**SHORT COMMUNICATION**

# ON WHEAT (*TRITICUM AESTIVUM* L. EM THELL.) BREEDING

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**Abstract:** A small data set on wheat breeding is used here to demonstrate a nonparametric statistical analysis to select desirable plant types. Only six varieties in three replications were evaluated on nineparameters. The proposed selection procedure has the flexibility to consider any combination of parameters and gives a preference order of selected plant types. The selection was carried out in two steps: 1. calculation of ranks of each genotype and summing the ranks to find cumulative ranks, and 2. normalizing the cumulative ranks by minimum value to find a preference order of genotypes by sorting the normalized cumulative ranks. The two steps are represented by the following set of two formulae: 1. $CR = \sum_{i=1}^{n} Ri$ and 2. NCR = CR/$CR_{min}$, where, CR = cumulative rank; NCR = normalized cumulative rank; R = Rank; n = number of parameters/characters evaluated. The values of NCR range from one to $CR_{max}/CR_{min}$. The higher valuesof NCR indicate the worst genotypes and range is an indicator of diversity evaluated. The NCR values near one indicate the most desired genotypes. In this example, the whole preference order is 1. HD3086, 2.Goal, 3.HD2967, 4.PBW502, 5.PBW343 and 6.NABI-BW.Crisscross planting, flowering synchronization and suitable modifications in crossing technique were also suggested for wheat breeding.

**Keywords:** Crop ideotype, Normalized cumulative ranks, Selection, Wheat breeding

## INTRODUCTION

Wheat is a self-pollinated crop.Therefore, breeding methods suitable for breeding wheat would be pure-line selection, pedigree method,bulk method, backcross method, single seed descent method, transgenic methods (Altpeter*et.al*. 1996a, b; Huber *et al* 2002).However, in all such breeding methods the selection is very crucial to pick up the right genotype/phenotype that is the vision/dream plant type of the plant breeder. Selection is practiced either on pre-existing variation or after creating it. While selecting, the subjectivity creeps in. Therefore, with a small set of data, a very objective method of selecting suitable plant types is demonstrated here.

Only six varieties namely Goal, PBW 343, PBW 502, HD 3086, HD 2967 and a newly released anthocyanin-rich variety NABI black wheat were evaluated at the college campus for nine characters. An effort was initiated to improve certain steps in wheat breeding. While making crosses in wheat, generally Borlaug method is used to emasculate florets. This is quite time-consuming and tedious. Therefore, an effort is being made to improve the process of making crosses in wheat. This paper reports the findings of this experiment and experience also. Thus the main objectives of this paper are: 1.to demonstrate a very objective way of selecting suitable plant types, and 2. to suggest certain novel steps in wheat breeding.

## MATERIALS AND METHODS

Six varieties, *viz*., Goal, PBW 343, PBW 502, HD 3086, HD 2967 and NABI – BW were planted in randomized block design (RBD). A very good cropof the wheat varieties was raised using standard package of practices. The crop stand was maintained at all life stages with special care. Plant heights were recorded on 5 to10 plants at 40,80,120 days after sowing to assess their early vigour & growth pattern.The data on plant heights(40 days after sowing (DAS), 80 DAS and 120 DAS), flag leaf (length, width and area) and spike characters(spikelets per spike, florets per spikelet and the total florets per spike) were summarized as shown in table 1.The data on flag leaf area were recorded in the form of leaf length and leaf width and calculated as per formula (Flag leaf area = Length x Width x 0.95**)** given by Thomas 1975. Some crosses were also made.Some novel ideas regarding wheat crossing came to the mind during experiment and these will be discussed at suitable points. These ideas are regarding emasculation & crossing of wheat. A large number of students take up wheat breeding but the current practice named as Borlaug method of emasculating wheat and making crosses seems to be very labor-intensive and back-breaking. A suitable modification is being tried and discussed in this paper.

## RESULTS AND DISCUSSION

In view of the objective number one of the experiment, the summarized data are given in table 1. On applying the NCR analysis, as advised by Singh (2017; 2018), on the summarized data, table 2 resulted. On sorting the data of table 2 on CR or NCR in increasing order, table 3 was obtained.

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**Table 1.**Summarized data set of six wheat varieties.

| | | Average pl. ht. at 40 DAS | | | Average pl. ht. at 80 DAS | | | Average pl. ht. at 120 DAS | | | Average Flag Leaf Area ($cm^2$) | | | Grand Mean Flag Leaf Area ($cm^2$) | Five ears' data on number, fertility & sterility of florets | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.N. | Variety | R1 | R2 | R3 | R1 | R2 | R3 | R1 | R2 | R3 | R1 | R2 | R3 | | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total |
| 1 | Goal | 36.26 | 39.37 | 38.08 | 91.58 | 87.38 | 86.4 | 95.52 | 100.02 | 101.3 | 53.88 | 55.49 | 49.51 | 52.96 | 69 | 26 | 95 | 76 | 28 | 104 | 74 | 32 | 106 | 80 | 30 | 110 | 81 | 34 | 115 |
| 2 | PBW343 | 28.18 | 27.74 | 26.44 | 93.42 | 81.54 | 70.8 | 95.96 | 94.3 | 98.22 | 31.61 | 37.14 | 39.9 | 36.22 | 79 | 28 | 107 | 70 | 31 | 101 | 61 | 27 | 88 | 67 | 29 | 96 | 72 | 29 | 101 |
| 3 | PBW502 | 32.83 | 26.67 | 31.53 | 97.9 | 96.4 | 75.14 | 96.85 | 91.96 | 101.86 | 41.74 | 42.45 | 43.21 | 42.47 | 88 | 34 | 122 | 74 | 28 | 102 | 75 | 31 | 106 | 69 | 33 | 102 | 67 | 30 | 97 |
| 4 | HD3086 | 32.64 | 30.96 | 31.2 | 93.22 | 87.08 | 84.56 | 100.42 | 103.76 | 95.08 | 48.86 | 50.48 | 36.47 | 45.27 | 75 | 17 | 92 | 68 | 24 | 92 | 93 | 23 | 116 | 74 | 24 | 98 | 73 | 26 | 99 |
| 5 | HD2967 | 34.79 | 29.88 | 31.19 | 101.68 | 95.4 | 80.34 | 94.28 | 98.5 | 277.42 | 45.56 | 52.1 | 45.81 | 47.82 | 88 | 34 | 122 | 80 | 34 | 114 | 73 | 32 | 105 | 74 | 30 | 104 | 75 | 32 | 107 |
| 6 | NABI-BW | 23.64 | 24.66 | 24.68 | 75.24 | 75.66 | 79.96 | 90.56 | 89.8 | 90.3 | 39.9 | 36.8 | 40.32 | 39.01 | 60 | 26 | 86 | 59 | 30 | 89 | 49 | 35 | 84 | 47 | 41 | 88 | 63 | 32 | 95 |

**Table 2.**Ranks, cumulative ranks and normalized cumulative ranks based on table 1.

| | | Average pl. ht. at 40 DAS | | | Average pl. ht. at 80 DAS | | | Average pl. ht. at 120 DAS | | | Average Flag Leaf Area ($cm^2$) | | | Grand Mean Flag Leaf Area ($cm^2$) | Five ears' data on number, fertility & sterility of florets | | | | | | | | | | | | | | CR | NCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.N. | Variety | R1 | R2 | R3 | R1 | R2 | R3 | R1 | R2 | R3 | R1 | R2 | R3 | | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | | |
| 1 | Goal | 1 | 1 | 1 | 5 | 3 | 1 | 4 | 2 | 3 | 6 | 6 | 6 | 6 | 5 | 2 | 4 | 2 | 2 | 2 | 3 | 4 | 2 | 1 | 3 | 1 | 1 | 6 | 1 | 84 | 1.06 |
| 2 | PBW343 | 5 | 4 | 5 | 3 | 5 | 6 | 3 | 4 | 4 | 1 | 2 | 2 | 1 | 3 | 4 | 3 | 4 | 5 | 4 | 5 | 2 | 5 | 5 | 2 | 5 | 4 | 2 | 3 | 101 | 1.28 |
| 3 | PBW502 | 3 | 5 | 2 | 2 | 1 | 5 | 2 | 5 | 2 | 3 | 3 | 4 | 3 | 1 | 5 | 1 | 3 | 2 | 3 | 2 | 3 | 2 | 4 | 5 | 3 | 5 | 3 | 5 | 87 | 1.1 |
| 4 | HD3086 | 4 | 2 | 3 | 4 | 4 | 2 | 1 | 1 | 5 | 5 | 4 | 1 | 4 | 4 | 1 | 5 | 5 | 1 | 5 | 1 | 1 | 1 | 2 | 1 | 4 | 3 | 1 | 4 | 79 | 1 |
| 5 | HD2967 | 2 | 3 | 4 | 1 | 2 | 3 | 5 | 3 | 1 | 4 | 5 | 5 | 5 | 1 | 5 | 1 | 1 | 6 | 1 | 4 | 4 | 4 | 2 | 3 | 2 | 2 | 4 | 2 | 85 | 1.08 |
| 6 | NABI-BW | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 6 | 2 | 1 | 3 | 2 | 6 | 2 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 142 | 1.8 |

**Table 3.**Data of table 2 sorted on CR or NCR.

| | | Average pl. ht. at 40 DAS | | | Average pl. ht. at 80 DAS | | | Average pl. ht. at 120 DAS | | | Average Flag Leaf Area ($cm^2$) | | | Grand Mean Flag Leaf Area ($cm^2$) | Five ears' data on number, fertility & sterility of florets | | | | | | | | | | | | | | CR | NCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.N. | Variety | R1 | R2 | R3 | R1 | R2 | R3 | R1 | R2 | R3 | R1 | R2 | R3 | | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | Fertile | Sterile | Total | | |
| 4 | HD3086 | 4 | 2 | 3 | 4 | 4 | 2 | 1 | 1 | 5 | 5 | 4 | 1 | 4 | 4 | 1 | 5 | 5 | 1 | 5 | 1 | 1 | 1 | 2 | 1 | 4 | 3 | 1 | 4 | 79 | 1 |
| 1 | Goal | 1 | 1 | 1 | 5 | 3 | 1 | 4 | 2 | 3 | 6 | 6 | 6 | 6 | 5 | 2 | 4 | 2 | 2 | 2 | 3 | 4 | 2 | 1 | 3 | 1 | 1 | 6 | 1 | 84 | 1.06 |
| 5 | HD2967 | 2 | 3 | 4 | 1 | 2 | 3 | 5 | 3 | 1 | 4 | 5 | 5 | 5 | 1 | 5 | 1 | 1 | 6 | 1 | 4 | 4 | 4 | 2 | 3 | 2 | 2 | 4 | 2 | 85 | 1.08 |
| 3 | PBW502 | 3 | 5 | 2 | 2 | 1 | 5 | 2 | 5 | 2 | 3 | 3 | 4 | 3 | 1 | 5 | 1 | 3 | 2 | 3 | 2 | 3 | 2 | 4 | 5 | 3 | 5 | 3 | 5 | 87 | 1.1 |
| 2 | PBW343 | 5 | 4 | 5 | 3 | 5 | 6 | 3 | 4 | 4 | 1 | 2 | 2 | 1 | 3 | 4 | 3 | 4 | 5 | 4 | 5 | 2 | 5 | 5 | 2 | 5 | 4 | 2 | 3 | 101 | 1.28 |
| 6 | NABI-BW | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 6 | 6 | 2 | 1 | 3 | 2 | 6 | 2 | 6 | 6 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 | 142 | 1.8 |

This table shows the order of preference of the evaluated wheat varieties that should be recommended to the farmers of this region for cultivation. This is a very objective way of selecting varieties for breeding and/or cultivation purposes.

The preference order of the wheat varieties as indicated in table 3 is 1. HD3086, 2.Goal, 3.HD2967, 4.PBW502, 5.PBW343 and 6.NABI-BW. This procedure should be used to analyze large data sets involving a large number of varieties so that many other inferences could be drawn for further wheat improvement. Plant types (wheat ideotypes) selected for early vigour would havean smothering effect on weeds resulting into effective weed control and increase in wheat yield. In paddy (*Oryza sativa*) also the varieties like Kaladhan, CRD 307, CRD 4, and CRD 3 have an smothering effect on weed. Generally, small leaves (and flag leaf) are being preferred in wheat (few small leaves, Donald (1968); Rasmuson(1987)0or paddy ideotypes (short erect leaves of medium width (Chandler and Robert(1969)). Long ears having more spikelets and fertile florets give high yield when high numbers of ears are maintained per unit area. If a large number of genotypes/varieties are evaluated, then we can get idea about suitable genes to be looked for further improvement of the improved varieties.

The second objective originated from the experiencegained during this experimentandresulted into suggesting certain steps to improve wheat breeding such as: 1. planting varieties in crisscross fashion to facilitate crossing. 2. synchronization of flowering with prior knowledge of days to 50% flowering and adjusting the sowing dates accordingly, and 3. exposing the reproductive organs (male/female *i.e.*, anthers and stigmas) and bagging both the parents together within a single bag of butter paper so as to get $P_1$, $P_2$, $F_1$ and its reciprocal at each crisscross. The crisscross could be either pots, lines or strips as per need and availability of seeds, land, human resource and other resources.The crisscross sowing facilitates crossing and increasing/opening variation. Furthermore, one can think of improving the shortcomings of the most suitable varieties that are very easy to be located from the ranking data. For example, the most suitable variety HD 3086 has scope for further improvements in flag leaf area and floret fertility. Thus, a crisscross planting, synchronizing flowering phenology and simultaneous emasculation/bagging would facilitate wheat breeding. Singh *et al.,* (2018) also tried this selection procedure in Quinoa (*Chenopodium quinoa*Willd.).

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