

Selection of New Barley Advanced Lines Considering Several Agricultural Traits Simultaneously: Comparison of Two Mathematical Procedures

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Received: April 25, 2016 Accepted: June 24, 2016 Online Published: August 12, 2016

DOI: 10.12735/as.v4n3p01


URL: <http://dx.doi.org/10.12735/as.v4n3p01>

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Abstract

Plant breeders often handle large number of plants in a segregating population using limited resources. Therefore, the sooner they can reduce the number of plants to the barest minimum, but more importantly, to the most desirable and promising individuals, the better. The present short report deals with the selection of new advanced barley lines considering several agricultural traits simultaneously. We exemplify two new alternative uses of the Euclidean distance to identify the best 20% plant materials from a gamma radiation-mutant population. Plant height; days to flowering; plant lodging; coefficient of infection with leaf rust (*Puccinia hordei*), with powdery mildew (*Blumeria graminis* f. sp. *hordei*), with spot blotch (*Cochliobolus sativus*); yield; test weight; grain protein content and 1000 kernel weight were recorded and considered in the simultaneous selections described here. Essentially, selection indexes are proposed to calculate an overall value to a breeders' germplasm based on a number of traits. In reality, for many of the traits listed above, breeders are aiming for acceptable values such as for disease resistance and perhaps some morphological traits. For other traits, such as yield, the breeders are looking for the highest possible value. Therefore, each breeder will have different selection indexes; however, the mathematically defined indexes shown here would be particularly practical for plant breeders.

Keywords: plant breeding; simultaneous selection; *Hordeum vulgare* L.

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How to cite this paper: Gomez-Pando, L. R., Aldaba, G., Ibañez, M., Argumedo, K., & Lorenzo, J. C. (2016). Selection of new barley advanced lines considering several agricultural traits simultaneously: Comparison of two mathematical procedures. *Agricultural Science*, 4(3), 1-5. <http://dx.doi.org/10.12735/as.v4n3p01>

1. Introduction

For each crop there are a number of characters which considered together defining the overall desirability of the cultivar from the combined perspective of the producer and the consumer. These characters may range between about a dozen to several dozens and constitute the primary pool of characters that the breeder may target for improvement. These characters differ in economic and agronomic importance as well as easy with which they can be manipulated through breeding. Moreover, plant breeders often handle large number of plants in a segregating population using limited resources, e.g. time, space, labor and money. Therefore, the sooner they can reduce the number of plants to the barest minimum, but more importantly, to the most desirable and promising individuals, the better (Acquaah, 2007).

The present short report deals with the selection of new advanced lines considering several agricultural traits simultaneously. Various procedures have been described by Rodríguez-Fuentes, Pérez-Ponce and Fuchs (1987) and Acquaah (2007). It has been recommended to do one-trait-at-a-time selection, and selection based on independent trait criteria (e.g. not more than 7 shoots per rice plant and not less than 180 grains per panicle). The scoring method based on an arbitrary scale designed by the breeder to score the plant traits has also been suggested. In the coefficient method, plant traits are scored according to the rate: trait value in the plant / trait average in the population. Here we exemplify two new alternative uses of the Euclidean distance to identify the best 20% plant materials from a gamma radiation-mutant population of barley (*Hordeum vulgare*) cv. UNAL 96. This integrating indicator has been widely used in many fields of science, such as data analysis and pattern recognition (Ichino, 1988), bioinformatics (Tavazoie, Hughes, Campbell, Cho & Church, 1999), intelligent control systems (Jafar & Zilouchian, 2001), spectral identification (Granahan & Sweet, 2001), information retrieval (Kogan, 2007) and plant breeding (Gomez-Pando *et al.*, 2009).

Although this report only shows data of 55 plant materials to describe the new mathematical method, the complete breeding program developed at the National Agricultural University La Molina (Peru) involved more than 665 mutants and the parental material (control). Plant height; days to flowering; plant lodging; coefficient of infection with leaf rust (*Puccinia hordei*), with powdery mildew (*Blumeria graminis* f. sp. *hordei*), with spot blotch (*Cochliobolus sativus*); yield; test weight; grain protein content and 1000 kernel weight were recorded. To the best of our knowledge, the comparison shown in this paper has not been published to date.

2. Materials and Methods

Barley mutant lines of cv. UNALM 96 were obtained by seed (12% moisture) gamma irradiation (200 Gy). As an example for this short paper, only data of 54 mutant lines of M₇ generation randomly chosen are shown here. Plants were grown without replication using non-irradiated parental material as a control. Plant height (cm); days to flowering; plant lodging (%); coefficient of infection with leaf rust (%), with powdery mildew (%), with spot blotch (%); yield (kg/ha); test weight (kg/hl); grain protein content (%) and 1000 kernel weight (g) were evaluated (IPGRI, 1994; Roelfs, Singh & Saari, 1992).

Ten characters were recorded and each one was standardized to vary from 0 to 1 according to Kantardzic (2003). Two alternatives were compared, in the first one all agricultural traits had the same importance for the breeder, while in the second, yield and grain protein content were more relevant. In both strategies, the breeder searched for: maximum values of yield, mass of 1000 grains and hectoliter mass (test weight); minimum values of plant height and lodging, number of days to flowering, and coefficients of fungal infections; and 12% of grain protein content.

3. Results

Table 1. Original data. The complete experimental program involved evaluation of more than 600 potential new plant genetic materials

Plant materials	Plant height (cm)	Days to flowering	Plant lodging (%)	Coefficient of infection with leaf rust (%)	Infection with powdery mildew (%)	Infection with spot blotch (%)	Yield (kg/ha)	Test weight (kg/hl)	Grain protein content (%)	1000 kernel weight (g)
1	100	85	75	10.00	30	20	3781	64	12.1	57.8
2	100	84	80	20.00	20	10	3325	64	11.9	52.8
3	95	83	70	0.10	20	20	3650	66	11.3	52.2
4	95	89	70	10.00	40	30	3475	63	12.8	52.6
5	105	86	65	0.10	50	30	3613	66	11.5	56.8
6	100	89	40	0.02	60	20	3406	62	11.8	55.8
7	105	85	60	0.10	40	30	3319	63	12.4	51.0
8	90	86	30	0.10	30	30	4713	65	11.6	56.4
9	110	85	20	10.00	40	40	5000	64	11.2	56.0
10	100	89	60	5.00	50	40	4213	63	11.5	56.2
11	100	84	60	0.10	40	30	3900	64	10.6	52.8
12	100	86	65	0.10	60	30	3294	64	12.4	50.3
13	100	85	65	0.10	30	20	4519	63	11.3	55.4
14	100	84	60	5.00	30	20	4231	63	11.6	52.0
15	105	85	30	0.10	20	50	4763	64	10.8	55.5
16	105	88	20	0.10	30	50	5881	63	10.4	60.5
17	100	88	40	0.02	10	30	4306	63	12.8	52.0
18	105	86	70	5.00	10	20	4731	64	11.5	55.4
19	105	85	10	8.00	10	20	5263	64	9.8	56.4
20	105	86	20	24.00	20	30	4094	65	11.8	59.3
21	105	86	60	16.00	10	20	3781	59	10.5	58.2
22	100	88	45	8.00	10	30	3269	53	12.2	55.5
23	100	84	35	8.00	10	20	5150	61	10.1	60.7
24	105	85	30	4.00	20	30	5681	64	10.4	60.0
25	105	83	50	60.00	20	30	3281	65	10.6	72.3
26	110	92	5	50.00	30	40	6294	63	10.1	78.8
27	115	97	15	40.00	10	10	5044	65	9.6	54.6
28	115	99	15	40.00	20	20	5075	67	9.6	56.2
29	90	82	60	20.00	10	20	3556	62	10.6	52.2
30	100	82	50	10.00	20	20	4444	61	11.1	56.2
31	100	83	50	10.00	30	40	3669	63	10.9	65.5
32	95	84	80	10.00	20	30	3181	61	10.5	52.6
33	90	85	80	5.00	20	30	4425	60	11.5	53.8
34	105	85	45	10.00	30	40	3331	61	11.0	54.1
35	90	83	75	0.10	40	30	4347	60	11.0	51.2
36	85	84	85	10.00	30	20	3419	64	11.4	50.1
37	105	85	60	10.00	30	20	3631	62	10.9	55.2
38	90	85	80	0.10	40	40	3663	61	11.0	56.1
39	90	83	70	0.10	20	20	3613	61	10.3	52.8
40	95	84	45	10.00	30	30	4181	60	10.2	55.4
41	100	84	80	0.10	40	30	3588	60	10.9	52.8
42	100	85	30	10.00	30	30	4113	64	10.8	58.4
43	100	84	60	0.10	20	30	3419	63	10.7	56.1
44	100	85	45	20.00	40	20	3494	63	11.2	53.6
45	90	84	45	20.00	20	30	3481	64	11.2	55.4
46	90	84	80	0.10	20	40	3256	63	11.0	54.4
47	95	85	75	0.10	30	30	4344	65	11.5	55.1
48	95	83	50	0.10	30	20	4263	64	10.3	53.8
49	95	88	40	8.00	40	50	5131	64	10.7	57.9
50	100	84	80	0.10	40	30	4331	64	11.0	59.1
51	90	87	80	20.00	70	30	4525	62	11.7	56.1
52	90	83	65	0.10	50	50	3881	65	11.4	47.5
53	90	84	65	0.10	40	50	3800	67	11.9	54.4
54	100	84	70	0.10	50	20	3650	64	11.0	51.9
Original plant material	98	76	62	8.00	17	27	4246	66	10.5	56.8

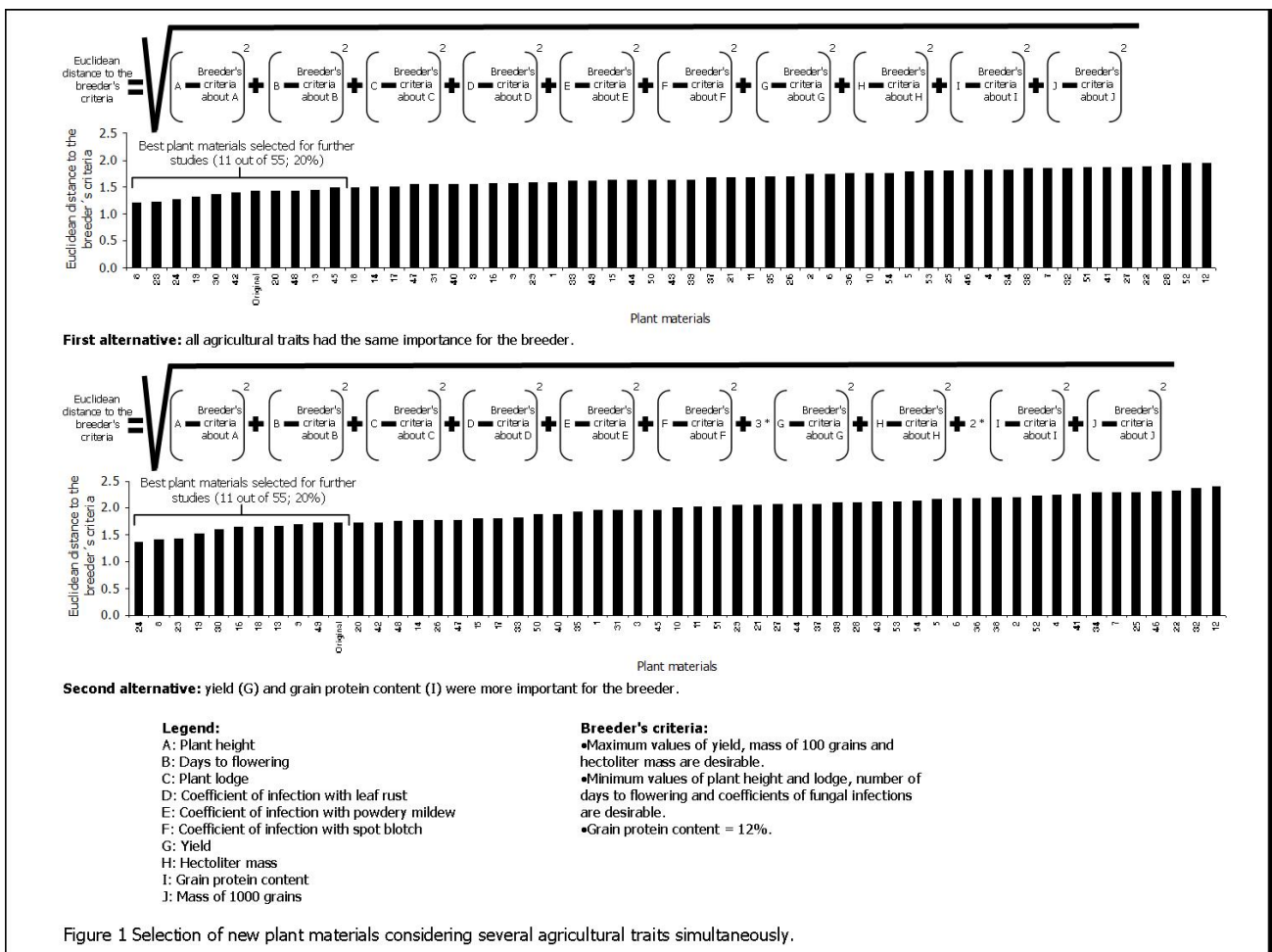


Table 1 shows the quantitative data of 54 mutants and the original plant material. Figure 1 shows the selection of new plant materials considering several agricultural traits simultaneously. Following the first alternative, where all characters had the same relevance, the following materials should be selected for further evaluation in the next generation: 8, 23, 24, 19, 30, 42, original, 20, 48, 13 and 45 (11 out of 55, 20%).

Results obtained following the second alternative, where yield and grain protein content had increased relevance over the other traits, identified 24, 8, 23, 19, 30, 16, 18, 13, 9, 49 and original as the best materials. Results of both alternatives were quite similar but materials were sorted differently. The breeder's experience is essential to increase the relative relevance of some traits, as shown in the second alternative.

4. Discussion

We have previously used the Euclidean distance to identify the best treatment in plant biotechnology experiments (Lorenzo *et al.*, 2013). Moreover, in our plant breeding research, we have employed the Euclidean distance to recognize the best field performance of new *in vitro* androgenesis-derived double haploids of barley (Gomez-Pando *et al.*, 2009). This paper shows a novel mathematical procedure useful for plant breeders that handle thousands plants in the field.

Acknowledgments

This research was supported by the Coordinated Research Project (CRP): “Improving Nutritional Quality by Altering Concentrations of Enhancing Factors Using Induced Mutation and Biotechnology in Crops”. CRP 15240.

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