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|  | **SINGLE-SEED-DESCENT** |  |
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|  | In single-seed-descent the progenies of the F2 plants are advanced rapidly through succeeding generations from single seeds (Fig). An example of the single-seed-descent procedure follows: |  |
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|  | ***Crossing generation*.** Cross cultivar A × cultivar B. |  |
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|  | ***F1* *generation*.** Grow 50 to 100 F1 plants. |  |
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|  | ***F2* *generation*.** Grow 2000 to 3000 F2 plants. Harvest a single seed from each plant. Identity of the F2 plant is not maintained. |  |
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|  | ***F3* *and F4* *generations*.** Grow seeds harvested in previous generation. Harvest a single seed from each plant. |  |
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|  | ***F5* *generation*.** Space plants in field from seeds harvested in previous generation. Select plants superior for desired characteristics and harvest seeds from the selected plants. |  |
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|  | ***F6* *generation*.** Grow progeny rows from plants harvested in the previous generation. Harvest rows superior for desired characteristics. Each row will have originated from a different F2 plant. |  |
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|  | ***F7* *generation*.** Grow preliminary yield trial from rows harvested in the previous generation. |  |
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|  | ***F8* *to F10* *generations*.** Continue yield trials in multiple locations as in pedigree-selection and bulk-population procedures. |  |
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|  | ***F11* *and F12* *generations***. Increase superior line and distribute as a new cultivar. |  |
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|  | An alternative procedure would be to space plant the F4 generation and plant the F5 in rows, thereby getting lines into yield trials one generation earlier. |  |
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|  | ***The single-seed-descent procedure was proposed as a means of maintaining descendants from the maximum number of F2 plants, thereby reducing the loss of genotypes during the segregating generations.*** As currently practiced, single-seed descent is utilized to reduce the time required to grow the segregating generations. Because only one seed is harvested from each plant, optimum plant development in the F2 to F4 generations is unnecessary. By thickly planting seeds in a greenhouse bench, growing plants with low soil fertility, and using temperature and lighting regimes that force early flowering, two to three generations are commonly harvested in a 1-year period, and the preliminary yield trial can be reached 1 to 2 years earlier. Species that can be forced to mature rapidly, such as soybean or summer-grown cereals (wheat, oat, barley), are suited for the single-seed-descent procedure.  With single-seed-descent, weak plants are not eliminated as in a field-grown nursery, and there is no provision for selection of superior segregates within families descendent from F2 plants. Modifications to the procedure may be introduced, such as screening for disease resistance or other appropriate characteristics in any generation. No record-keeping is required during the early segregating generations. Final evaluation of progenies and yield trials are conducted in the field. |  |
| |  |  | | --- | --- | | 0169-001.gif |  | |  | | |  | |  |  | | --- | | Fig. 9.4. Single-seed-descent method of selection. Seeds harvested from F1 plants are  space planted in F2. A single seed harvested from each F2 plant is used  to plant the F3. Succeeding generations through the F5 are likewise planted  from single seeds harvested from each plant grown in the preceding generation.  In the F5 generation plants are harvested and a progeny row grown in the F6.  A preliminary yield trial is grown in the F7 and yield trials continued through the F10.  Some breeders combine single-seed descent with the pedigree selection procedure,  by growing only the F3 and F4 by single-seed descent to accelerate the time required  to reach a yield trial. | | | | | |

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|  |  | **A modification of the procedure** has developed in soybean in which several pods are harvested from each plant instead of a single seed. A two- to three-seed sample from each plant is bulked to grow the next generation. This modified single-seed-descent procedure has become the principal method of advancing early generations in soybean breeding programs. With tropical winter nurseries, two or three generations can be advanced in a year with the modified procedure. |  |  |
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|  | **DOUBLED-HAPLOID** | | |  |
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|  | In the doubled-haploid procedure, haploid plants are generated from anthers of F1 plants, or by other means, and the chromosomes of the haploid plants are doubled with colchicine to produce diploid plants (Fig. 9.5). An example of the doubled-haploid procedure using anther culture follows: |  |
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|  | ***Crossing generation*.** Cross cultivar A × cultivar B. |  |
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|  | ***F1* *generation*.** Culture anthers to produce 2000 to 3000 haploid plants. |  |
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|  | ***F2* *generation*.** Double chromosomes of haploid plants and harvest seeds from the doubled-haploid plants produced. |  |
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|  | ***F3* *generation*.** Grow progeny rows from doubled-haploid plants and harvest seed from superior rows. |  |
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|  | ***F4* *generation*.** Grow progeny rows in the field and select superior lines. |  |
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|  | ***F5* *generation*.** Grow preliminary yield trial. |  |
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|  | ***F6* to *F8* *generations*.** Continue yield trials. |  |
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|  | ***F9* *and F10* *generations*.** Increase and distribute superior line as a new cultivar. |  |
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|  | Doubled-haploid plants are normally **homozygous at all loci** and it is **unnecessary to grow segregating generations**. Lines generated by the doubled-haploid procedure may reach preliminary yield trials two to three generations earlier than with the pedigree-selection or bulk-population procedures. Like the single-seed-descent procedure, early generations are not exposed to environmental stresses in the field, and attrition of lines is greater in initial field evaluation trials than with pedigree-selection or bulk-population procedures, in which the early generations are field grown. For successful use of the doubled-haploid procedure in plant breeding, efficient and reliable techniques for generating haploid and doubled-haploid plants are essential. The doubled-haploids should be vigorous, stable, free from tissue-culture-induced variations, and represent a random selection of the F1 pollen gametes. Current procedures for production of haploids and doubled-haploids have only been partially successful in attaining these characteristics. |  |
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|  | ***Choice of Procedure*** |  |
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|  | The superiority of a new cultivar is determined by the combination of genes that it contains, not by the procedure by which the cultivar was produced. Choice of procedure should be determined by the efficiency with which a superior combination can be assured and will vary with the crop species, the breeding objectives, and the resources available to the breeder. The current trend is to adopt breeding procedures that will reduce the number of years to develop and release a cultivar, and that will enable the breeder to grow and examine the largest number of lines with the resources available. Reduction in years may be accomplished by |  |

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| Fig. 9.5. Doubled-haploid procedure. Crosses are made and F1 progeny grown as in  previous procedures. Anthers from F1 plants are cultured and chromosome number  of haploid plants generated is doubled with colchicine to produce doubled haploids.  Progenies of doubled-haploid plants are evaluated in the field in F3 and F4 and superior  lines tested in yield trials in F5 to F5 generations.   |  |  |  | | --- | --- | --- | |  | growing two or more generations per year through winter nurseries, by single-seed-descent, or by reducing the number of segregating generations as with the doubled-haploid procedure. |  | |  | | | |  | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | The pedigree-selection procedure is certainly the most precise system when the objective is to combine particular parent traits that are simply inherited and easily observed in progeny plants, but it is less precise if the characters to be combined are quantitatively inherited, particularly if the heritability is low. It is labor-intensive in the early generations, due to the extensive seed packaging, planting, note-taking, and record-keeping required. The bulk-population system has gained favor due to the economy of labor and ease of growing large populations in the early generations. Single-seed-descent is suitable for crops that can be grown in a greenhouse environment or in winter nurseries in a semitropical climate. It is economical to pursue, and reduces the time required to grow the early segregating generations. The doubled-haploid procedure is labor intensive in the production of haploids and does not have the proven reliability of the other procedures. |  | |  | | | |  | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | Success in the hybridization method of breeding self-pollinated crops is dependent upon: |  | |  | | | |  | | |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | |  |  | | | | | | |  | |  | | | | | | | |  | * Choosing the correct parents, and | | | | |  | |  | * Identifying the superior plants from the segregating populations. |  |  | |  | |  | The choice of parents will be facilitated by clear and specific breeding objectives and superiority of the parents in characteristics contributing to those objectives. The contributions from the parents should complement each other, so that selected progeny plants will not be lacking in some important agronomic characteristic. Identification of the superior genotypes in the segregating progenies requires exhaustive testing and exposure to many adversities (e.g., disease, drought, or cold), extensive observation in various stages of growth, and accurate recording of the observations. Testing in different seasons at several locations with diverse climatic conditions will aid in identifying genotypes adapted over wide geographic areas. Only those lines that are distinctly superior and fulfill the objectives of the cross should be propagated, with rigorous rejection of mediocre selections or crosses. *The latter requires judgment decisions that can best be made by a skilled and experienced breeder*. | | |  | |  | |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | |  |  | | |  | |  | | | |  | If only one quantitative character is being emphasized in a cross, it should be possible to select transgressive segregates superior to either parent. If two or more quantitative characters are being improved, some compromise may be necessary, because one would seldom find superior transgressive segregation occurring simultaneously for two or more characters. At this point the breeder must choose which line best exemplifies the objectives of the cross and will be increased for further evaluation. |  | |  | | | |  | | |  |  |  |  | | --- | --- | --- | |  |  |  | |  | |