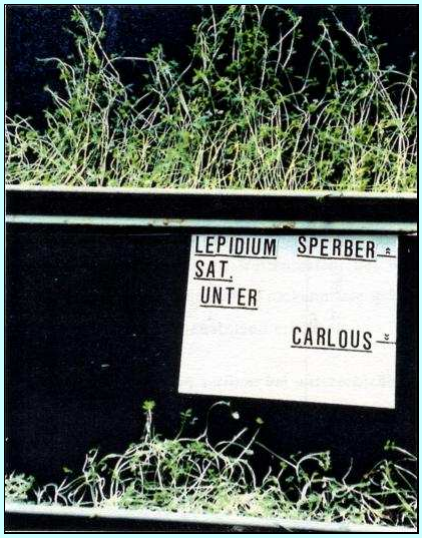
**Daily course of ground shading measured on soil surface under the cultivars Sperber and Carolus**



*Lepidium sativum* in boxes under winterwheat cultivars *Carolus* (planophil, bottom) and *Sperber* (erectophil, top), grown from 3.May - 15.June 1990




EISELE 1992

(Wiesengut 1990, EC 33)

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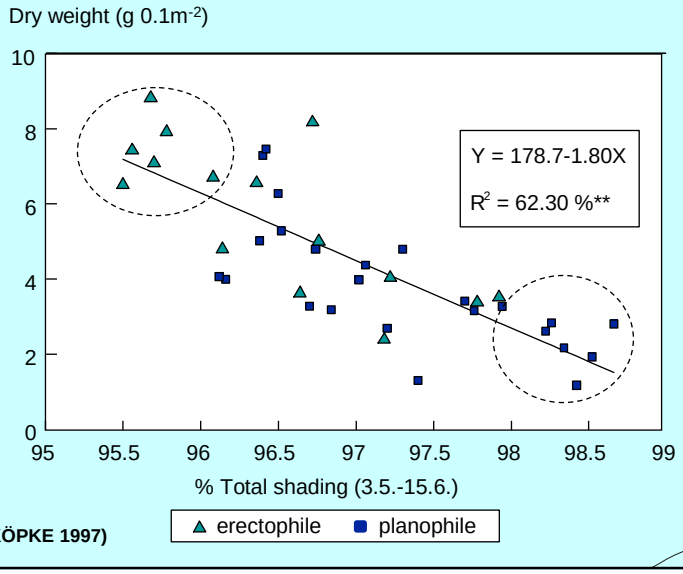
## Dry weight production of *Lepidium sativum* L. in relation to total shading at growth stages EC 30-70




**(EISELE & KÖPKE 1997)**

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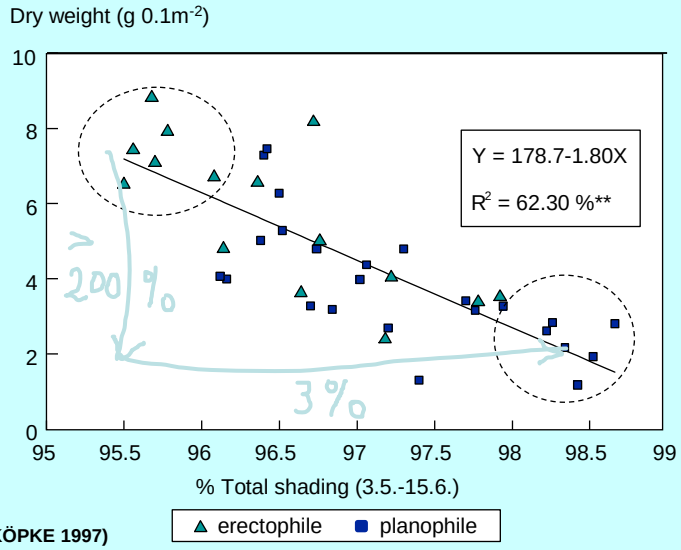
## Dry weight production of *Lepidium sativum* L. in relation to total shading at growth stages EC 30-70

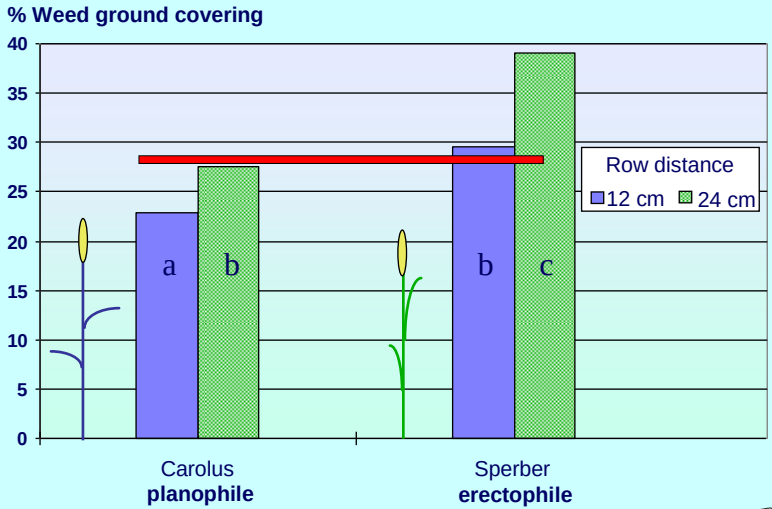



**(EISELE & KÖPKE 1997)**



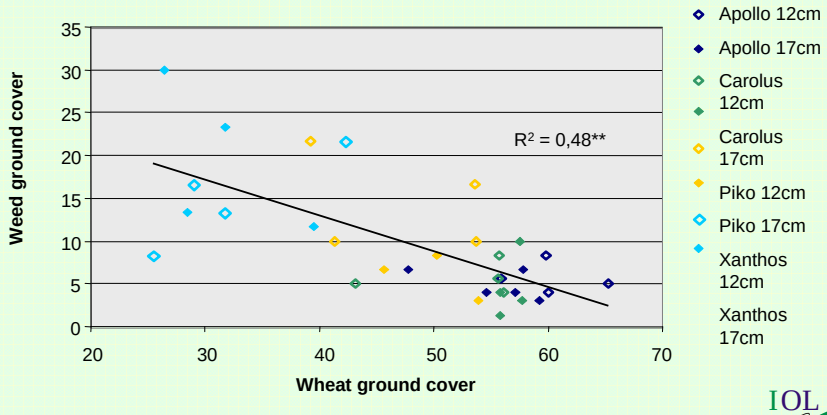
## Weed ground covering under two winter wheat cultivars

*Compensating sub-optimal spacing with planophile type*




(KÖPKE & EISELE 1997)

## Weed ground cover (BBCH 33-37) as a function of wheat coverage (BBCH 30= (1998)

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## Cultivar´s growth habit


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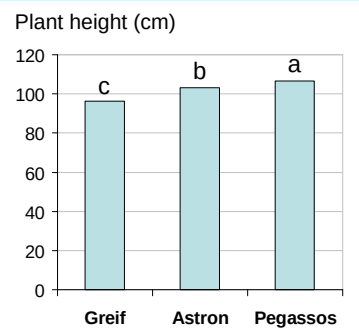
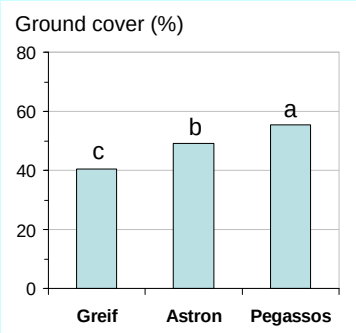
# Morphological differences in wheat varities




**Plant height**: **Pegassos > Astron > Greif**

**Ground Cover (%)**: **Pegassos > Astron > Greif**



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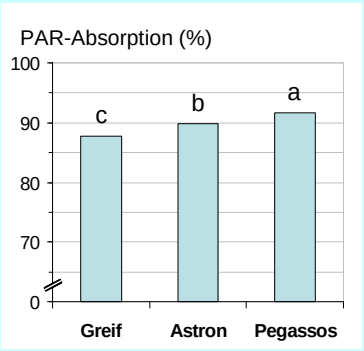
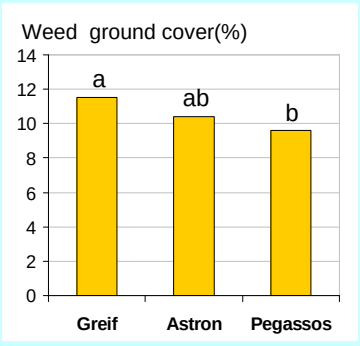
# Wheat cultivars: Light interception und weed ground cover (WG 2 - EC 55)




Drews 1/03

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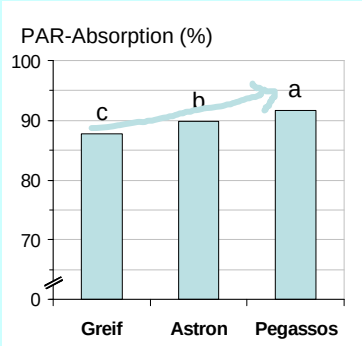


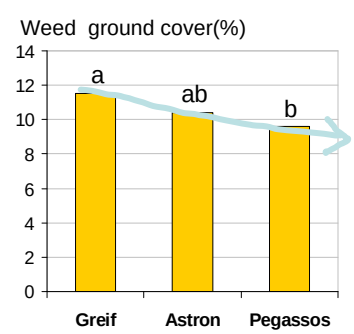




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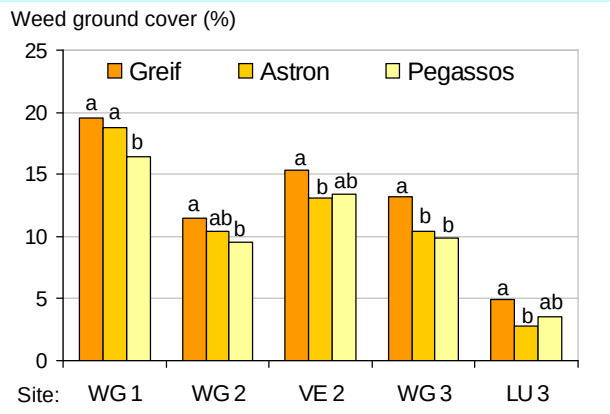
# Cultivars´ effect on weed ground cover

IOL- core trials, EC 49-65, five sites




* without KL 1 (63 % weed ground cover)

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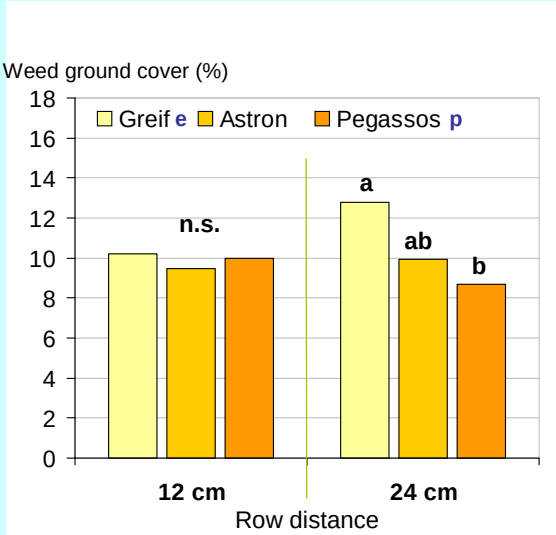
## Crop morphology: cultivar choice especially useful for wide row distances (WG 2 - GS 55)



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## Different growth habits of winter wheat

**Row distance 24 cm**

*Cv.* **Pegassos**

planophile

*Cv.* **Greif**

erectophile



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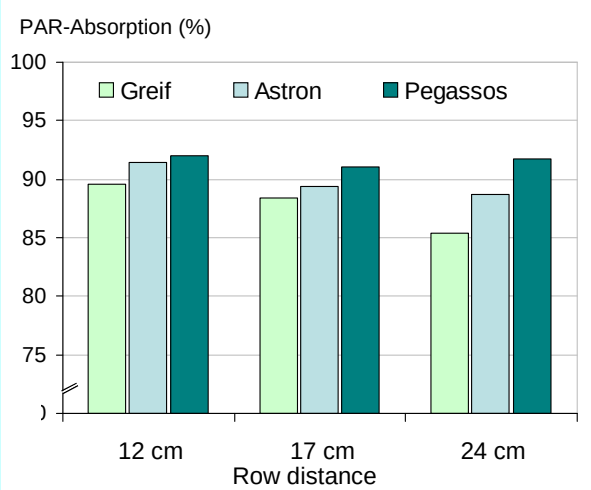
# Influence of row distance on the shading ability of cultivars (WG 2 - EC 55)



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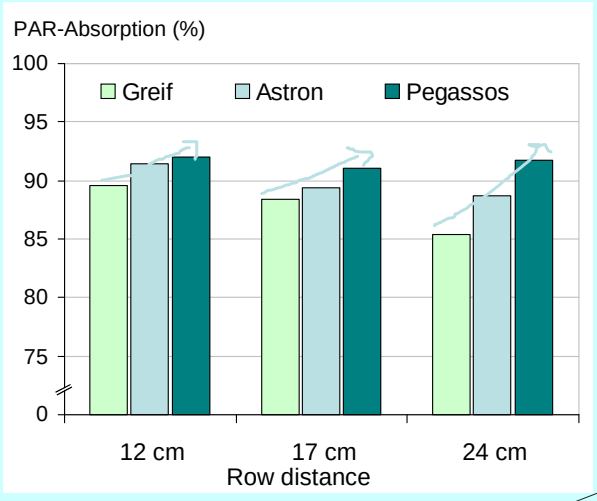


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**The row width, crop height, leaf area index (LAI) and extinction coefficients (k) for the ideotypes at the key growth stages**

| Ideotype | Growth stage | Row width (m) | Crop height (m) | LAI ($m^2$ leaf)/ ($m^2$ ground) | k |
|---|---|---|---|---|---|
| Planophile | 13-21 | 0.05 | 0.04 | 0.3 | 1.20 |
| | 31 | 0.09 | 0.20 | 0.9 | 1.14 |
| | 49 | 0.13 | 0.60 | 3.5 | 0.67 |
| | 65 | 0.24 | 0.85 | 4.5 | 0.66 |
| Erectophile | 13-21 | 0.03 | 0.06 | 0.3 | 1.00 |
| | 31 | 0.06 | 0.30 | 1.2 | 0.95 |
| | 49 | 0.10 | 0.80 | 4.0 | 0.61 |
| | 65 | 0.15 | 0.85 | 5.5 | 0.63 |
| Planophile2 | 13-21 | 0.05 | 0.04 | 0.3 | 1.20 |
| | 31 | 0.09 | 0.20 | 1.2 | 1.14 |
| | 49 | 0.13 | 0.60 | 4.0 | 0.67 |
| | 65 | 0.24 | 0.85 | 5.5 | 0.66 |
| Erectophile2 | 13-21 | 0.03 | 0.06 | 0.3 | 1.00 |
| | 31 | 0.06 | 0.30 | 0.9 | 0.95 |
| | 49 | 0.10 | 0.80 | 3.5 | 0.61 |
| | 65 | 0.15 | 0.85 | 4.5 | 0.63 |

**Topp et al 2004**

## The percentage of light intercepted by the crop at the key growth stages

| Ideotype | Growth stage | Light intercepted by the crop (%) | | |
|---|---|---|---|---|
| | | 12 cm | 17cm | 24 cm |
| Planophile | 13-21 | 0.06 | 0.04 | 0.03 |
| | 31 | 4.07 | 2.88 | 2.05 |
| | 49 | 47.62 | 36.08 | 25.71 |
| | 65 | 88.89 | 89.00 | 89.09 |
| Erectophile | 13-21 | 0.07 | 0.05 | 0.03 |
| | 31 | 4.62 | 3.28 | 2.33 |
| | 49 | 54.08 | 38.16 | 27.11 |
| | 65 | 100.00 | 91.92 | 65.20 |
| Planophile2 | 13-21 | 0.06 | 0.04 | 0.03 |
| | 31 | 6.19 | 4.38 | 3.12 |
| | 49 | 55.67 | 42.19 | 30.06 |
| | 65 | 100.00 | 100.00 | 100.00 |
| Erectophile2 | 13-21 | 0.07 | 0.05 | 0.03 |
| | 31 | 2.98 | 2.12 | 1.50 |
| | 49 | 45.98 | 32.45 | 23.05 |
| | 65 | 84.33 | 73.56 | 52.19 |

**Topp et al 2004**

## The percentage of light intercepted by the crop at the key growth stages

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|---|---|---|---|---|
| | | 12 cm | 17cm | 24 cm |
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| Planophile2 | 13-21 | 0.06 | 0.04 | 0.03 |
| | 31 | 6.19 | 4.38 | 3.12 |
| | 49 | 55.67 | 42.19 | 30.06 |
| | 65 | 100.00 | 100.00 | 100.00 |
| Erectophile2 | 13-21 | 0.07 | 0.05 | 0.03 |
| | 31 | 2.98 | 2.12 | 1.50 |
| | 49 | 45.98 | 32.45 | 23.05 |
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**Topp et al 2004**

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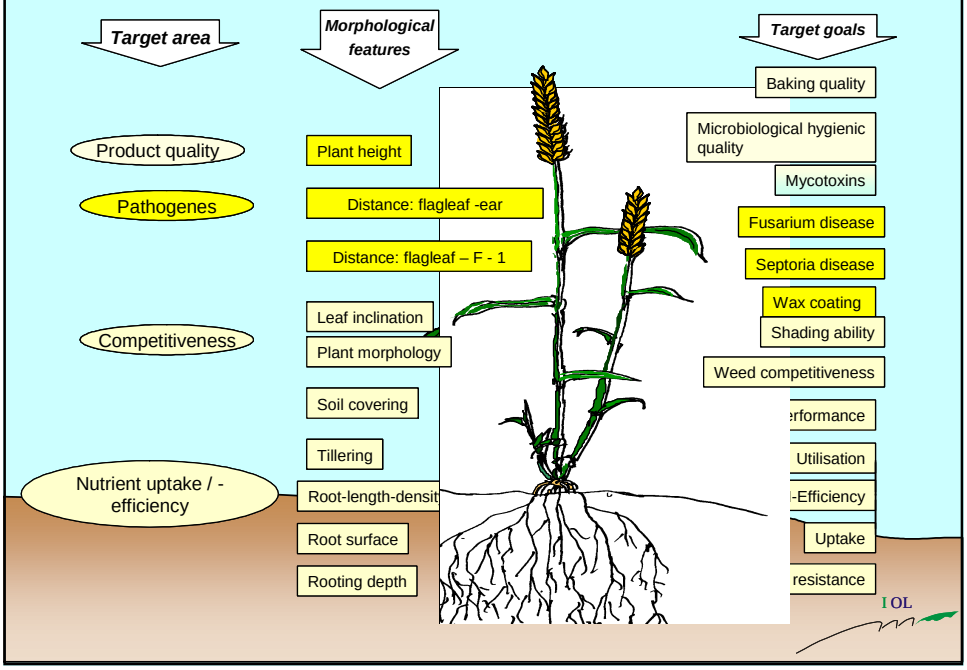
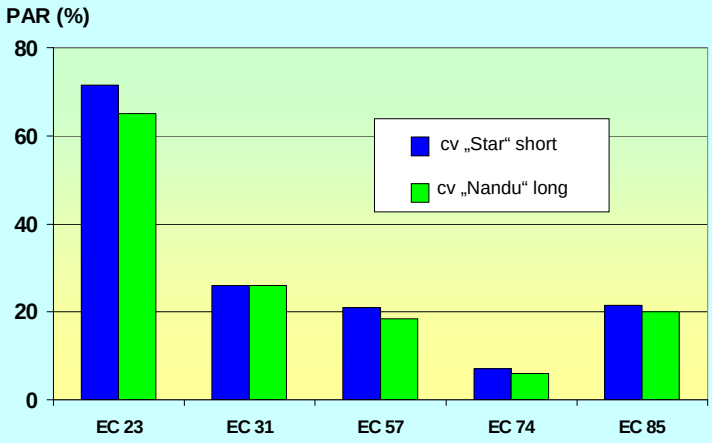
## Cereal ideotypes ( Wheat ) for organic Agriculture



## Shoot morphology ( plant height) of spring wheat: Shading ability and weed pressure

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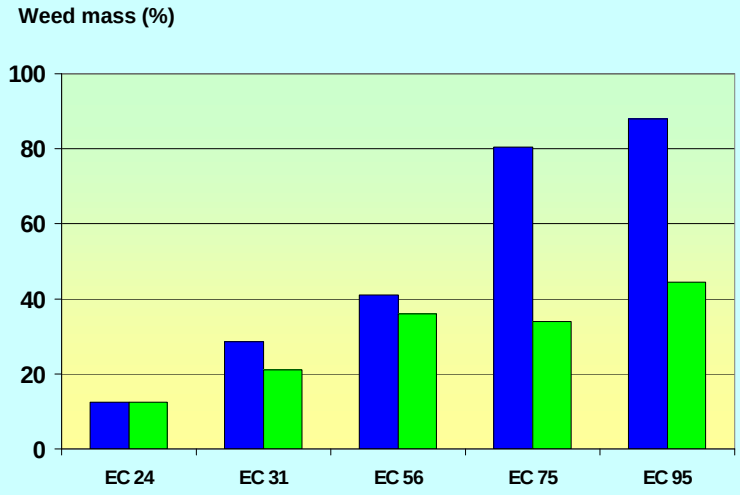


(KORR et al. 1996)

## Competitiveness during GS 31-75 influenced by shoot parameters:

- *Crop ground cover*
- *Shoot mass*
- *LAI*
- *Crop height*
- *light interception*

➡ All negatively correlated with weed parameters.

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## Winter wheat: correlation of light absorption and crop morphology

| | Absorption PAR | | | | | |
|---|---|---|---|---|---|---|
| | Trial WG 1 | | Trial WG 2 | | Trial VE 2 | |
| | EC 39 | EC 65 | EC 32 | EC 55 | EC 32 | EC 59 |
| **Soil cover** | 0.40*** | 0.57*** | 0.65*** | 0.63*** | 0.57*** | 0.31** |
| **Plant height** | 0.44*** | 0.46*** | 0.67*** | 0.54*** | 0.21 | 0.40*** |
| **Shoot mass** | 0.17 | 0.34** | 0.57*** | 0.46*** | 0.28* | 0.02 |
| **LAI** | 0.24* | 0.29* | 0.64*** | 0.53*** | 0.35** | 0.12 |

n= 72 ; Siginificance: * $\alpha$ = 0.05 / ** $\alpha$ = 0.01 / *** $\alpha$ = 0.001

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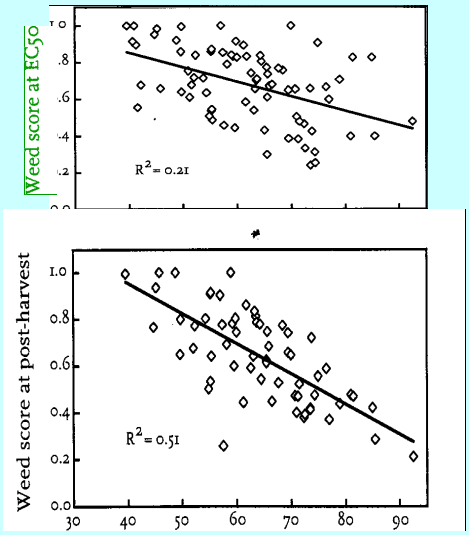
***Relationship between crop ground cover (%) at EC50 and weed ground cover at EC50 (upper figure) and post-harvest (lower figure).***




## 2nd Trial "La Bomba"

| Berdun | Marius | Texel |
|---|---|---|

## Core trial La Bomba (LB)

| Cultivar | GS | 2001/2002 | | | 2002/2003 | | |
|---|---|---|---|---|---|---|---|
| | | Berdun | Marius | Texel | Berdun | Marius | Texel |
| Crop Ground Cover (%) | 32 | | | | 57,2 | 62,2 | 66,1 |
| | 67 | | | | 43,1 c | 50,2 b | 55,5 a |
| Light Interception across (intercepted PAR (%)) | 32 | | | | 91,9 c | 96,8 a | 94,2 b |
| | 67 | | | | 84,9 b | 92,2 a | 93,1 a |
| Crop Plant Height (cm) | 32 | | | | 34,6 c | 47,6 a | 40,4 b |
| | 67 | | | | 77,2 c | 106,4 a | 98,4 b |
| LAI leaves | 32 | | | | 5,95 b | 7,24 a | 6,91 a |
| | 67 | | | | 4,23 | 4,58 | 4,75 |
| Crop biomass (g $m^{-2}$ d.m.) | 32 | | | | 396,3 b | 481,9 a | 418,7 b |
| | 67 | | | | 1233,7 b | 1346,7 a | 1277,7 ab |
| Tillering (tillers/plant) | 32 | | | | 4,9 ab | 4,5 b^^ | 5,3 a |
| | 67 | | | | 4,5 a | 3,7 b | 4,5 a |
| Weed Density (plants $m^{-2}$) | 32 | | | | 153,2 a | 119,9 b | 124,4 b |
| | 67 | | | | 63.8 a | 32,7 b | 37,6 b |
| Weed Biomass (g $m^{-2}$) | 32 | | | | 41,6 a | 22,9 b | 28,2 b |
| | 67 | | | | 44,4 a | 20,7 b | 24,4 b |



*Generally:*

Breeding programs performed under the typical (specific) growing conditions resulted in well adapted cultivars

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## Plant height (late phase)

- Tall plants often realize higher crop ground cover & higher competitiveness against tall weeds (grasses e.g. *Br. tectorum* or *Apera spica ventii )*

- *Breeding progress based on increased harvest index*
  - ➡ *Straw needed in mixed farms for bedding*
  - ➡ *Lower grain yield level not effected by straw-length*
  - ➡ *Dwarf types less competitive for controlling weeds*

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## Effect of variety height on undersown clover relatively minor

| Cereal straw length | Spring barley | | Spring oats | |
|---|---|---|---|---|
| | Grain yield 15% D.M.(t*ha$^{-1}$) | Clover biomass (kg D.M ha$^{-1}$) | Grain yield 15% D.M.(t*ha$^{-1}$) | Clover biomass (kg D.M ha$^{-1}$) |
| Short | 5.1 | 1.45 | 5.9 | 0.34 |
| Medium | 5.1 | 1.16 | 6.3 | 0.24 |
| Long | 5.7 | 1.27 | 6.2 | 0.22 |

Trend for shorter cultivars to encourage clover biomass

**D. YOUNIE**

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## Grain yield

• Planophile types can realize higher flag leaf area resulting in higher photosynthesis rate and yield performance also with low LAI

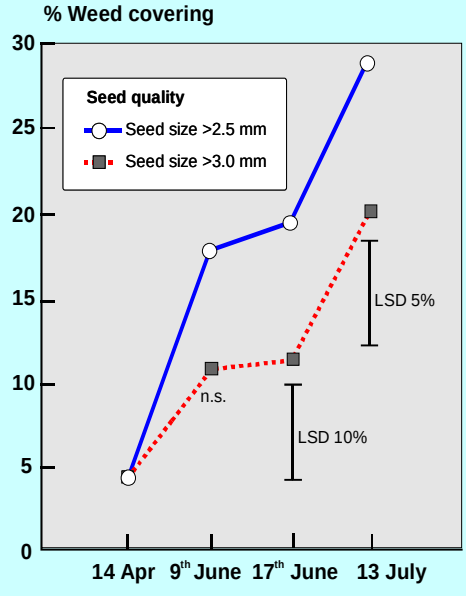
• should be based on high 1000-seed weight

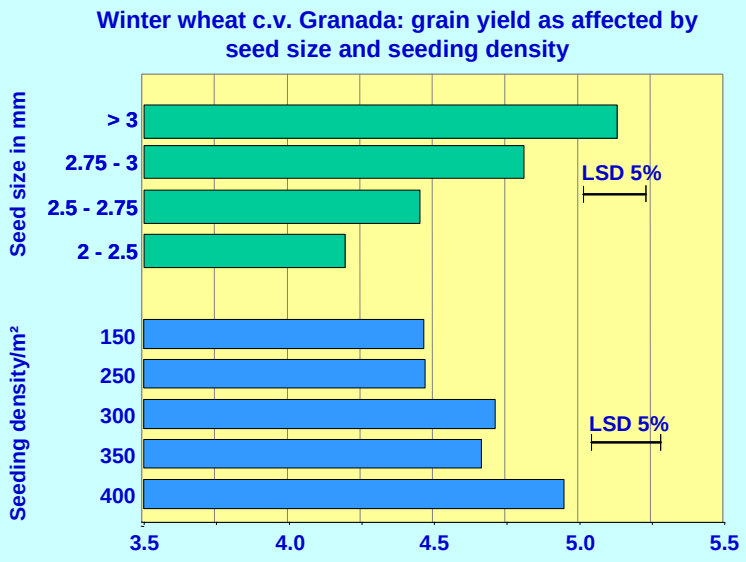
➡ Bigger grains result in competitive vigorous seedlings as a function of

- *earlier emergence*
- *higher root-length density, root surface*
- *seed health enhanced*



## Weed competitiveness as influenced by seed size



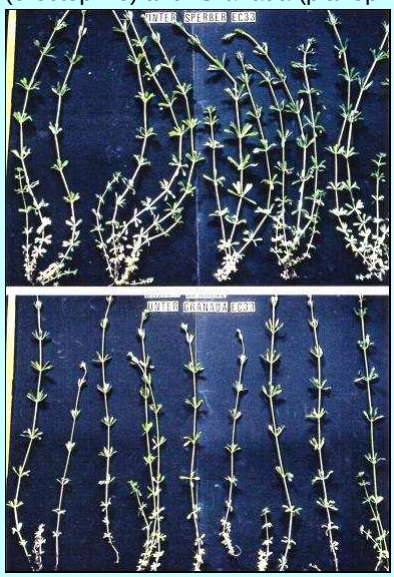



(PIORR 1991)



# Problem weeds

*Galium aparine* as affected by winter wheat cultivars *Sperber* (erectophile) and *Granada* (planophile)



EISELE 1992

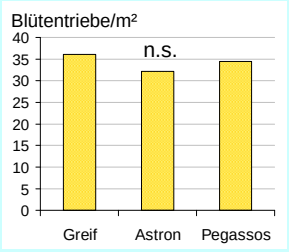


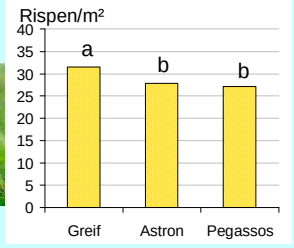
# Effects by shading

I

EC 55

EC 71




***Galium aparine***

- Scrambling weed

➡ Shading sensitivity: low

(corr. with wheat -PAR: r= -0.08)

- But: sensitivity high in dry soil (dwarf G. aparine plants) (SEAVERS & WRIGHT 1999)

***Apera spica-venti***

- Shorter than wheat during vegetative growth, flowering shoots higher
- Long vegetative phase, late floering

➡ shading sensitivity: high

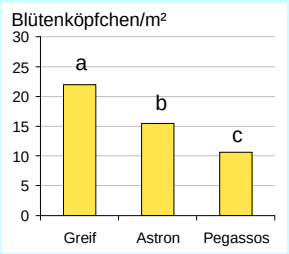
(corr. mit wheat-PAR: r= -0,41***)

Drews 1/03

# Effects by shading

II

EC 55




***Matricaria recutita***

- Shorter than wheat during vegetation time

Shading sensitivity : high
➡ (corr. With wheat – PAR: r= -0.62***)

⇒ **sensitivity to shading: f ( plant height of weed relative to wheat**

Drews 1/03

IOL
Institut für Organischen Landbau
Universität Bonn

**Bewertung der beiden Standard-Winterweizensorten 'Batis' und 'Ritmo' nach Angaben in der Beschreibenden Sortenliste**

(BUNDESSORTENAMT, 1999)

| Merkmal | Batis | Ritmo |
|---|---|---|
| Vermehrungsfläche 1998 | 3.800 ha (3. Sorte) | 7.300 ha (1. Sorte) |
| Qualitätsgruppe | A | B |
| Kornertrag | 6 | 7 |
| Mehltauanfälligkeit | 3 | 5 |
| Lagerneigung | 5 | 3 |
| Tausendkorngewicht | 7 | 5 |
| Auswinterungsneigung | 5 | 3 |
| Unkrautunterdrückung [1)] | 8 | 4 |

[1)] nach eigenen Bonitierungen (NIEMANN, 2000)

Quelle: NIEMANN, P., BBA-Berichte, Heft 72 - 2000

Bewertung Batis und Ritmo.cdr, FT, 4.12.00

## Bewertung der interspezifischen Konkurrenzkraft von Winterweizensorten nach verschiedenen Kriterien

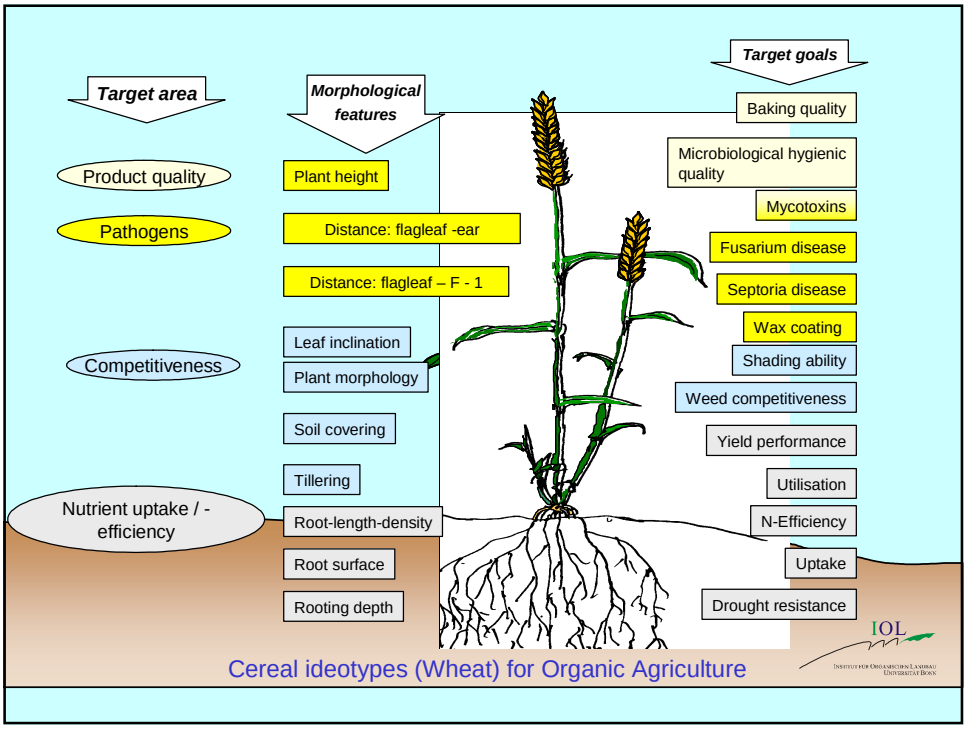
(VERSCHWELE und NIEMANN, 1993)

| Sorte | Deckungsgrad | Höhe | Wachstum | Note |
|---|---|---|---|---|
| Orestis | ++ | 0 | + | ++ |
| Pagode | ++ | 0 | - | ++ |
| Obelisk | ++ | 0 | + | ++ |
| Boheme | + | 0 | + | + |
| Rektor | + | 0 | 0 | + |
| Astron | + | 0 | 0 | + |
| Kanzler | 0 | + | 0 | 0 |
| Andros | + | 0 | 0 | 0 |
| Contra | 0 | - | + | 0 |
| Tristan | 0 | + | 0 | 0 |
| Sperber | -- | + | 0 | - |
| Kraka | -- | + | - | - |
| Slejpner | - | -- | - | -- |

+ hohe, 0 mittlere, - niedrige Ausprägung

Quelle: NIEMANN, P., BBA-Berichte, Heft 72 - 2000

interspezifische Konkurrenzkraft.cdr, FT, 4.12.00



# Plant health / resistance - quality

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INSTITUTE OF ORGANIC AGRICULTURE
UNIVERSITY OF BONN

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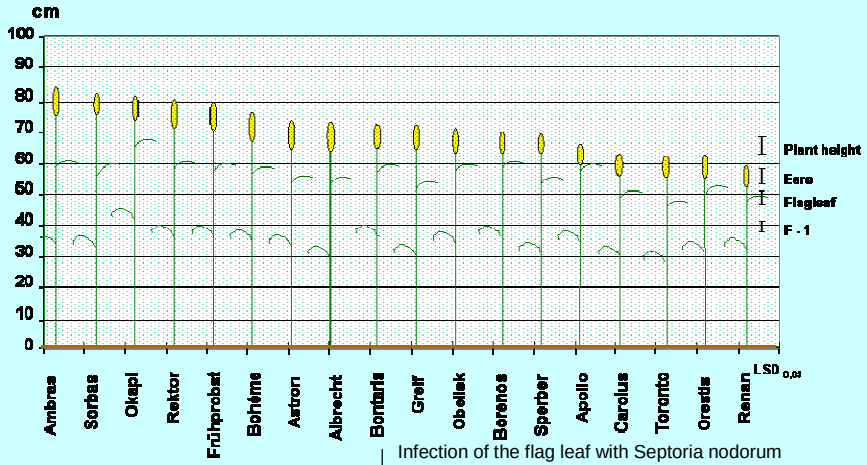
Produktqualität

**Anteil von Sorten (mit wichtigen Eigenschaften) an der Vermehrungsfläche (VMF)**
VMF (2003 – 2005) = 178,184 ha, APS = Ausprägungsstufe lt. BSL

| | APS | VMF |
|---|---|---|
| **1a) Qualitätsgruppe** | | |
| Eliteweizen | E | 12 % |
| Qualitätsweizen | A | 42 % |
| Brotweizen | B | 36 % |
| Futterweizen | C | 9 % |
| **1b) Pflanzenlänge** | | |
| sehr kurz bis mittelkurz | 2 – 4 | 51 % |
| sehr kurz bis mittel | 2 – 5 | 78 % |
| länger als mittel | 6 – 8 | 21 % |
| **1c) Anfälligkeit für Lager** | | |
| sehr gering bis gering | 2 – 3 | 40 % |
| sehr gering bis mittel | 2 – 5 | 92 % |
| stärker als mittel | 6 – 9 | 7 % |
| **1d) Anfälligkeit für Blattkrankheiten** | | |
| (Mittelwert aus Mehltau, Blattseptoria, Braunrost und DTR) | | |
| sehr gering bis gering | 2,7 – 3,5 | 17 % |
| sehr gering bis mittel | 2,7 – 4,5 | 56 % |
| stärker als mittel | 5,6 – 7,8 | 11 % |
| **1e) Anfälligkeit für Ährenfusarium** | | |
| sehr gering bis mittel | 2 – 5 | 92 % |
| stärker als mittel | 6 – 7 | 8 % |

Quelle: Beschreibende Sortenliste 2005 (BSL)

## Resistance: shoot morphology prevents ear diseases




| | | Infection of the flag leaf with Septoria nodorum | |
|---|---|---|---|
| | | EC 63 - 67 (r) | EC 74 - 76 (r) |
| Insertion heigt | Flagleaf | -0,34 | -0,40 |
| Distance 2. Leaf - | Flagleaf | -0,64** | -0,71** |
| Distance 3. Leaf - | Flagleaf | -0,52** | -0,61** |

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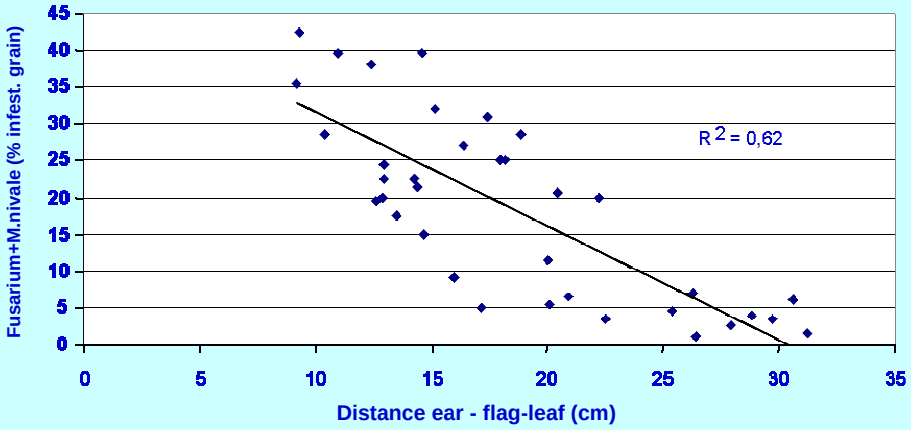
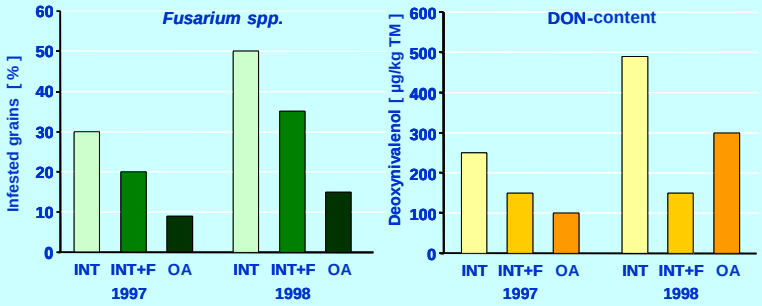
## *Fusarium* spp and *Microdochium nivale*: Grain infestation as a function of the ear to flag-leaf distance



**_Fusarium_ infestation and Deoxynivalenol (DON) mycotoxin content of winter wheat grains derived from organic and integrated cultivation**




OA= Organic Agriculture Int= Integrated Agriculture +F= Fusarium-Fungicide applied

***Fusarium* infested grains and DON content ➡ Lower in Organic Agriculture**

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## Breeding aim: Leaf area duration (LAD)

Accounting for about half of the variation in grain yields performed by

- *healthy cultivars ( leaf diseases ,e.g. DTR)*
- *Nitrogen efficency (utilization)*
- *Extended 'post-floral phase'*

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Thank you
for your attention !

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