RRCF, Fortaleza, v.13, n. 2, Jul. /Dez. 2022
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ECONOMIC COSTS OF DEVELOPING NEW FIELD CROP CULTIVARS: A METHODOLOGICAL APPROACH

CUSTOS ECONÔMICOS DE DESENVOLVIMENTO DE NOVAS CULTIVARES DE CULTURAS AGRÍCOLAS: UMA ABORDAGEM METODOLÓGICA

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Recebido em 6 de agosto de 2022
Aprovado em 26 de agosto de 2022

ABSTRACT

This article proposes a methodology for calculating the average cost of developing cultivars to support plant breeding programs. The methodological proposal is exclusively for structured plant breeding programs, with constant inputs (activities, costs) and outputs (generated cultivars). In structured plant breeding programs, with regular inputs and outputs, it is possible to obtain the average cost of developing a cultivar from the sum of the annual costs with personnel, funding, and investments, divided by the number of cultivars generated (finalized) in the same year.

Keywords: average cost, plant breeding, new cultivars

RESUMO

Este artigo propõe uma metodologia de apuração do custo médio de desenvolvimento de cultivares para subsidiar programas de melhoramento genético vegetal. A proposta metodológica é destinada exclusivamente para programas de melhoramento vegetal estruturado, com entradas (atividades, custos) e saídas (cultivares geradas) constantes. Em programas de melhoramento genético vegetal estruturados, com entradas e saídas constantes, é possível se obter o custo médio de desenvolvimento de uma cultivar a partir do somatório dos custos anuais com pessoal, custeio e investimentos, dividido pelo número de cultivares geradas (finalizadas) no mesmo ano.

Palavras-chave: custo médio, melhoramento genético vegetal, novas cultivares

INTRODUCTION

Alston et al. (1995) showed that funding for breeding new cultivars is scarce. Therefore, it is crucial to know how much we spend on agricultural research and how to prioritize different possibilities. Public and private plant breeding programs invest scarce resources in developing new cultivars for agriculture. In this context, one of the difficulties breeding programs faces is knowing the development costs of each new cultivar delivered to farmers. The breeding-related economic literature is scarce in options that could be easily applied at the field level. Almeida and Yokoyama (2000) proposed a systematic methodology to determine the development costs of a new upland rice cultivar. However, due to changes over the last two decades in the research organization focused on innovation and the complexity of this methodology, it was felt to develop a new approach that would meet the new requirements, be as easy-to-apply as possible, and be adapted to different plant breeding programs. Therefore, the present note proposes a methodology for calculating the average cost of developing new cultivars to support plant breeding programs.

The inputs of the plant breeding program (~ costs)

The primary data required is the volume of financial resources invested (personnel, investment, and funding) in plant breeding programs. It is understood that the resources allocated to the costs include all the economic costs related to laboratory analyses, field operations, greenhouses, and the necessary inputs at each stage. If any proprietary technologies are used (e.g., transgenic traits, etc.), the costs of accessing these must be included in the costs of the breeding program. Personnel costs include all salaries and any additional costs related to the entire team involved.

Only structured genetic improvement programs are considered here, with a continuous flow of development activities and delivery of new finalized breeding lines that can be made available in the form of new cultivars (Table 1).

Table 1 - Illustration of activities, ranging from initial crosses to delivery of finished cultivars, repeated every year over time, featuring a consolidated plant breeding program, which carries out all activities simultaneously every year.

Year 1		Year 2		Year 3		...		Year *i*
Activity 1_1	=	Activity 1_2	=	Activity 1_3	=	...	=	Activity 1_i
Activity 2_1	=	Activity 2_2	=	Activity 2_3	=	...	=	Activity 2_i
Activity 3_1	=	Activity 3_2	=	Activity 3_3	=		=	Activity 3_i
...	=	...	=	...	=	...	=	...
Activity n_1	=	Activity n_2	=	Activity n_3	=	...	=	Activity n_i

Source: The authors.

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By "cultivar" it is understood as a breeding line that has passed all the evaluations foreseen, having demonstrated its superiority to other reference cultivars in the production environment for which it is being released.

If the costs over the years are similar, the activities are continuous (from new crosses to the delivery of new cultivars). The deliveries (number of new cultivars) are constant; it is enough to consider the costs and deliveries of a single year to estimate the average cost of developing a new cultivar.

So, if the costs of Activities 1 to n of Year 1 are repeated each year, that is, they are the same for Years 1 to i, then it is enough to consider the sum of the costs of all the activities of the improvement program in a selected year, as represented in Equation 1.

$$TAC_i = \sum_{A=1}^{n} CA_i \qquad (1)$$

Being:

- TAC_i = Total annual cost of the breeding program in year i;
- A = Activities 1 to n of the breeding program in year i;
- CA_i = Cost of Activity 1 to n of the breeding program in year i.

For analytical convenience (more accessible access to the most recent data), it is recommended to consider the last full year.

Thus, for the selected year i, list all costs for the set of activities 1 to n, considering personnel, funding, and investments, as shown in Table 2. In personnel expenses, consider the entire team involved, including researchers, analysts, technicians, and assistants (or equivalent categories), internally and externally to the organization.

Table 2. Personnel costs of the plant breeding program.

Team member	Dedication time (%)	Position/profile	Monthly cost (salary + taxes)
Person 1			
Person 2			
Person 3			
...			
Person n			

Source: The authors.

In Table 2, care must be taken to correctly weigh the costs of each member according to their time allocation (percentage of time dedicated to the program).

For analytical convenience, the indicator “dedication time (%)” (Table 2) can be transformed into the equivalent number of full-time people, for each position/profile, who effectively worked in the development process until the final product launch, in this case, the new cultivar. It is important to remember that personnel costs (Table 2) are monthly and must be multiplied by the monthly salaries per year to obtain the annual costs.

In addition to personnel costs, add current and investment expenses (annual depreciation) to obtain the value corresponding to the total costs per year (TAC).

The outputs of the plant breeding program (generated new cultivars)

Even if the average development time of a new cultivar of annual crops is ten to 12 years, if the program is well-structured and has a continuous flow, with regular deliveries (Table 3), every year, there may be new cultivars being delivered.

Table 3. Illustration of a set of cultivars delivered by the breeding program each year.

Year 1	Year 2	Year 3	...	Year *i*
Cultivar 1_1	Cultivar 1_2	Cultivar 1_3	...	Cultivar 1_i
Cultivar 2_1	Cultivar 2_2	Cultivar 2_3	...	Cultivar 2_i
Cultivar 3_1	Cultivar 3_2	Cultivar 3_3		Cultivar 3_i
...	...	...	...	...
Cultivar n_1	Cultivar n_2	Cultivar n_3	...	Cultivar n_i

Source: The authors.

So, the number of cultivars delivered each year can be represented by Equation 2.

$$NCD_i = \sum_{C=1}^{n} C_i \quad (2)$$

Being:

- NCD_i = Number of cultivars delivered by the breeding program in year *i*;
- C_i = Cultivars 1 to *n* delivered in year *i*;

The average cost of each delivered cultivar

The average cost of a new cultivar would be the sum of all costs of the breeding program during a year (assuming that these are constant and cover all program activities, from new crosses to the delivery of new cultivars) divided by the number of cultivars delivered per year, as represented in Equation 3.

$$ACC_i = \frac{TAC_i}{NCD_i} \quad (3)$$

Being:

- ACC_i = Average cost per cultivar delivered by the breeding program in year i;
- TAC_i = Total annual cost of the breeding program in year i;
- NCD_i = Number of cultivars delivered by the breeding program in year i.

This average cost of generating a cultivar can be used according to the interests of the program and the organization. It can be used for negotiations of lines with partners and decision-making regarding the structure and operations of the referred plant breeding program.

CONCLUDING REMARKS

It was possible to propose a simplified methodology for calculating the average cost of developing cultivars to support plant breeding programs.

However, it should be noted that this methodology is only applicable to already structured breeding programs, where there is a regularity of activities (inputs) and the number of generated new cultivars (outputs).

We believe that this methodology can be applied to any breeding program of any crop, annuals, or perennials, regardless of their production cycle. Thus, its main economic implications are related to the possibility of easily quantify the costs of developing new crop cultivars, enabling private and public breeding programs to take sound decisions regarding research priority-setting as well as business plan development.

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