Evaluation of Saline Tolerant Wheat (*Triticum aestivum* L.) in F_2 Segregating Populations

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Abstract- Wheat is the major staple food crop worldwide and frequently cultivated on saline soil. Salinity is the serious factor hampering wheat productivity with adverse effect on germination, growth and final economic yield. This study was carried out to evaluate six F_2 segregating populations at Pindi Bhattiyan, Pakistan under normal and saline conditions during 2013-14. Individual plants of each population were selected and evaluated on the basis of plant height, number of tillers, spike length, spikelets per spike, grain per spike, grains weight per spike, 100 grain weight and average grain yield per plant under saline and normal environments using biplot analysis. Biplot analysis appeared valuable screening tool to identify the slat tolerant wheat genotypes due to its graphical nature. Based on biplot plants of each F_2 population are classified into four groups. First group A contained the F_2plant with high saline tolerance suitable for saline environment. Second group B having the F_2 plant with good performance under normal condition. 3rd group C and 4th group D having the poor performing F_2 plant in both normal and saline environmental condition.

Index Terms- Biplot analysis, F_2 population, Saline tolerance, Wheat

I. Introduction

Salinity is the major threat to crop yield worldwide (Ali *et al*., 2012), and also restrict lands which are uncultivated. More than 6 % of areas through-out the world is saline affected (FAO, 2010) most importantly in semi-arid and arid areas of the world. It has been expected that about 12 billion US dollar loss of world economy (Lauchli and Luttge, 2004), 20 % of irrigated lands (Dashti *et al*., 2012), 20 % of agriculture lands and 50 % of cropped lands in the world suffer due to salinity (Flowers and Yeo, 1995).Saline soils amelioration is non-economical process, selection and breeding has received the considerable attention as it is an effective, efficient and cheaper strategy to improve salinity tolerance in crops (Ashraf, 2009). Enhancing the saline tolerance of two staple crops viz. rice, wheat are of major concern to meet the demand of rapid increasing population than improving the un-cultivated land (FAO 2010).

Wheat (*Triticum aestivum* L.) is major staple food crop worldwide and frequently cultivated on saline soils. Soil salinity affects the wheat productivity with a loss of about 1.2 Million tons account for 150 US Dollar M per annum in Pakistan (FAO, 2005). Genetic improvement of wheat for salinity tolerance and enhancement of production by using existing genetic resources are the key aims of our breeding program. Screening methodology for evaluating the available genetic resources, prevalence of genetic variation for salinity tolerance, implementation of suitable breeding methodology and appropriate biometrical techniques is perquisite for improving the salinity tolerance. The best way for yield improvement and its stability under saline condition, is to develop saline tolerant varieties.

Salinity tolerance is the complex quantitative trait. Various statistical measures like relative salt tolerance (Ali *et al*., 2007), absolute salt tolerance (Dewy, 1962) and stress susceptibility index (Fisher and Maurer, 1978), provide the confusing and complicated results. Therefore there is need to evaluate the salt tolerance by the use of simple, ease to interpret the results and accuracy of the statistical methods is high priority. In this regard biplot is simple, accurate and easy to understand the results because of its graphical nature. Biplot analysis also explains the genotype × environment interactions.

The objective of this study is to exploit variation within wheat F_2segregating populations for salinity tolerance and to identify new saline tolerant lines

II. MATERIALS AND METHODS

Plant Material and Layout

Three lines and two testers viz, PARC-9, PARC-10, WN-73, WN-64 and WN-85 respectively were crossed in line × tester fashion. PARC-9, PARC-10 was collected from NARC, Islamabad, Pakistan and WN-73, WN-64 and WN-85 from CIMMYT. F_2 plant material is raised through the F_1generation which was developed by line × tester fashion including six F_2 generations and their respective parents.

The plant material was sown following two factor factorial randomized complete block design with three replicates under normal and saline conditions. One row of each parent, check and twelve rows of each F_2 population were sown per replication. Each row was one meter long and kept 22 cm apart while plants were spaced 15 cm apart. Two seeds per hole were sown with the help of dibbler and later thinned to one healthy seedling per hole after germination.

Growing Condition and Cultural Practices

This study was carried out in the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, to evaluate six F_2 segregating populations at Pindi Bhattiyan, Pakistan located between longitude 73.5° East, latitude 32° North, under normal and saline conditions from the end of November to the mid of May 2013-14. The average minimum temperature was 8.2°C and average maximum temperature was 27.4°C during November to May. The soil condition of normal field experiment was slightly saline and slightly sodic having pH value 8.10, electric conductivity (ECe) 4.0 dsm^{-1} and sodium absorption ratio (SAR) 22.8 $(mmolL^{-1})^{1/2}$. The soil condition of saline field experiment was slightly saline and moderately sodic having pH value 8.5, electric conductivity (ECe) 4.8 dsm^{-1} and sodium absorption ratio (SAR) 30.2 $(mmolL^{-1})^{1/2}$.

Three irrigations were applied at tillering, booting and grain formation stages to both field experiments. The fertilizers NPK was applied to both experimental fields in ratio of 120:110:70 kg/ha respectively. All other recommended agronomic practices and plant protection care were followed uniformly.

Traits measure

At grain maturity, fifty plants of F_2 generation and ten plants of parents from each replication were harvested. For hundred-grain weight and average grain yield per plant, tagging was done on the basis of tillering capacity of each plant within the population. At grain maturity, data were recorded on 50 plants of six F_2 populations in each replication and ten well-guarded plants from each parent for the traits mentioned below: Plant height (cm), Fertile tillers/plant, Spike length (cm), Spikelets per spike, Grains per spike, Grain weight/spike (g), 100 grain weight (g) and Grain yield per plant (g).

Statistical analysis

The data were subjected to statistical analysis to analyze the effects of salinity on F_2 generations using analysis of variance technique (Steel *et al*., 1997). Further mean data were subjected to Biplot analysis using Gen Stat v 10 software to identify salt tolerant/sensitive plants.

III. RESULTS

Analysis of variance

Analysis of variance were carried out for all morphological characters including plant height, number of tillers, spike length, spikelets per spike, grain per spike, grains weight per spike, 100 grain weight and average yield per plant as illustrated in Table 2. Family demonstrated the highly significant results for number of tillers, 100 grain weight and average yield per plant whereas significant differences for spikelets per spike. Treatment and family × treatment showed significant results for all traits while family showed significant variations for number of tillers, spikelet per spike, 100grain weight and yield per plant.

Biplot graph under normal and saline conditions

Individual plant data of various traits like plant height, number of tillers per plant, spike length, spikelets per spike, grain per spike, grain weight of spike, hundred grain weight and average yield per plant of six F_2 wheat segregating populations grown under normal and saline conditions were subjected to biplot analysis in order to identifying the salt tolerant/sensitive plants.

A comparison of all traits viz. plant height, number of tillers, spike length, spikelet's per spike, grain per spike, grain weight per spike, 100grain weight and grain yield for PARC-9 × WN-64 population under normal and salinity condition illustrated in Figure 1(a-h). Biplot revealed that group-A plants made longest OP vector with all the traits in saline condition and were tolerant under saline stress. Group B plants had longest OP vector with all traits in normal condition. Whereas, group C and D fall opposite to saline and normal vector, respectively in all traits and thus poor performer for all traits under both conditions.

Biplot graph are made to compare all traits viz. plant height, number of tillers, spike length, spikelet's per spike, grain per spike, grain weight per spike, 100grain weight and grain yield for PARC-9 × WN-85 population for normal and saline condition demonstrated in Figure 2(a-h). Biplot showed that group-A plants had longest vector with all the traits in saline condition and were tolerant under saline stress. Group B plants had longest vector with all traits in normal condition. Whereas, group C and D fall opposite to saline and normal vector, respectively in all traits and thus poor performer for all traits under both conditions.

Evaluate the PARC-10× WN-64 population under normal and saline condition for all traits viz. plant height, number of tillers, spike length, spikelet's per spike, grain per spike, grain weight per spike, 100grain weight and grain yield illustrated in Figure 3(a-h). Biplot graph suggested that group-A plants made longest OP vector with all the traits in saline condition and were tolerant under saline stress. Group B plants had longest OP vector with all traits in normal condition. Whereas, group C and D fall opposite to saline and normal vector, respectively in all traits and thus poor performer for all traits under both conditions.

Biplot analysis of all traits viz. plant height, number of tillers, spike length, spikelet's per spike, grain per spike, grain weight per spike, 100grain weight and grain yield for PARC-10 × WN-85 population under normal and saline condition demonstrated in Figure 4(a-h). Biplot showed that group-A plants made longest OP vector with all the traits in saline condition and were tolerant under saline stress. Group B plants had longest OP vector with all traits in normal condition. Whereas, group C and D fall opposite to saline and normal vector, respectively in all traits and thus poor performer for all traits under both conditions.

Under study traits viz. plant height, number of tillers, spike length, spikelet's per spike, grain per spike, grain weight per spike, 100grain weight and grain yield were evaluated for WN-73 × WN-64 population under normal and saline condition demonstrated in Figure 5(a-h). Biplot showed that group-A plants made longest OP vector with all the traits in saline condition and were tolerant under saline stress. Group B plants had longest OP vector with all traits in normal condition. Whereas, group C and D fall opposite to saline and normal vector, respectively in all traits and thus poor performer for all traits under both conditions.

Biplot analysis ofWN-73 × WN-85 population for all traits viz. plant height, number of tillers, spike length, spikelet's per spike,

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grain per spike, grain weight per spike, 100grain weight and grain yield under normal and saline condition demonstrated in Figure 6(a-h). Biplot showed that group-A plants made longest OP vector with all the traits in saline condition and were tolerant under saline stress. Group B plants had longest OP vector with all traits in normal condition. Whereas, group C and D fall opposite to saline and normal vector, respectively in all traits and thus poor performer for all traits under both conditions.

IV. DISCUSSION

Highly significant differences among six F_2families for traits viz. plant height, number of tillers, spike length, spikelet's per spike, grain per spike, grain weight per spike, 100grain weight and grain yield revealed the prevalence of genetic variability and possibility of selection under both normal and saline conditions. Environmental variances were also found to be highly significant suggested that all traits were influenced under both normal and saline environmental conditions. The family × environment interactions were also found to be highly significant for all traits. Table 2 suggested the six families were influenced by both environmental conditions. These results were in accordance with earlier studies (Ali *et al*., 2012; Babar *et al*, 2015 and Nourai Rad *et al*., 2012), indicated the importance of G × E interaction. The importance of G × E interaction has been demonstrated by different breeding programs for major crops. Plant breeders have great interest to evaluate the genotype × environment interaction and select the superior plants with stable performance under both normal and saline conditions. G × E interaction also complicates the selection of superior genotypes over the range of environment (Yaghotipoor and Farshadfar, 2007).

Scientists have been made different attempts to develop the statistical analysis for the better understanding and explanation of G × E interaction. Biplot analysis is popular among the plant breeder for investigating the genotype performance and mega-environment identification (Yan *et al*., 2001). Biplot is easy to understand and interpret the salt tolerance and susceptible genotype because of graphical demonstration of data. It also demonstrated the overall average performance of six families across environments and helped to identify the salt tolerant plants across the treatment. These advantages of biplot analysis over the other biometrical analysis, considered as reliable procedure for evaluating the genotype performance under both environments (Ali *et al*., 2012), hence biplot method is recommended for screening analysis. Results concluded that significant genetic variation for salt tolerance was observed among six families. Biplot identified the group A as tolerant group of plants whereas group C and B plants were identified as most susceptible.

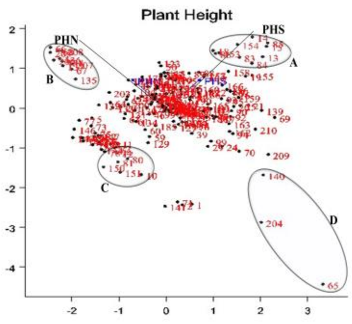
[1] Appendix

Table 1: List of wheat plant material including six F_2 generations and their parents

Sr. No.	Genotype	Parentage
1	PARC-9 × Wn-85	(FERT2/KURUKU//FERT2) × (WBLLI*2/BRAMBLING)
2	PARC-9 × Wn-64	(FERT2/KURUKU//FERT2) × (WAXWING*2/KUKUNA)
3	PARC-10 × Wn-85	(RAWAL 87/80 73) × (WBLLI*2/BRAMBLING)
4	PARC-10 × Wn-64	(RAWAL 87/80 73) × (WAXWING*2/KUKUNA)
5	Wn-73 × Wn-85	(WAXWING*2/TUKURU) × (WBLLI*2/BRAMBLING)
6	Wn-73 × Wn-64	(WAXWING*2/TUKURU) ×(WAXWING*2/KUKUNA)
7	Wn-85	WBLLI*2/BRAMBLING
8	Wn-64	WAXWING*2/KUKUNA
9	PARC-9	FERT2/KURUKU//FERT2
10	PARC-10	RAWAL 87/80 73
11	Wn-73	WAXWING*2/TUKURU

Table 2: Analysis of variance analysis results for eight yield and yield related traits of six F_2 populations under normal and saline conditions

S. No.	Characters	Family	Treatment	Family × Treatment
1	Plant Height	20.41^{ns}	2379.00^{**}	29.41^{*}
2	Number of Tiller	1.70^{**}	50.67^{**}	1.50^{**}
3	Spike Length	0.998^{ns}	37.78^{**}	0.980^{**}
4	Spikelet per Spike	6.27^{*}	69.78^{**}	3.50^{**}
5	Grain per spike	29.95^{ns}	2868.67^{**}	105.11^{**}
6	Grain Weight per Spike	0.088^{ns}	3.074^{**}	0.197^{**}
7	100 Grain Weight	0.152^{**}	0.389^{**}	0.018^{**}
8	Average Yield per Plant	13.63^{**}	204.97^{**}	0.654^{**}



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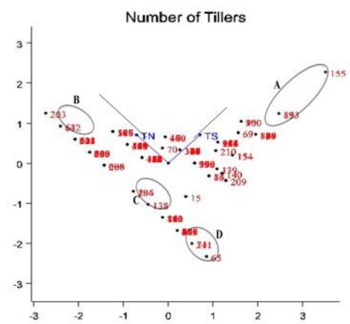

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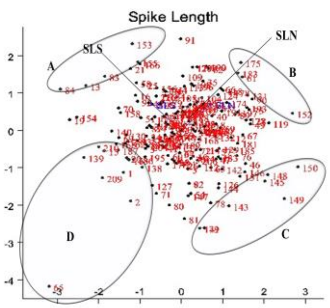

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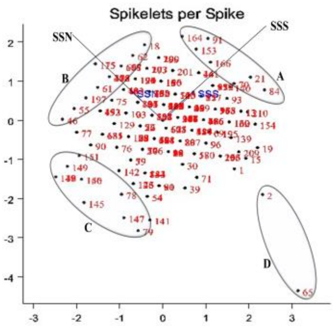

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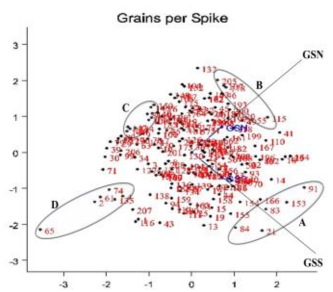

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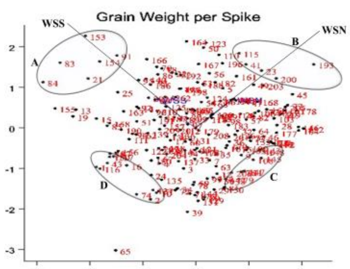


Figure 1f

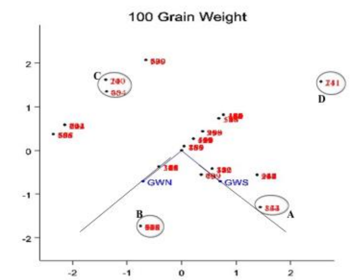


Figure 1g

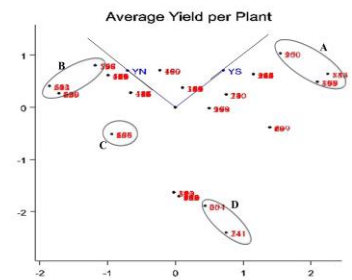
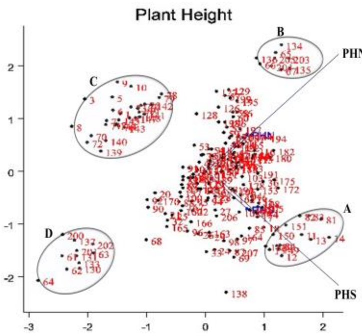


Figure 1h

Figure 1: Biplot of Wheat F_2 PARC-9 × WN-64 population for normal and saline conditions



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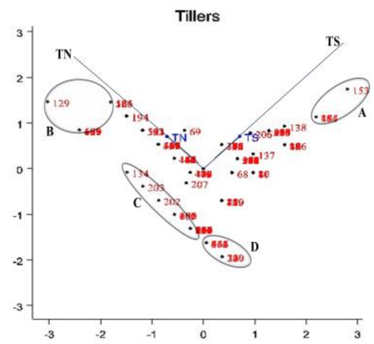

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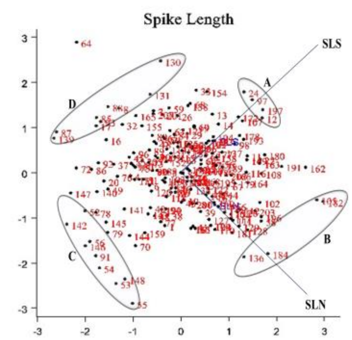

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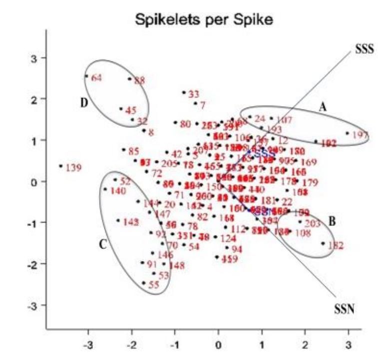

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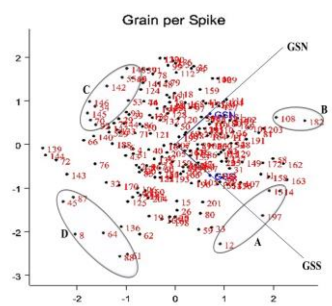

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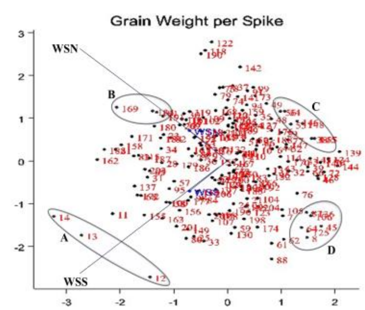

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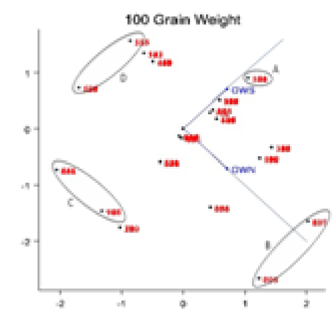

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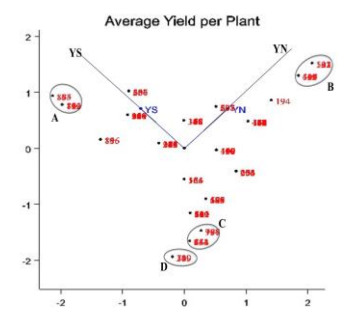
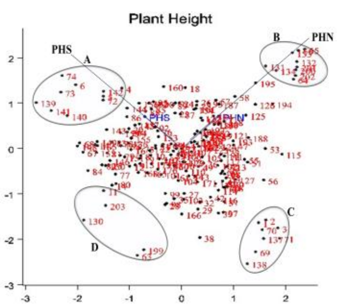


Figure 2h

Figure 2: Biplot of Wheat F_2 PARC-9 × WN-85 population for normal and saline conditions



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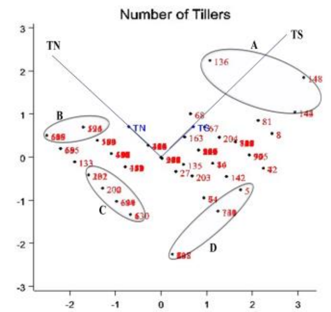

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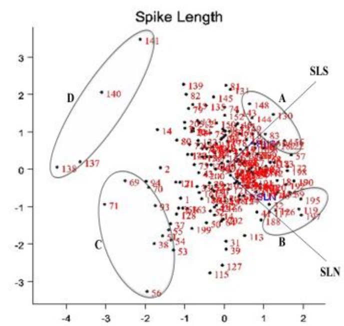

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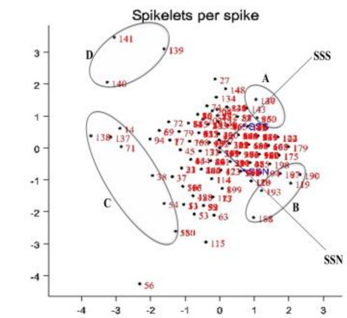

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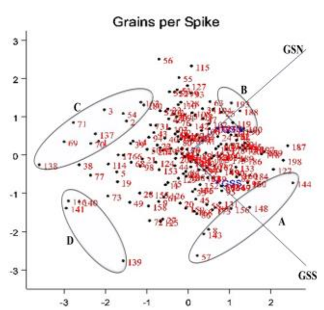

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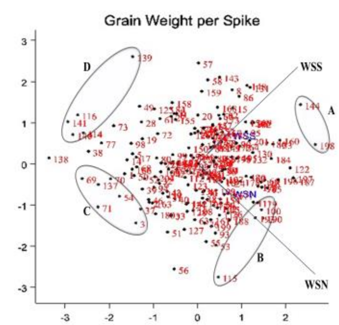

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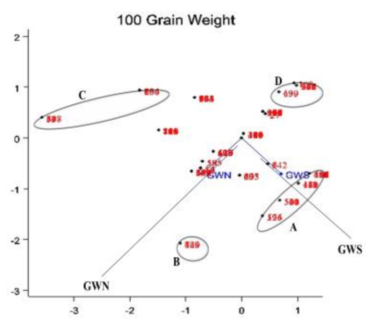

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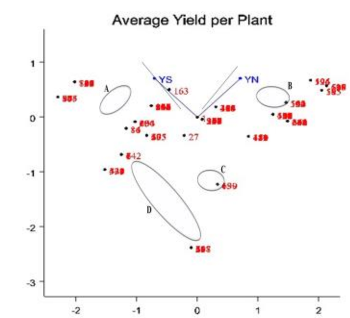
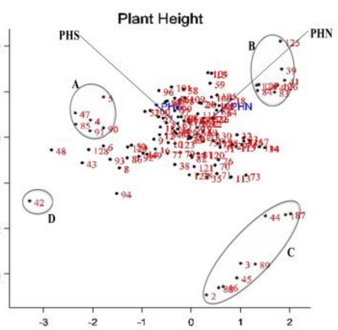


Figure 3h

Figure 3: Biplot of Wheat F_2 PARC-10 × WN-64 population for normal and saline conditions



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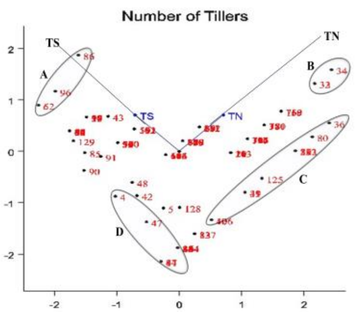

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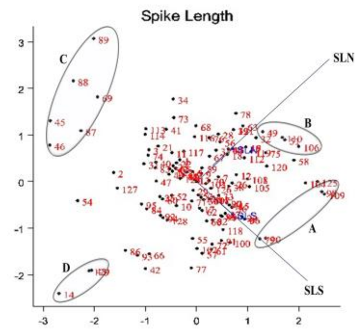

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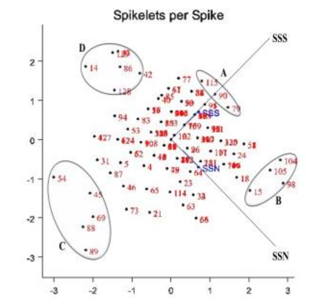

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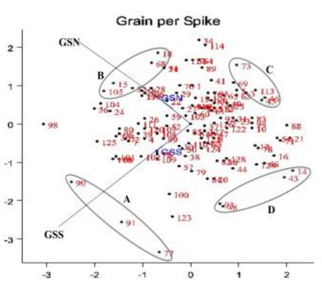

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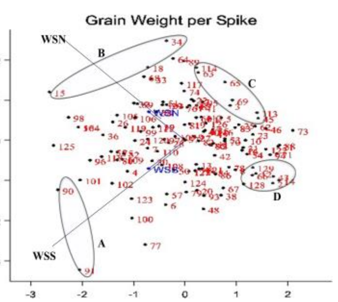

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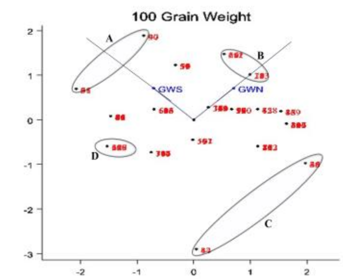

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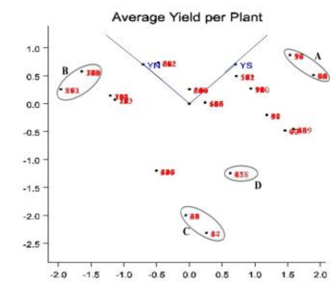

Figure 4h

Figure 4: Biplot of Wheat F_2 PARC-10 × WN-85 population for normal and saline conditions

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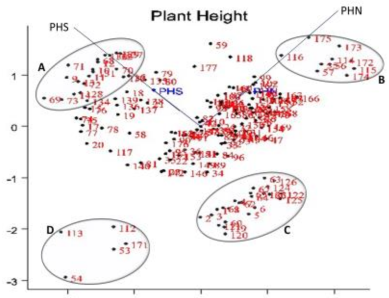

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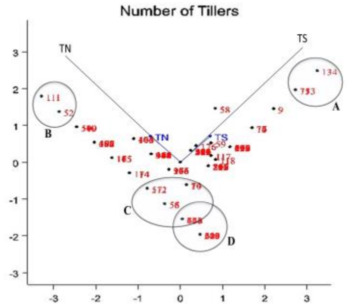

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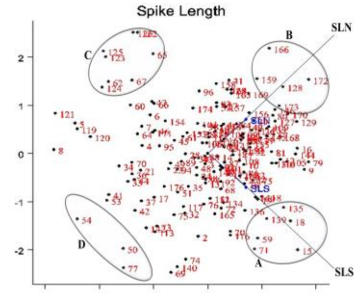

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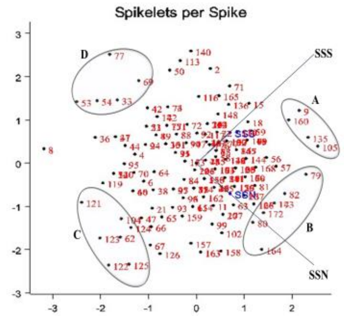

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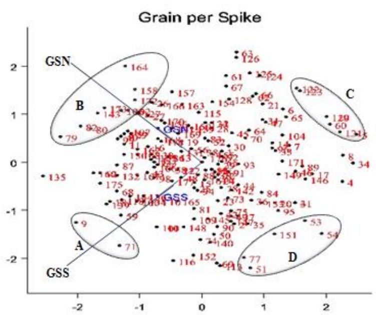

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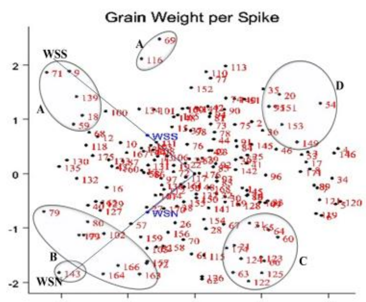

Figure 5f

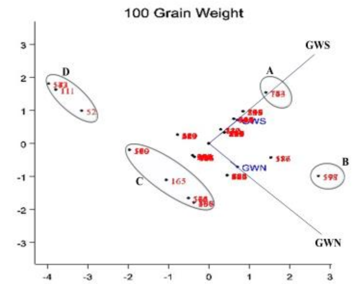

Figure 5g

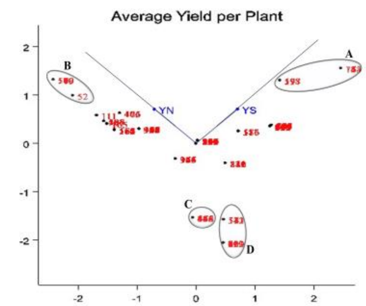

Figure 5h

Figure 5: Biplot of Wheat F_2 WN-73 × WN-64 population for normal and saline conditions

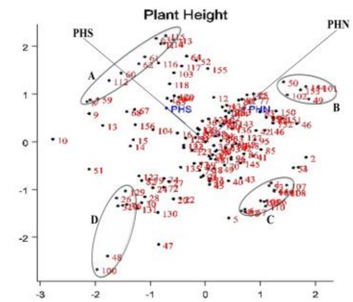

Figure 6a

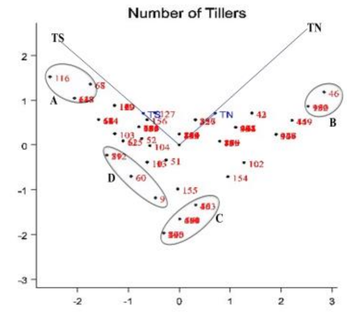

Figure 6b

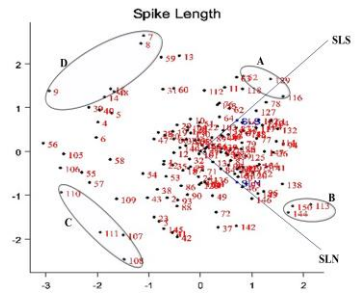

Figure 6c

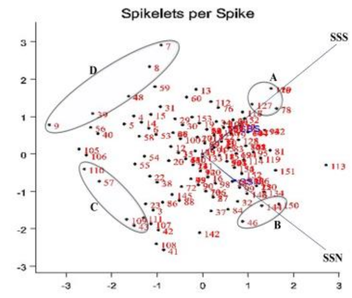

Figure 6d

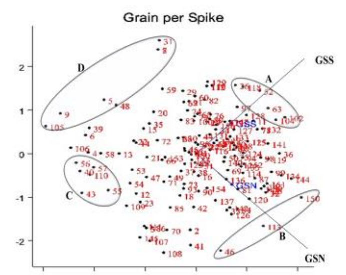

Figure 6e

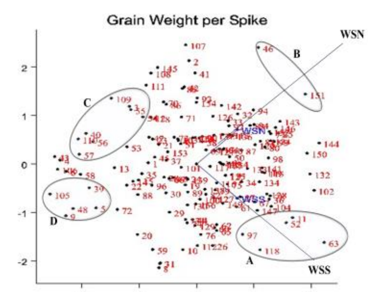

Figure 6f

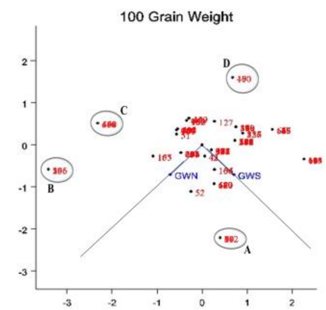

Figure 6g

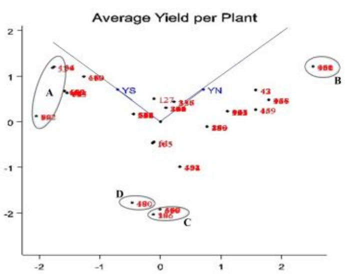

Figure 6h

Figure 6: Biplot of Wheat F_2 WN-73 × WN-85 population for normal and saline conditions

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