Discrimination of new dwarf oat lines by allelism tests, SSR markers and plant height components

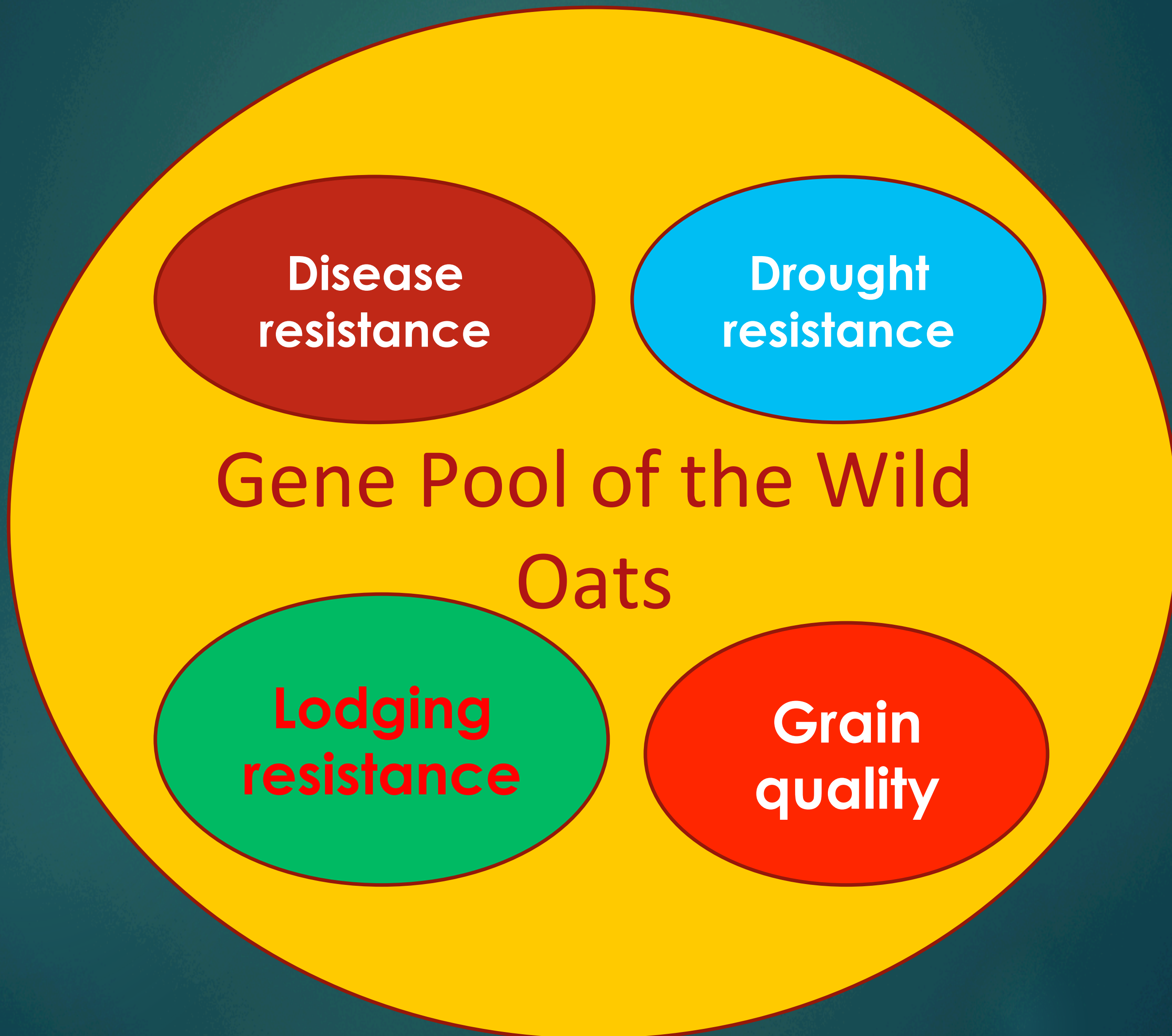
Toshinobu Morikawa, Shinya Uemura and Satoshi Kuriyama

Graduate School of Life and Environmental Sciences, Osaka Prefecture University, Japan

Purposes

1. Collecting the *Avena fatua* dwarfing germplasm from East Asia.
2. Transferring the wild dwarfing genes into the cultivated form 'Kanota'.
3. SSR analysis on the genetic background differences between wild and inbred dwarf lines
4. Allelism tests of the recessive and dominant dwarfing genes.
5. Multivariate analysis on plant height components

Gene pool of the wild oats, *Avena fatua*, of East Asia having so many useful genes



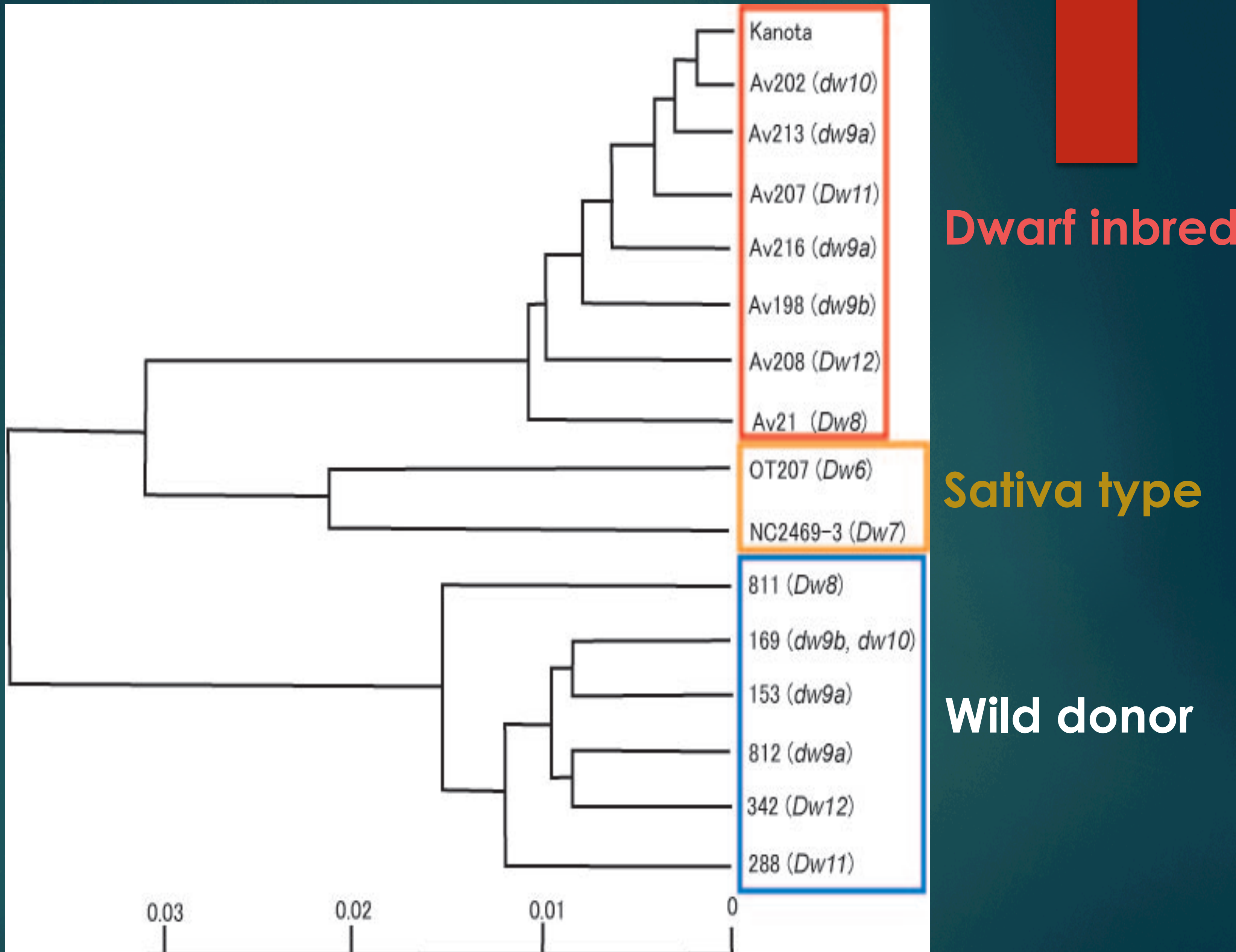


Fig .1 Dendrogram of dwarf inbred, wild donor and *A. sativa* revealed by microsatellites.

Table 1. Mean plant height of dwarf and tall lines grown in field nurseries at Sakai

Variety or line	Plant height	SD	Phenotype
Unknown recessive	cm		
Av198/7	87.8	7.2	Semi-dwarf
Av198/8	85.2	7.0	Semi-dwarf
Av202/2	63.4	6.4	Dwarf
Av202/4	63.9	6.6	Dwarf
Av202/14	59.6	7.1	Dwarf
Av213/10	63.9	7.3	Dwarf
Av216/6	60.5	7.1	Dwarf
Known dominant			
OT207 (*Dw6*)	79.5	8.6	Dwarf
NC2469-3 (*Dw7*)	63.4	7.0	Compact-Dwarf
Av21/2 (*Dw8*)	51.3	4.6	Extreme-dwarf
Kanota	119.0	7.8	Tall

Table 2. Plant heights of F_1s and their segregation in F_2s from the crosses between unknown recessive and known dominant dwarf lines

Cross combination	Chi square value for Dwarf : Tall=13:3	P-value
Av198 X OT207(Dw6) Av198 X NC2469-3(Dw7) Av198 X Av21/2(Dw8)	1.58 0.17 0	0.21 0.68 0.99
Av202 X OT207(Dw6) Av202 X NC2469-3(Dw7) Av202 X Av21/2(Dw8)	2.38 0.64 1.04	0.12 0.42 0.31
Av213 X OT207(Dw6) Av213 X NC2469-3(Dw7) Av213 X Av21/2(Dw8)	2.61 2.35 2.12	0.11 0.13 0.15
Av216 X OT207(Dw6) Av216 X NC2469-3(Dw7) Av216 X Av21/2(Dw8)	0.09 2.66 3.02	0.76 0.10 0.08

Table 3. Plant heights of F_1s and their segregation in F_2s when crossed among unknown recessive dwarf lines

Cross combination	Plant height of F_1 (cm)	Number of F_2 plants Dwarf	Tall	Total	Expected ratio	Classifying	Chi-square	P-value
A:Av202/2 × Av198/7	51.2	190	0	190	1:0	-	-	-
E: Av213/10 × Av202/14	99.8	69	110	179	7:9	72	1.97	0.16
D: Av213/10 × Av198/7	55.6	178	0	178	1:0	-	-	-
F: Av213/10 × Av216/6	64.3	173	0	173	1:0	-	-	-
B: Av216/6 × Av198/7	53.7	169	0	169	1:0	-	-	-
C: Av216/6 × Av202/14	114.3	73	114	187	7:9	80	1.69	0.19

Two different complementary recessive genes segregated

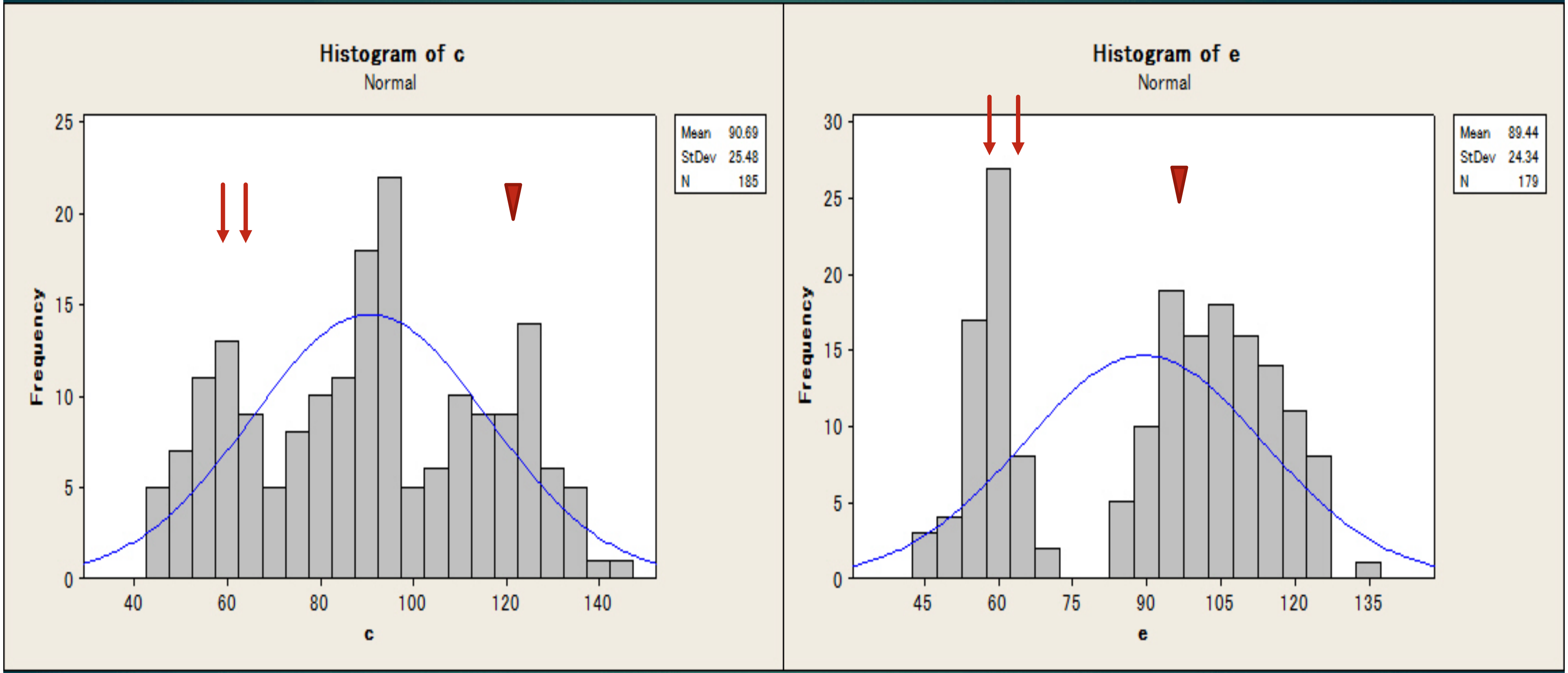


Fig. 2 Frequency distribution of plant heights in the F2s when crossed between two complementary lines. F1:Arrow head, P1 and P2: Arrows.

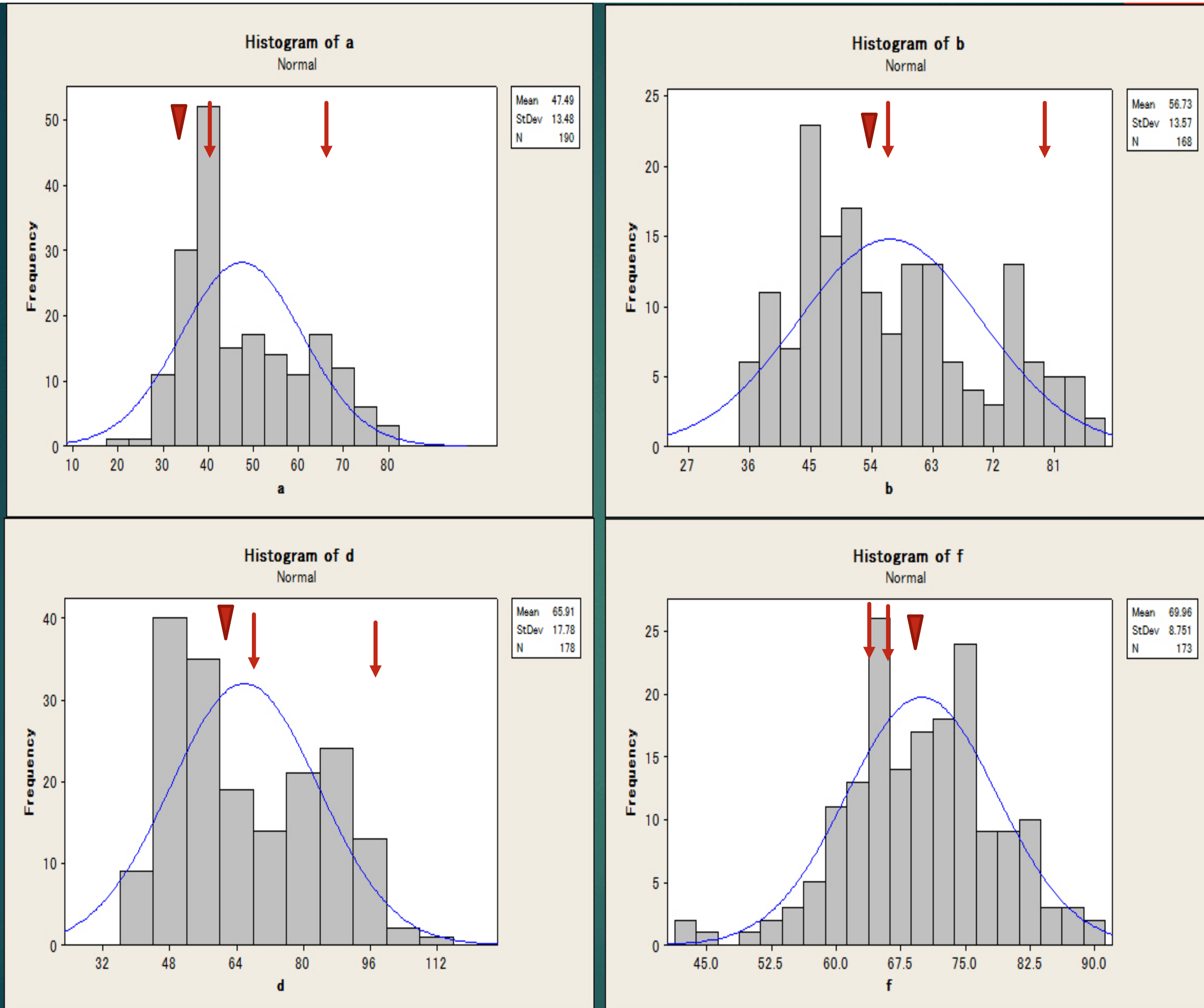


Fig.3 Frequency distribution of plant heights in the F2s when crossed between two allelic lines.


Dw12
Dw11
dw9b
dw10
Kanota

The plant of *Dw11*, **The panicle of *Dw11*,** **The plant of *Dw12*,** **The panicle of *Dw12***

Table 4. Plant heights of F_1s and their segregation in F_2s from the crosses between a new semi-dominant and known dominant dwarf lines

Cross combination	Plant height of F_1 (cm)	Number of F_2 plants Dwarf	Tall	Total	Classifying (cm)	Chi-square (15:1)	P-value
Av207 x OT207(*Dw6*)	85.9	138	12	150	130	0.78	0.38
Av207 x NC2469-3(*Dw7*)	50.1	83	5	88	110	0.05	0.83
Av207 x Av21(*Dw8*)	81.5	157	14	171	120	1.1	0.30

Table 5. Plant heights of F_1s and their segregation in F_2s from the crosses between a new dominant and known dominant dwarf lines

Cross combination	Plant height of F_1 (cm)	Number of F_2 plants			Clas sifyi ng (cm)	Chi-squa re (15:1)	P-valu e
		Dwarf	Tall	Total			
Av208 x OT207(*Dw6*)	**67.2**	**163**	**7**	**170**	**110**	**1.32**	**0.25**
Av208 x NC2469-3(*Dw7*)	**71.7**	**119**	**6**	**125**	**110**	**0.45**	**0.50**
Av208 x Av21(*Dw8*)	**72.4**	**171**	**8**	**179**	**100**	**0.97**	**0.33**
Av208 x Av207(*Dw11*)	**123**	**173**	**18**	**191**	**130**	**3.28**	**0.07**

The Panicle of double homozygotes (*Dw7Dw7,Dw12Dw12*)

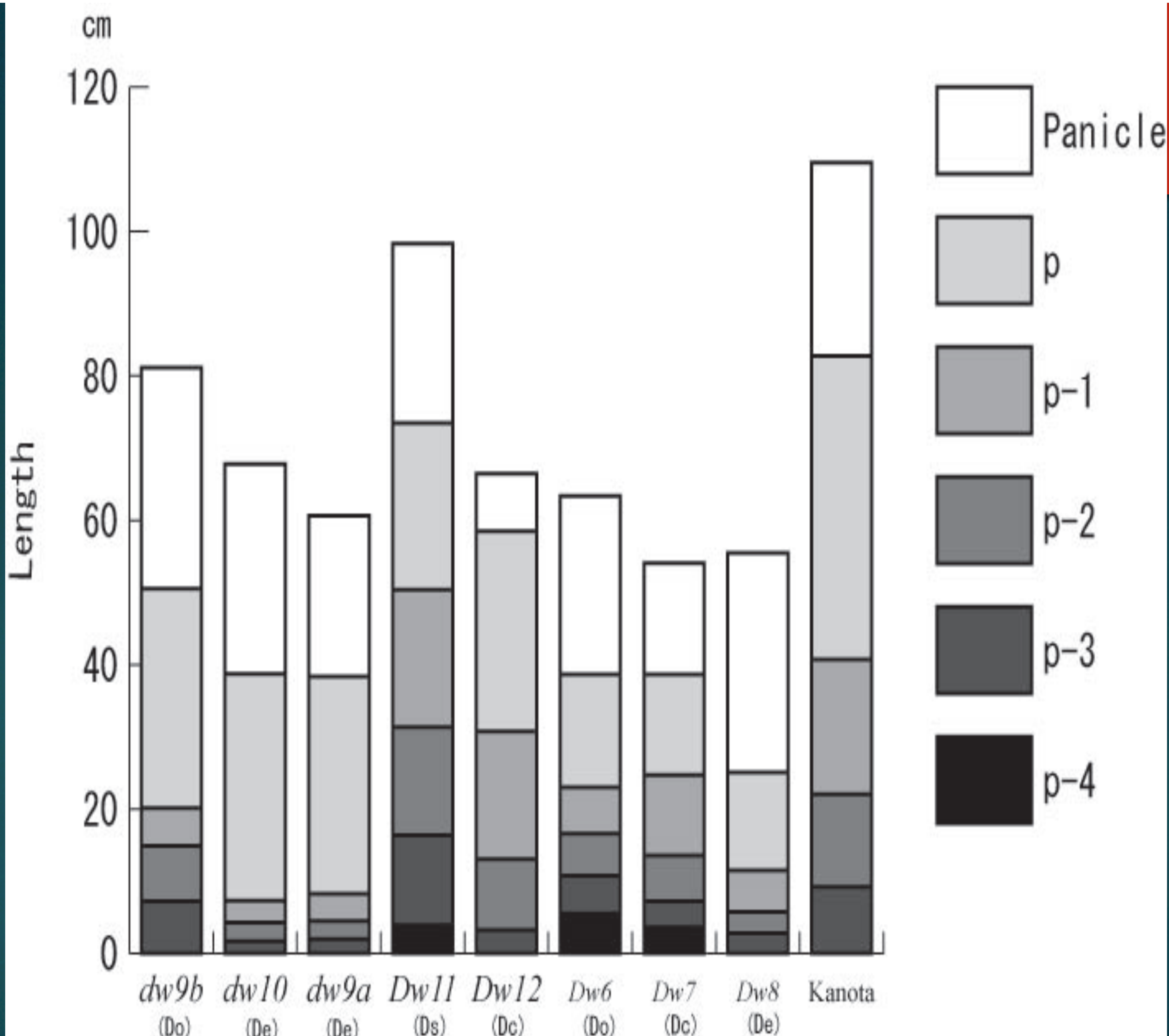
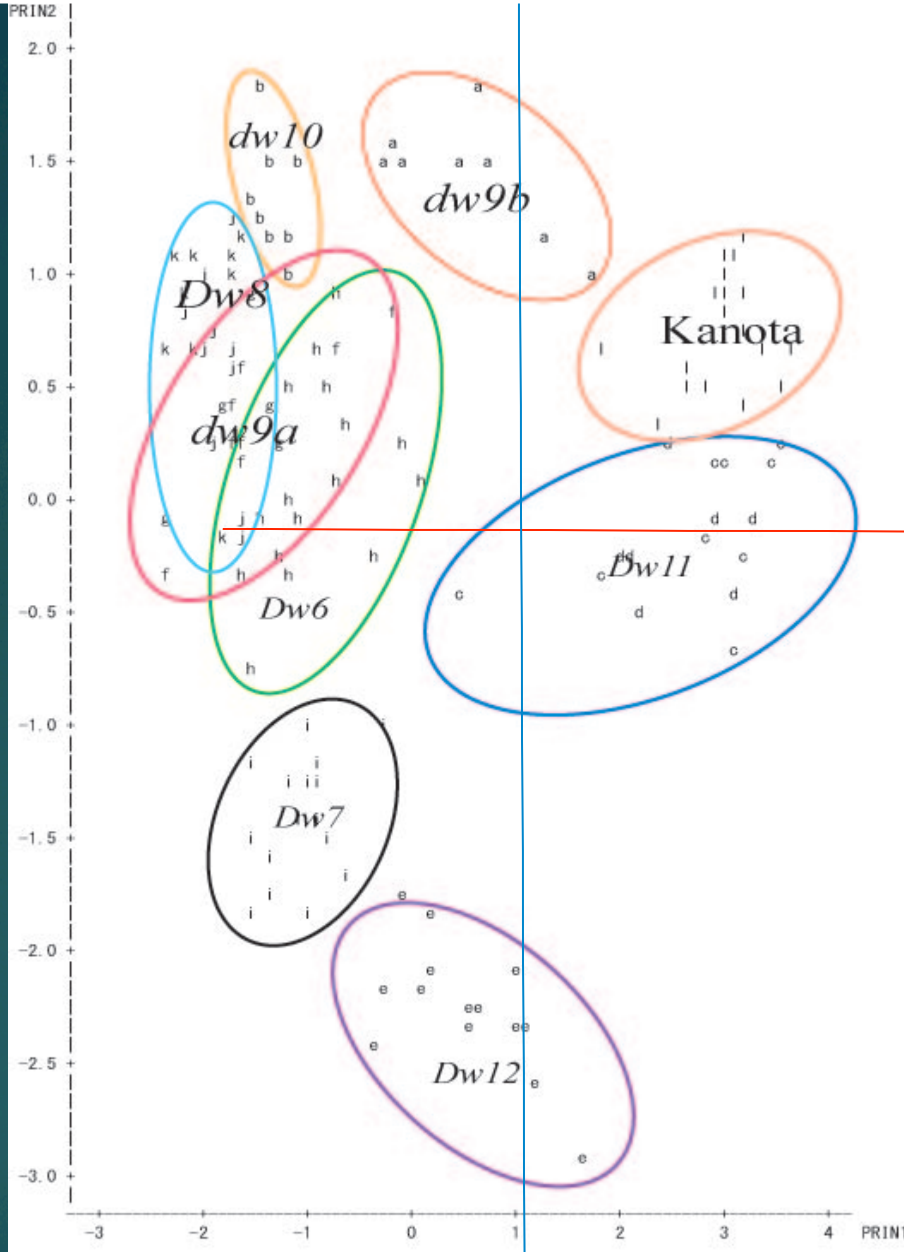


Fig. 4 Panicle and inter-node elongation patterns in dwarf and nondwarf plants of oats. The dwarf plants of ordinal (Do), extreme (De), semi (Ds) groups were categorized.



The first component (orange line) shows mainly p-2 length and plant height.

The second component (blue line) shows mainly panicle length.

Fig. 5 Scatter diagram of the first two principal components for plant height components of eleven dwarf oat lines and non-dwarf 'Kanota'

The list of unavailable dwarfing genes already reported

Gene Symbol	Description	References
dw-1	Recessive gene conditioning grassy dwarfness in plants derived from 'Victory'	Warburton (1919)
Dw-2	Gene for semi-dwarfness in progeny of 'Winter Turf' x 'Sixty Day'	Cotner (1929) Florell (1931) Litzenberger(1949b)
Dw-3	Gene for semi-dwarfness in progeny of 'Aurora' x 'Pringle Progress'	Cotner (1929) Florell (1931) Litzenberger(1949b)
Dw-4	Gene for semi-dwarfness in Trelle Dwarf	Patterson (1968)
dw-5	Recessive genes for dwarfness in progeny of *A.barbata* x *A.strigosa*	Nishiyama (1957)

The list of available dwarfing genes already reported

Gene Symbol	Description	References
Dw-6	A completely dominant gene for dwarfness in a 'Harmon' derivative induced by irradiation	Brown and McKenzie (1976)
Dw-7	Gene for compact-dwarfness in progeny of three oat crosses.	Marshal and Murphy (1981)
Dw-8	Gene for extreme-dwarfness in progeny of 'Kanota' x *A. fatua (Av21)*	Milach et al. (1998)

Summary of the new dwarfing genes identified here

Gene Symbol	Description	Dwarf type
dw-9a	Recessive gene conditioning grassy dwarfness in plants	Extreme-dwarf De-type
dw-9b	Do-type (*dw9b*) and De-type (*dw10*) were involved in the same L169 dwarf line.	Ordinary-dwarf Do-type
dw-10	The dwarfing gene controlls all inter-node lengths much shorter than the *dw9b*. Do-type (*dw9b*) and De-type (*dw10*) were involved in the same L169 dwarf line.	Extreme-dwarf De-type
Dw-11	This unique dwarfness is characterized as short peduncle length, unilateral panicle, stiff inter-node and large grains producing high yield caused by strong resistance to lodging.	Semi-dwarf Ds-type
Dw-12	The phenotypic expression is similar to the Dc-type dwarfness of *Dw7* but the *Dw12* panicle is shorter than the *Dw7*.	Compact-dwarf Dc-type

Thank you for your attention