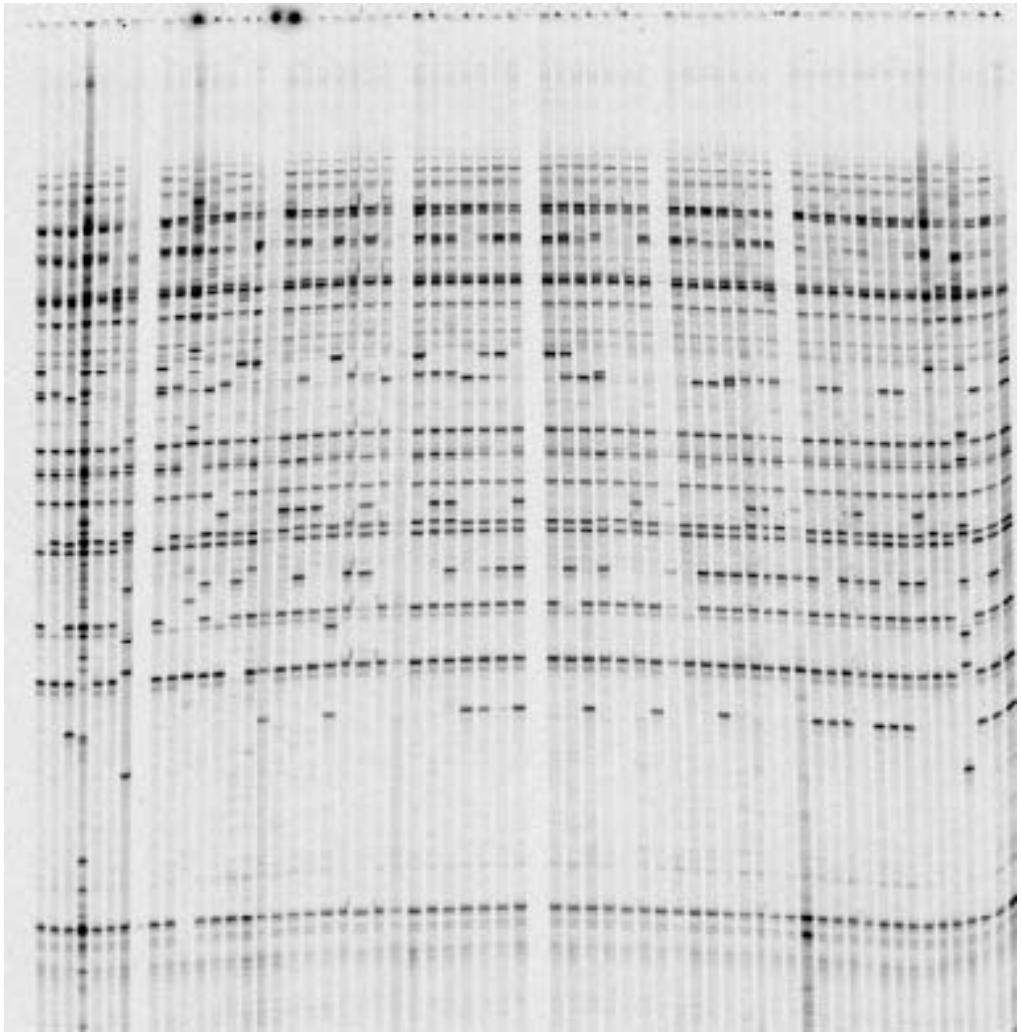
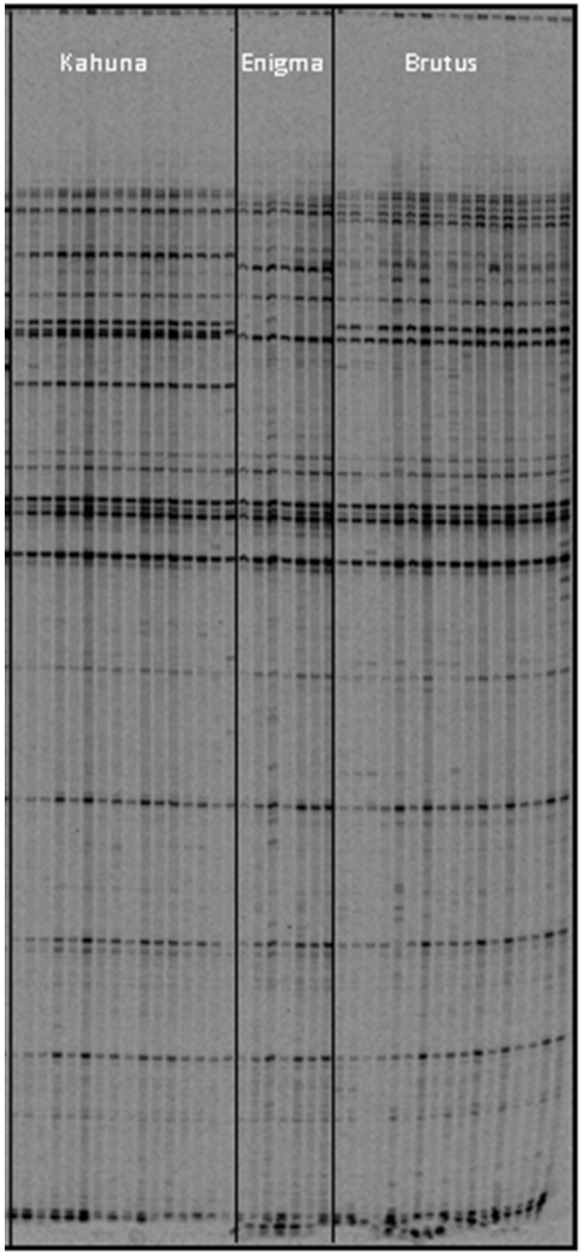
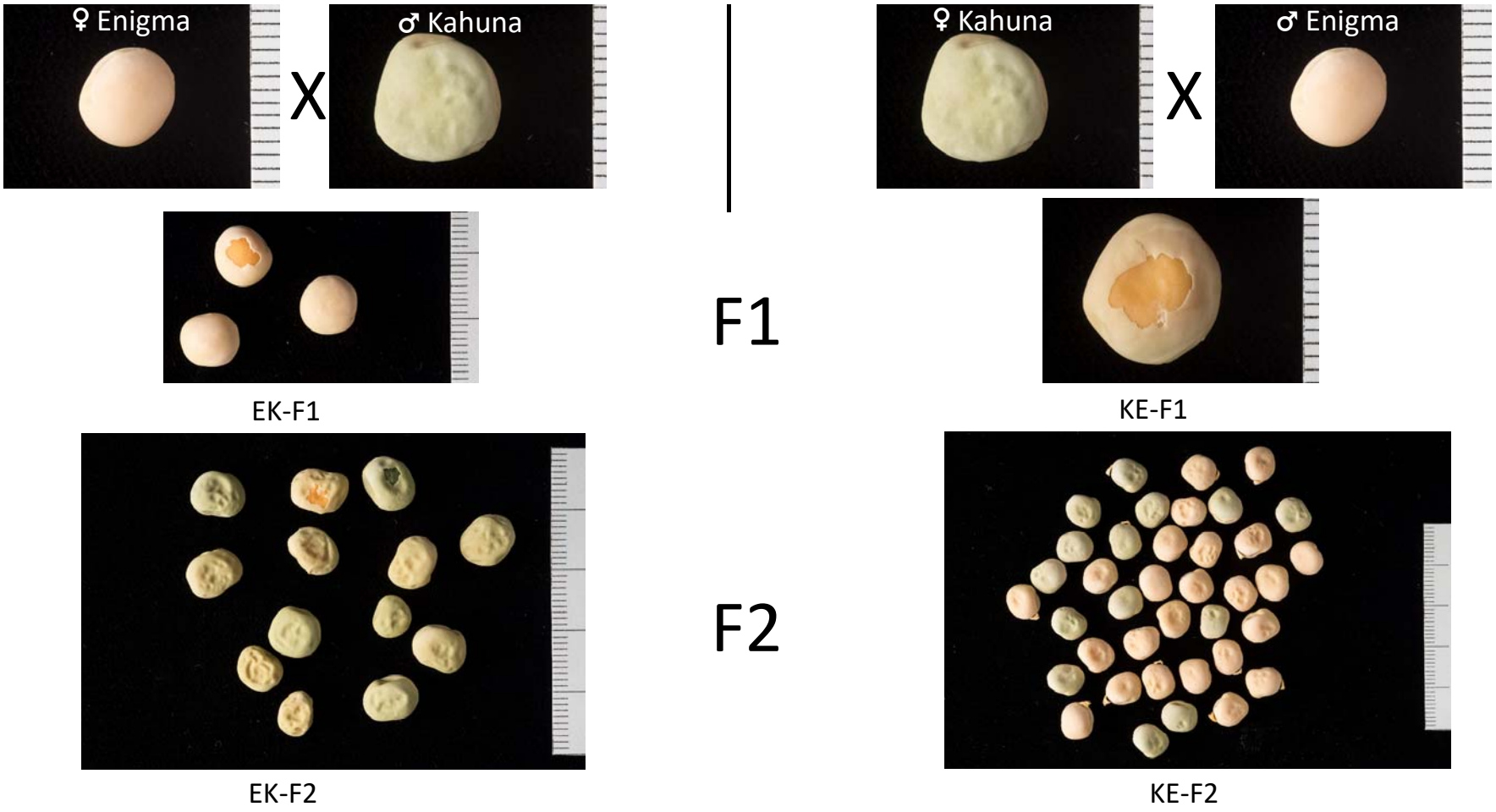


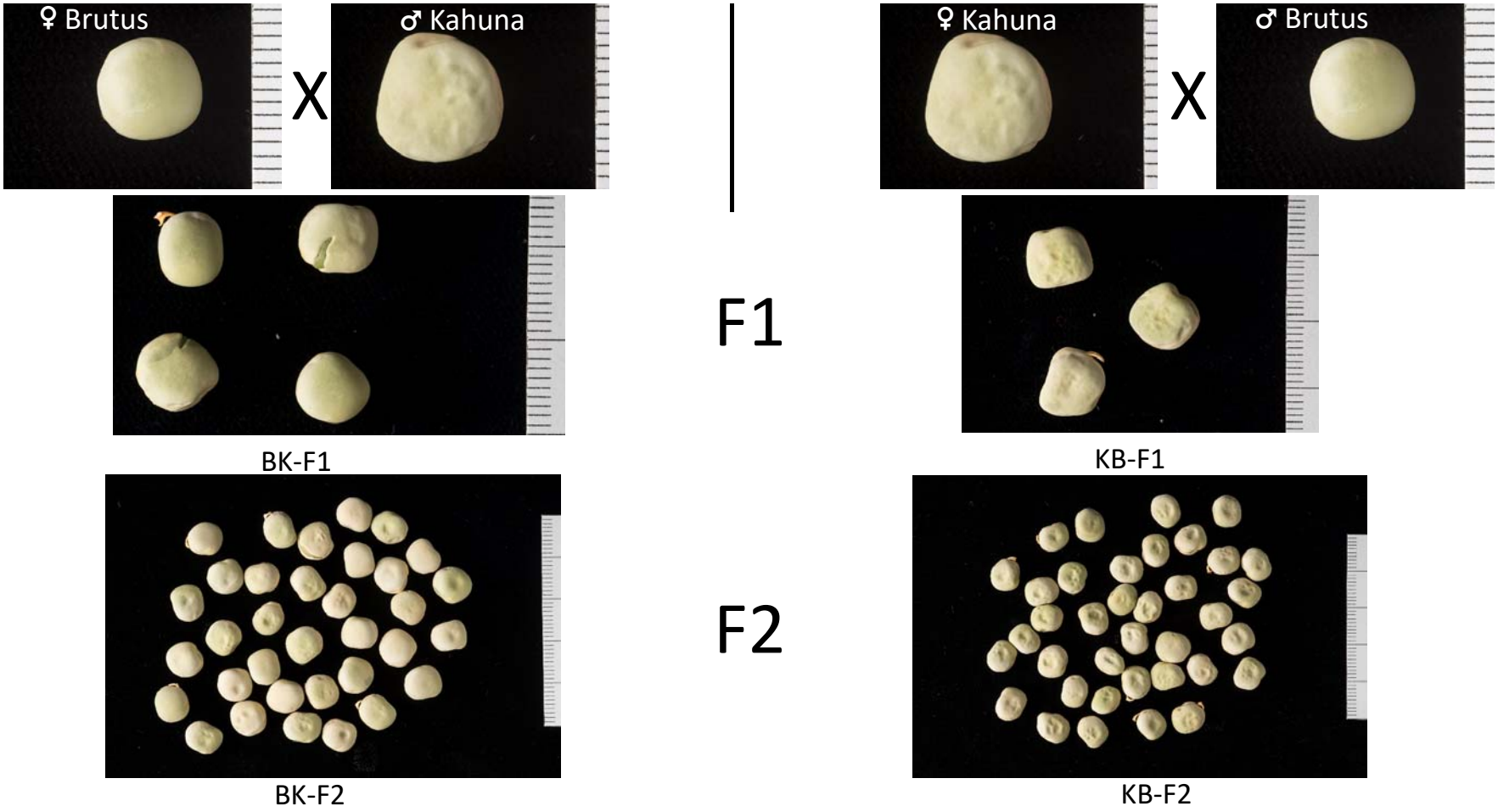
Supplementary Figure S1: An example of one of the gels (PDR1 SSAP / Taq +AA) used to genotype the panel of cultivars



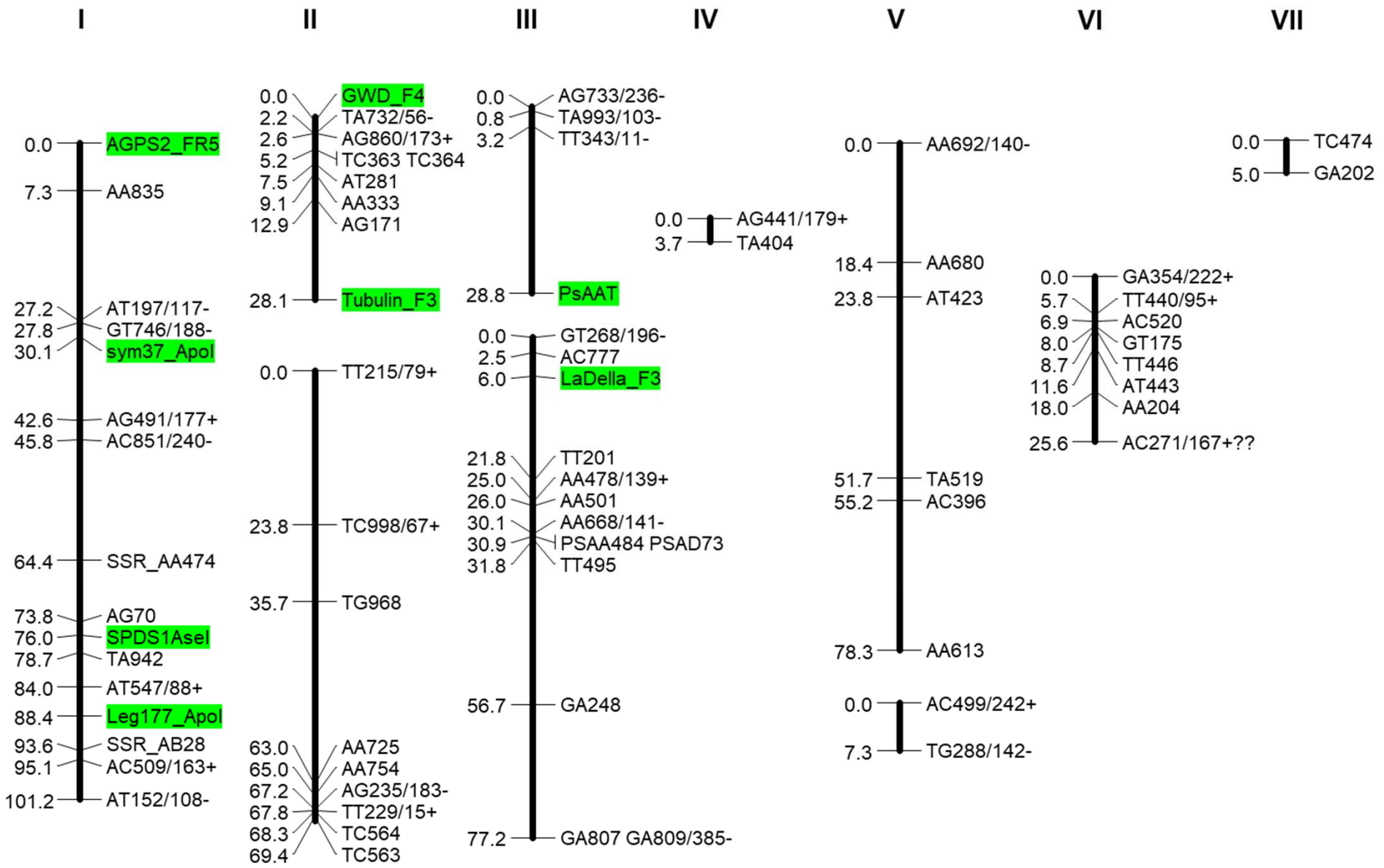
Supplementary Figure S2: Comparison of replicate plants from each of the chosen parent cultivars, using one of the PDR1 SSAP assays (Taq +AA) for genotyping



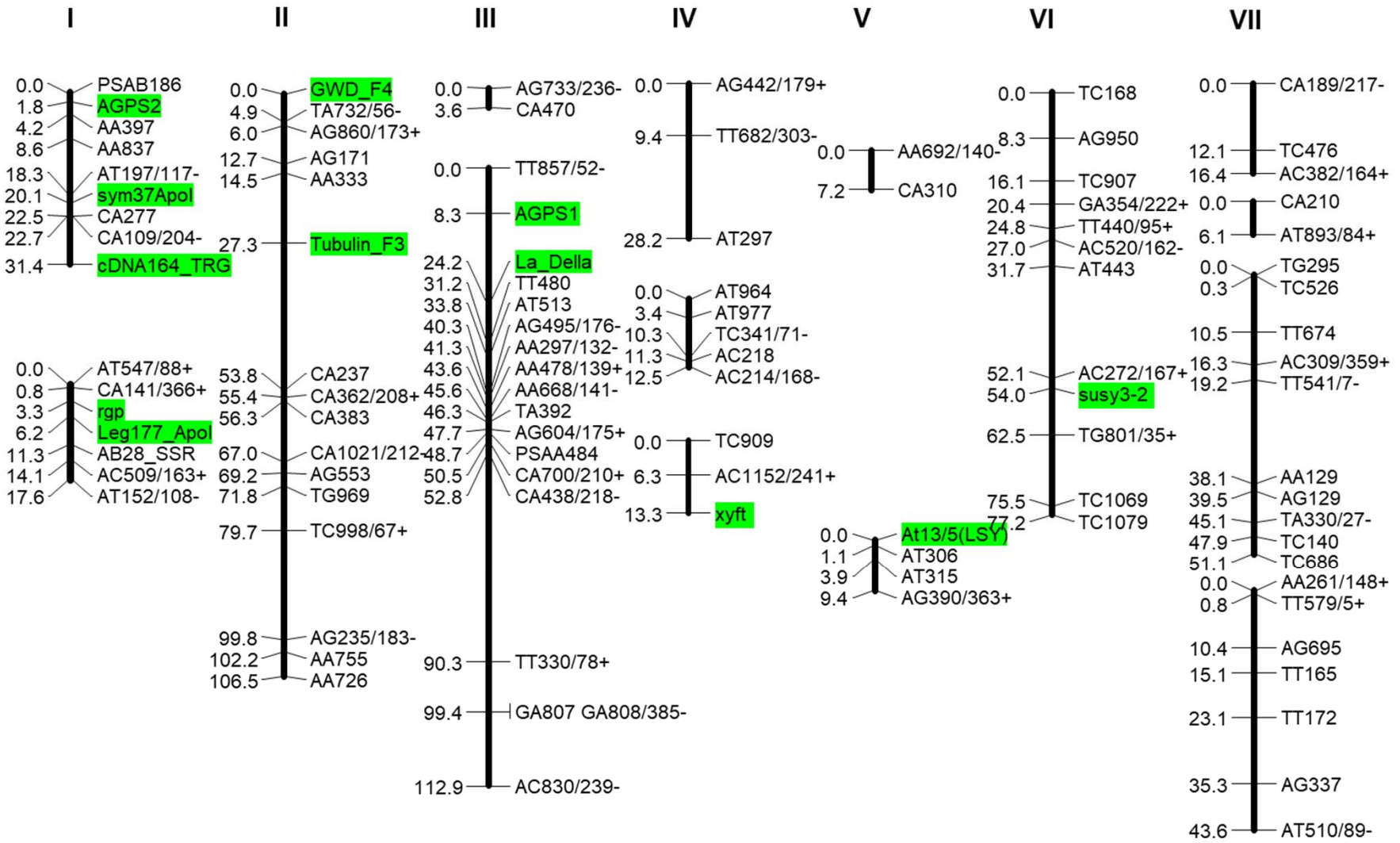
Supplementary Figure S3: A Phenotypes of parent, F1 and F2 progeny seeds from reciprocal crosses between the cvs. Kahuna and Enigma. The testa has been removed from two F2 seeds to reveal the cotyledon colour. A ruler scale is shown (mm).



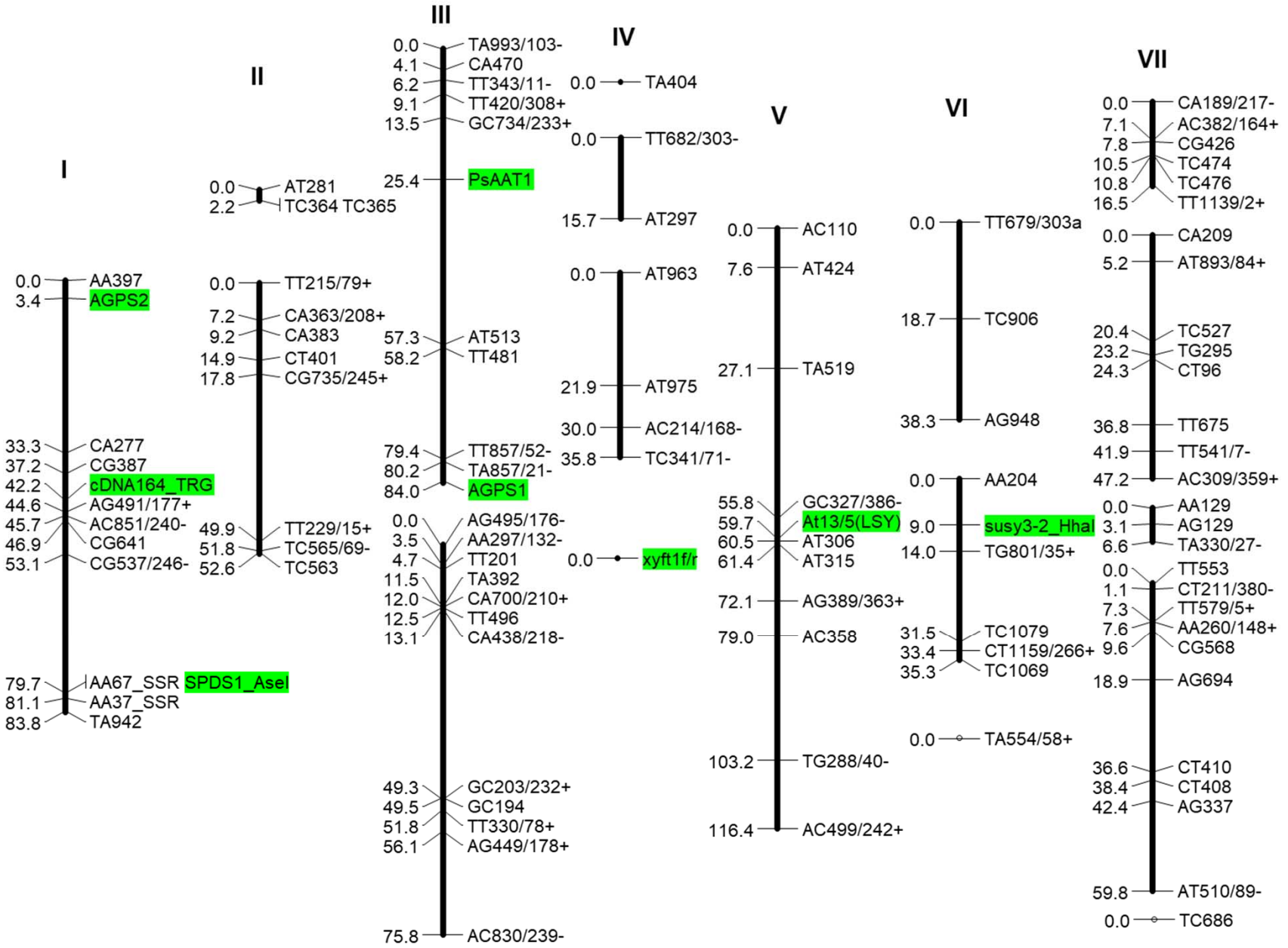
Supplementary Figure S3: B Phenotypes of parent, F1 and F2 progeny seed from reciprocal crosses between the cvs. Kahuna and Brutus. A ruler scale is shown (mm).



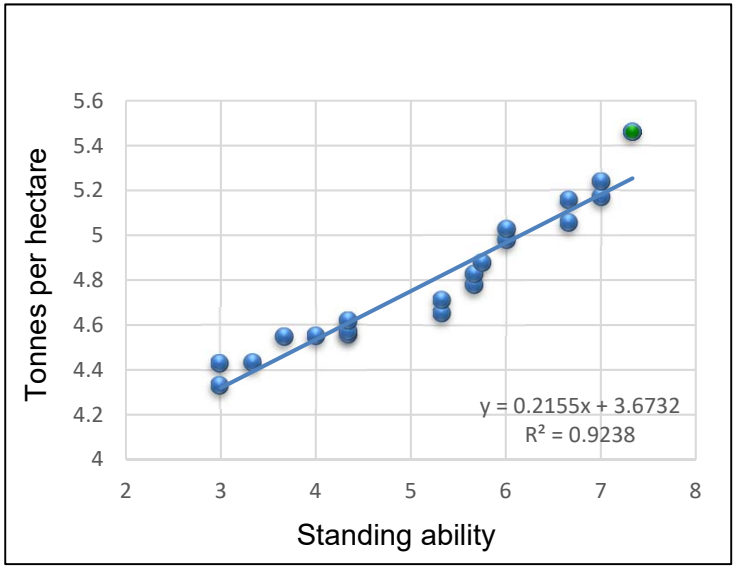
Supplementary Figure S4: Genetic map determined for the recombinant inbred lines derived from the cross between the cvs. Brutus and Enigma (BE/EB) at F6. Highlighted in green are genetic markers which correspond to gene-specific markers that allow maps to be cross-referenced, largely based on those of Aubert et al. (2006); for those assays which used a restriction enzyme, the enzyme is indicated in the marker name.



Supplementary Figure S5: Genetic map determined for the recombinant inbred lines derived from the cross between the cvs. Brutus and Kahuna (BK/KB) at F6. Highlighted in green are genetic markers which correspond to gene-specific markers that allow maps to be cross-referenced, largely based on those of Aubert et al. (2006); for those assays which used a restriction enzyme, the enzyme is indicated in the marker name.



Supplementary Figure S6: Genetic map determined for the recombinant inbred lines derived from the cross between the cvs. Enigma and Kahuna (EK/KE) at F6. Highlighted in green are genetic markers which correspond to gene-specific markers that allow maps to be cross-referenced, largely based on those of Aubert et al. (2006); for those assays which used a restriction enzyme, the enzyme is indicated in the marker name.



Supplementary Figure S7: Comparison of yield (tonnes per hectare) with standing ability scores for a subset of RILs with contrasting yields (blue dots) and the high-yielding cv. Prophet (green dot) at the PGRO site. The regression equation and correlation coefficient are shown.

Supplementary Figure S8: Predicted amino acid sequences for the small subunit 2 of ADP-glucose pyrophosphorylase (AgpS2) in ten lines of pea, including the cultivar parents, cvs. Brutus, Enigma and Kahuna. The cv. Princess is an additional marrowfat line, whereas JI 2822, JI 15, JI 399, JI 281, JI 1194 and JI 185 are the parents of additional sets of recombinant inbred lines. A single amino acid difference is highlighted (yellow).

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Enig_AGPS2        MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
Bru_AGPS2         MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
JI15_AGPS2        MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
JI399_AGPS2       MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
JI281_AGPS2       MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
JI1194_AGPS2      MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
JI185_AGPS2       MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
Princ_AGPS2       MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
Kah_AGPS2         MSSIVTSSVINVPRSSSSSKNLSFSSSQLSGDKILTVSGKGAPRGRCTRKHVIVTPKAVS 60
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Enig_AGPS2        DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
Bru_AGPS2         DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
JI15_AGPS2        DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
JI399_AGPS2       DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
JI281_AGPS2       DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
JI1194_AGPS2      DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
JI185_AGPS2       DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
Princ_AGPS2       DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
Kah_AGPS2         DSQNSQTCLDPDASRSVLGIILGGGAGTRLYPLTKKRAKPAVPLGANYRLIDIPVSNCLN 120
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Enig_AGPS2        SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
Bru_AGPS2         SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
JI15_AGPS2        SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
JI399_AGPS2       SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
JI281_AGPS2       SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
JI1194_AGPS2      SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
JI185_AGPS2       SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
Princ_AGPS2       SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
Kah_AGPS2         SNISKIYVLTQFNSASLNRHLSRAYASNLGGYKNEGFVEVLAAQQSPENPNWFQGTADAV 180
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Bru_AGPS2         RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
JI15_AGPS2        RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
JI399_AGPS2       RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
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JI1194_AGPS2      RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
JI185_AGPS2       RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
Princ_AGPS2       RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
Kah_AGPS2         RQYLWLFEEHNVLEYLILAGDHLYRMDYEKFIQAHRESDADITVAALPMDEKRATAFGLM 240
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Enig_AGPS2        KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
Bru_AGPS2         KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
JI15_AGPS2        KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
JI399_AGPS2       KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
JI281_AGPS2       KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
JI1194_AGPS2      KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
JI185_AGPS2       KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
Princ_AGPS2       KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
Kah_AGPS2         KIDEEGRIIEFAEKPKGEQLKAMKVDTTILGLDDERAKEMPFIASMGIYVISKNVMLDLL 300
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JI2822_AGPS2      RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
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Bru_AGPS2         RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
JI15_AGPS2        RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
JI399_AGPS2       RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
JI281_AGPS2       RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
JI1194_AGPS2      RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
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JI185_AGPS2       RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
Princ_AGPS2       RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
Kah_AGPS2         RDKFPGANDFGSEVIPGATSVGMRVQAYLYDGYWEDIGTIEAFYNANLGITKKPVPDFSF 360
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Enig_AGPS2        YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
Bru_AGPS2         YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
JI15_AGPS2        YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
JI399_AGPS2       YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
JI281_AGPS2       YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
JI1194_AGPS2      YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
JI185_AGPS2       YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
Princ_AGPS2       YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
Kah_AGPS2         YDRSSPIYTQPRYLPPSKMLDADITDSVIGEGCVIKNCKIFHSVVGLRSCISEGAIIEDT 420
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JI2822_AGPS2      LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
Enig_AGPS2        LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
Bru_AGPS2         LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
JI15_AGPS2        LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
JI399_AGPS2       LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
JI281_AGPS2       LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
JI1194_AGPS2      LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
JI185_AGPS2       LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
Princ_AGPS2       LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIKRAIVDKNARIGENVKIINSDNVQEAA 480
Kah_AGPS2         LLMGADYYETEADKRFLAAKGSVPIGIGKNSHIIRAIVDKNARIGENVKIINSDNVQEAA 480
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JI2822_AGPS2      RETEGYFIKSGIVTIIKDALIPSGTVI 507
Enig_AGPS2        RETEGYFIKSGIVTIIKDALIPSGTVI 507
Bru_AGPS2         RETEGYFIKSGIVTIIKDALIPSGTVI 507
JI15_AGPS2        RETEGYFIKSGIVTIIKDALIPSGTVI 507
JI399_AGPS2       RETEGYFIKSGIVTIIKDALIPSGTVI 507
JI281_AGPS2       RETEGYFIKSGIVTIIKDALIPSGTVI 507
JI1194_AGPS2      RETEGYFIKSGIVTIIKDALIPSGTVI 507
JI185_AGPS2       RETEGYFIKSGIVTIIKDALIPSGTVI 507
Princ_AGPS2       RETEGYFIKSGIVTIIKDALIPSGTVI 507
Kah_AGPS2         RETEGYFIKSGIVTIIKDALIPSGTVI 507
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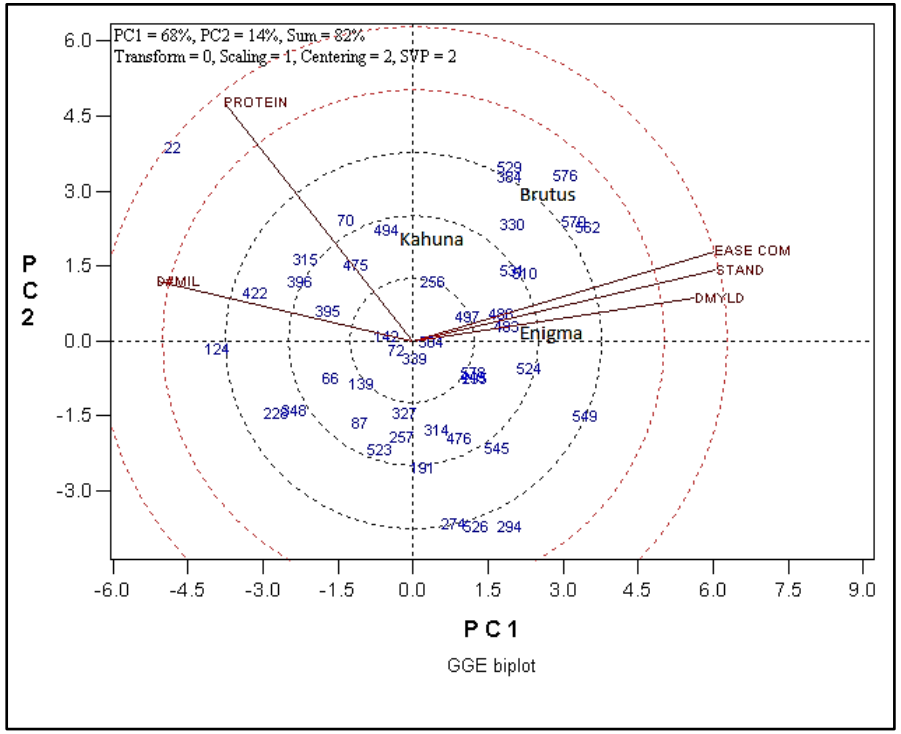
Supplementary Table S1: List of cultivars from which parents were chosen based on combined phenotypic and genotypic data
Astina
Atomic
Backgammon
Baroness
Baryton
Beaumont
Beetle
Big Daddy
Bilbo
Bohatyr
Brazil
Brutus
Carlton
Celica
Chambord
Cooper
Cosmic
Cratos
Croma
Delta
Enigma
Espace
Faust
Guido
Hawaii
Javlo
Kahuna
Lumina
Magnus
Maro
Minerva
Nitouche
Orb
Orka
Profi
Prophet
Princess
Racer
Rambo
Renata
Rose Maple
Samson
Santana

Setchey
Solara
Supra
Pidgin
Woodcock

Supplementary Table S2: Summary data from breeders' trials*, showing positive and negative responses of cultivars to yield, downy mildew, seed protein content and standing ability/ease of combining. The market classes of the varieties are indicated (marrowfat, white, large or small blues, maple). Green and red colours indicate the best and worst scores for the four traits, respectively, with pink and pale green representing lower scores than the stronger colours. Positive and negative scores are indicated; note that a plus score for downy mildew reflects an undesirable trait, in contrast to the other traits. A zero score means neither a positive or negative for the trait compared to other varieties. AFP refers to the unique reference number for the variety as it enters testing in the UK. The derived GGE biplot is shown alongside the table, based on the AFP numbers and the listed traits plus ease of combining (EASE COM) which is strongly correlated with standing ability. The three chosen parental lines are highlighted in the table and indicated in the biplot. Note that there were very limited data available for seven cultivars, including cv. Minerva. These varieties are listed at the end of the table but were excluded from the biplot.

*Source of breeders' trial records: NIAB

AFP	Market class	Cultivar name	Dry Matter Yield (DMYLD)	Downy Mildew (D MIL)	Protein Content (PROTEIN)	Standing Ability (STAND)
124	Marrowfat	Guido	- poor	+ poor	+	- poor
139	White	Renata	-	+	0	- poor
142	White	Baroness	-	+	+	-
191	White	Profi	-	-	-	-
228	Maple	Setchey	- poor	+	0	- poor
22	Marrowfat	Maro	-	+ poor	+ good	-
256	White	Delta	+	+	+	+
257	Marrowfat	Celica	-	-	-	-
25	White	Birte	-	+	-	-
274	L. Blue	Atomic	+	0	- poor	-
294	L. Blue	Espace	+	-	- poor	+
295	L. Blue	Astina	+	- good	-	+
314	White	Croma	0	-	-	0
315	Marrowfat	Supra	-	+	+ good	-
327	L. Blue	Woodcock	-	-	-	-
330	L. Blue	Nitouche	+	+	+	+



348	Maple	Racer	- poor	+	0	- poor
384	L. Blue	Brutus	+	0	+	+
395	Marrowfat	Samson	- poor	+ poor	+	-
396	Marrowfat	Rambo	-	+ poor	+	-
422	Marrowfat	Big Daddy	-	+ poor	+	-
443	White	Lumina	+	-	-	+
475	Marrowfat	Cratos	-	+	+ good	-
476	L. Blue	Carlton	0	-	- poor	0
483	White	Enigma	+ good	- good	-	+
486	White	Baryton	+	-	-	+ good
494	Marrowfat	Kahuna	0	+	+ good	0
497	White	Beetle	+	-	0	+
504	L. Blue	Backgammon	+	-	-	+
510	White	Santana	+	-	0	+ good
523	Marrowfat	Orka	-	0	-	-
524	L. Blue	Cooper	+ good	- good	-	+
526	L. Blue	Beaumont	0	-	- poor	0
529	White	Bilbo	+	-	+	+
531	Maple	Rose Maple	+	-	0	+ good
545	S. Blue	Hawaii	+	-	- poor	+
562	L. Blue	Prophet	+ good	-	0	+ good
66	White	Bohatyr	- poor	+	+	- poor
70	Marrowfat	Princess	-	+	+ good	-
72	L. Blue	Solara	-	+	+	-
87	S. Blue	Orb	-	+	-	-
113	Maple	Magnus	+	+	-	+
5	Maple	Minerva	-	+	+	-
441	Maple	Pidgin				
556	Marrowfat	Brazil				
533	White	Chambord				
260	White	Cosmic				
454	White	Faust				
458	White	Javlo				