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Research Article

Cluster analysis of bread wheat genotypes for quality traits and yield under late sown conditions at *Kymore* hills of *Narmada* Valley

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Abstract

High temperature stress during late planting conditions specifically at the time of grain filling adversely affects the quality of grain by reducing plant growth and ultimately the nutrient content of sink that is grain. Quality traits such as sedimentation value (mm), protein %, starch %, wet gluten, moisture content and grain yield plant^{-1}, were studied in thirty bread wheat genotypes with three replications in randomized block design, seed breeding farm, J.N.K.V.V., Jabalpur, during the year 2012 and 2013 with the target to cluster genotypes with superior quality in response to heat stress during late planting. A Dendrogram was obtained that is based on variance dividing the total genotypes in seven clusters with distinct characteristics, and grouped under two major clusters A and B. Cluster I to IV belong to group A whereas cluster B had V and VI cluster. Cluster I had maximum and cluster VII had minimum genotypes. Cluster VII and cluster IV showed maximum inter cluster distance and intra cluster distance were maximum in cluster VII. Further, Cluster VII consist of genotypes with maximum sedimentation value, cluster I had genotypes with maximum hectoliter weight, cluster VII had genotypes with highest protein %, cluster IV had maximum wet gluten, cluster V had genotypes with maximum starch content, maximum moisture level after harvesting was observed in genotypes under cluster IV, whereas genotypes with maximum grain yield fall under cluster IV, were found most tolerant to terminal heat stress. The genotypes MP-3368/MP-4669 and 31ESWYT-123 are highest yielding genotypes belonging to superior cluster IV and considered as very important for developing heat tolerant variety with good quality index and other plant breeding strategies.

Keywords: Bread wheat, Dendrogram, Inter-cluster distance, Intra-cluster distance, Heat stress

1. Introduction

Many important cereals were under cultivation but wheat had its own importance among rice, maize, barley, oat and rye. Wheat (*Triticum aestivum* L.) from *Poaceae* family along with other cereal crops, being primary staple food crop of many South Asian countries, is considered as the world's major staple food. Wheat flour from whole-grain contains 408 calories/120 g of serving. One serving contains fat (3 g), protein (16 g) and carbohydrate (86 g), which is composed of sugar (0.5 g) and other dietary fiber (13 g). Wheat whole-grain flour, contains saturated fat (0.5

g) and no cholesterol in a serving. Wheat whole-grain flour, categorised under "Cereal Grains and Pasta", food (USDA, 2021). Its flour is also used in the preparation of bread, biscuits, noodles and other confectionary items.

It is also used as feed for animals, production of ethanol and wheat beer. Almost, 55 percent of carbohydrate is sourced from wheat globally (Gupta *et al.,* 1999). Many factors like biotic and abiotic stresses are responsible for decreased production and quality of wheat grain. Among abiotic stress, due to late planting of wheat in central zone crop usually faces after anthesis terminal heat stress caused due to rise in temperature during reproductive stage which leads to reduction in grain filling period and hence reduces the crop productivity. Increase in terminal heat stress severely affects physiological processes of plant and thereby limiting growth and reduction in grain yield. Temperature stress affects grain filling which leads to reduction in yield, (Al Khatib and Paulsen, 1984; Tashiro and Wardlaw, 1990; Wardlaw *et al.,* 1989; Weigand and Cueller, 1981). Whereas, it requires 15-18^{0}C of optimal temperature at the grain filling stage (Chowdhury and Wardlaw, 1978). Heat stress, which is encountered by wheat crop because of late maturation and harvesting of paddy in paddy-wheat system of cropping, delays the sowing of winter wheat. (Hobbs and Giri, 1997). Farmers have to wait for too long after harvesting of paddy as the field is still wet for longer duration. Under stressed conditions traditional breeding methods are limited due to low genetic variability, complexity of stress tolerance traits and yield components and the lack of efficient selection techniques (Mishra *et al.,* 2020). There is about 40% reduction in yield due to late sowing in wheat crop (Sharma and Duveiller, 2004). The world's population is increasing day by day, there is an urgent need to increase the yield of wheat crop to feed the continuously increasing population. Along, with that quality is the another important aspect which had to be covered so that a balance of nutrition in the diet could be maintained. Quantity is useless without quality so the present investigation has been conducted to identify baking, milling quality of grain with their protein, gluten, starch content and hectoliter weight, which is the direct measure of flour yield from grain. There is an urgent need of developing heat stress genotypes with good quality traits, for that purpose; clustering of genotypes was done in response to heat stress based on the quality traits. However, improvement of quality traits and micro- nutrient content along with yield in wheat are the new objective of the breeding programmes to attain food and nutrition security in India. Specially, in late sown area (peninsular zone) of wheat in is also in an increasing trend due to diverse crop cultivation practices and in this area needs wheat varieties tolerance to terminal heat stress (Prasad *et al.,* 2021).

2. Material and Methods

The field investigation was carried out during the years, 2012 and 2013. The main features are hot and dry summer and cold winter with occasional showers. In this experimental year the average rainfall was about 55.4 mm, received mostly during the month of February. Temperature ranged from 5.0^{o}C (minimum) during the month of December to 39.5^{o}C (maximum) during the month of April. The genotypes were received from International Maize and Wheat Improvement Centre (CIMMYT) and different wheat improvement projects of India presented in (Table 2.1). Field experiment was conducted in randomized block design, with three replications. Each plot had 6 rows with spacing of 25 cm between rows. Recommended dose of fertilizers was applied *i.e.,* 120:60:60 kg NPK per hectare. Irrigation was done at the three important stages; crown root, initiation (CRI) stage, flowering stage and milking stage. Data entry and processing was carried out by using Microsoft Office Excel 2007. Standard statistical procedures were used to analyse the average data by using Windostat software (Windostat version 9.2). Genetic divergence analysis through non-hierarchical cluster analysis (Beale,1969 and Mutwali, *et al.,* 2016) and genotypes were grouped into different clusters on Tocher's method (Rao,1952).

Table 2.1. List of Genotypes of Wheat under study of *Kymore* Hills *Narmada* Valley

S.No.	Genotype	S.No.	Genotype	S.No.	Genotype
1	JW-3269	11	PBW-343/CDWR-9563-1	21	CIMMYT-2
2	GW-366	12	MP-3349/MP-3222	22	CIMMYT-4
3	LOK-1	13	MP-3342/PBW-343/K-9924	23	CIMMYT-5

4	JW-3211	14	PBW-343/CDWR-9563-6	24	CIMMYT-6
5	JW-3336	15	MP-3368/MP-4669	25	CIMMYT-7
6	HD-2864	16	MP-3359/WH-1092	26	CIMMYT-8
7	HD-2932	17	MP-3372/NTAW-1395	27	CIMMYT-9
8	HI-1544	18	MP-3360/RAJ-4213	28	CIMMYT-10
9	MP-3324/MP-3092/MP-322	19	CIMMYT-3	29	CIMMYT-11
10	401-136/JW-17-1	20	CIMMYT-1	30	CIMMYT-12

Observations were recorded for grain yield (gm plot^{-1}), hectoliter weight (gl^{-1}), sedimentation value, protein (%), wet gluten (%), starch (%) and moisture (%). These traits were calculated as follows:

2.1 Hectoliter weight (kg /hl):

The hectoliter weight of the samples was estimated using hectoliter machine developed by DWR-Karnal, which gives the weight in terms of kg per hectoliter.

2.2 Sedimentation value (SDS value in ml):

It measures the quality of proteins and is based on the fact that gluten protein absorbs water and swells considerably when treated with lactic acid in the presence of sodium dodecyl sulphate (SDS). The volume of sediment depends on the extent of swelling of gluten protein and correlates significantly (+0.7) with loaf volume. SDS. Unlike other quality test for baking, the sedimentation test also does not assess the rheological properties of wheat flour-based doughs. Instead, it's similar to the solvent retention capacity.

The protein, wet gluten, starch and moisture were estimated from non-destructive method by NIR-instrument "Infratec ™ 1241 grain analyser" of FOSS.

2.3 Protein (%):

Estimation by NIR equipment, protein content influences the functional quality of the product and has a greater influence on overall processing quality than any other single factor. While the environment is the major determinant of the actual protein level achieved and the variability between wheat varieties for their capacity to accumulate protein is also important. Flour dough strength is related to the combination of total protein and also protein quality. It is therefore not only influenced by the environment, but also has a major genetic component. The wheat has different protein requirements for various products like chapatti, bread, biscuit and pasta etc. Protein percentage of more than 12 % in *aestivum* wheat is needed for good bread, $<$ 10 % for biscuit, 10 to 12 % for chapatti, and $>$ 12 % in durum wheat for good pasta products.

2.4 Wet gluten (%):

Gluten is a composite found in foods processed from and related grain species. It gives elasticity to dough, helps in rise and maintains shape of dough, and gives chewy texture to end product. Gluten is the composite of a gliadin and a glutelin, which is conjoined with starch in the endosperm of various grass-related grains. The glutelin and prolamin from wheat (gliadin, which is alcohol-soluble, and glutenin, which is only soluble in dilute acids or alkalis) constitute about 80% of the protein contained in seed of wheat. Being insoluble in water, they can be purified by washing away the associated starch. Globally, gluten is a source of protein, both in foods prepared directly from sources containing it, and as an additive to foods otherwise low in protein.

2.5 Starch content:

Starch is the major constitute of wheat endosperm and its importance to the properties of wheat product has been recognized. Starch is also an important industrial raw material; most proposal of the starch is either separately or as a part of flour.

3. Results and discussions

The genotypes were clustered on the basis of quality traits *viz*., hectoliter weight (g l^{-1}), sedimentation value, protein (%), wet gluten (%), starch (%) and moisture (%), along with the grain yield, observed under late sown terminal heat stressed conditions. The dendrogram for the investigated traits under different clusters is presented in (Figure 3.1 and Table 3.2) represents inter and intra cluster distances among the genotypes. The clusters grouped under two major clusters A and B. Cluster I to IV belong to group A, whereas cluster B had V to VI cluster. The maximum inter cluster distances were present in the cluster IV and cluster VI. However, maximum intra-cluster distance was present within the cluster VII suggesting that more diverse genotypes were present in this group.

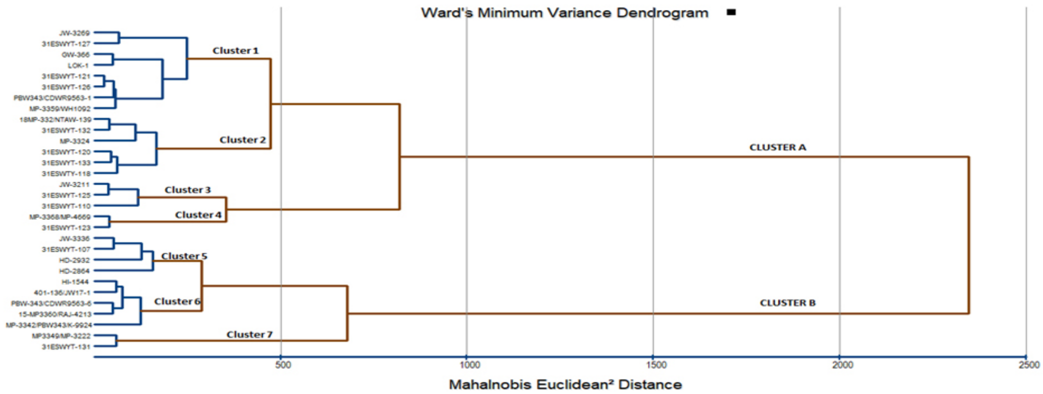

Fig. 3.1. Clustering of 30 wheat genotypes under late sown conditions of *Kymore* Hills *Narmada* Valley

Table 3.2. Distance among the different Clusters of Bread Wheat Genotypes under Late Sown Condition of *Kymore* Hills *Narmada* Valley

Clusters	I	II	III	IV	V	VI	VII
I	194.892	293.833	383.478	332.310	427.118	773.272	1178.395
II		170.124	517.070	612.580	318.575	567.263	1145.755
III			155.529	366.919	363.264	436.777	490.739
IV				81.202	654.981	863.523	1240.958
V					223.857	275.622	651.362
VI						155.488	465.697
VII							118.198

Cluster VII consist of genotypes with maximum sedimentation value (35.500), cluster I had genotypes with maximum hectoliter weight (76.583), cluster VII had genotypes with highest protein % (12.283), cluster IV had maximum wet gluten (28.833), cluster V had genotypes with maximum starch content (67.583), maximum moisture level after harvesting was observed in genotypes under cluster IV (7.633) whereas genotypes with maximum grain yield falls under cluster IV (13.238) (Table 3.3).

Table 3.3. Cluster means value by Tocher method of Quality Traits and Yield under different Clusters Under Late Sown conditions of *Kymore* Hills *Narmada* Valley

Cluster	Hectoliter weight (g /l)	Sedimentation value	Protein (%)	Wet gluten (%)	Starch (%)	Moisture (%)	Yield plant-1 (g)
I	76.583	25.617	10.279	22.204	67.271	6.833	13.034
II	75.889	27.317	10.128	22.117	65.061	7.150	11.104
III	75.667	29.767	10.878	26.344	66.478	6.611	8.999
IV	75.333	29.583	10.567	24.117	67.050	7.633	13.238
V	77.250	28.192	10.783	25.617	67.583	7.225	12.078
VI	77.400	31.433	11.213	28.253	65.553	6.787	9.952
VII	77.000	35.500	12.283	28.833	63.883	7.367	10.000
Mean	76.522	28.608	10.684	24.633	66.264	7.008	11.415

Cluster I having maximum number eight of genotypes within the group of second highest yielding genotypes *viz*., JW-3269, GW-366, LOK-1, PBW343/CDWR9563-1, MP-3359/WH1092, 31ESWYT-121, 31ESWYT-126, 31ESWYT-127 followed by cluster II, with six genotypes (MP-3324, 31ESWYT-132, 31ESWYT-133, 31ESWYT-120, 31ESWTY-118 & 18MP-332/NTAW-139), cluster VI with five genotypes (MP-3342/PBW343/K-9924, PBW-343/CDWR9563-6, 15-MP3360/RAJ-4213, HI-1544, 401-136/JW17-1), cluster V with four genotypes (JW-3336, HD-2864, HD-2932 & 31ESWYT-107), cluster III with three genotypes (JW-3211, 31ESWYT-110 & 31ESWYT-125), cluster IV and VII with two genotypes (MP-3368/MP-4669, 31ESWYT-123 and MP3349/MP-3222, 31ESWYT-131, respectively). The genotypes of cluster IV were the high yielding genotypes among all.

Hectolitre weight is the weight of 100 litres of wheat or weight/unit volume and is the simplest criteria of wheat quality assessment. A rough index of flour yield will be obtained on the basis of hector litre weight. Higher the weight, the better flour yield is obtained. Although, the density of the grain influenced by structure, chemical composition, shape, uniformity, size and orientation of kernels when it is filled in container. Genotypes, JW-3269, GW-366, LOK-1, PBW343/CDWR9563-1, MP-3359/WH1092, 31ESWYT-121, 31ESWYT-126 and 31ESWYT-127, belong to cluster I and considered as genotypes with maximum hector-litre weight, suggesting that these genotypes possess a good index of flour yield and its quality. These are considered as genotypes with better milling quality in terms of yield of flour. Other, quality index sedimentation value is a physicochemical test provides information about flour baking quality. The results were based on particles of flour sediments which suspended in a dilute alcohol and solution of acid. (Finnie and Atwell, 2016; Paul 1964). Maximum genotypes of the present investigation in different clusters fall under this category of medium textured wheat which is suitable for chapatti/bread making. Also, the higher the value of sedimentation, greater will be the volume of the baked bread therefore MP3349/MP-3222 and 31ESWYT-131 genotypes of cluster VII can be used for this purpose. This test grades the different classes or types of wheat according to their protein quality and quantity. Also, it is a screening tool for developing new bread wheat genotypes by plant breeders. Genotypes, MP3349/MP-3222 and 31ESWYT-131 of Cluster VII also contains maximum protein %, truly depicting the positive correlation between sedimentation value and protein (%), this hard wheat genotypes can be utilized as high pretentious wheat.

Gluten is an important trait of wheat which provides strength and texture to baked products of wheat by making it capable to form number of bakery products. The maximum gluten content indicates better protein and baking quality of and bread wheat flour. Two types of gluten (Esteller *et al.,* 2005), 'vital' (have intrinsic functionality) and 'non-vital' (irreversible denaturation). For performance of baking functionality of gluten is very important factor and affected by many factors at various stages during extraction of gluten. Therefore, again genotypes, MP3349/MP-3222 and 31ESWYT-131 of cluster VII again considered as genotypes with good baking quality. Followed by genotypes MP-3342/PBW343/K-9924, PBW-343/CDWR9563-6, 15-MP3360/RAJ-4213, HI-1544, 401-136/JW17-1 of cluster VI. Starch is the trait in the form of storage carbohydrate and forms 70–80% of flour and 60–75% of grain. Starch of soft wheat had high amounts of surface lipids and proteins with lower viscosity of paste (Khetan *et al.,* 2016). Although, hard wheat contains high proportion of small granules and amylose along with the lower temperature of gelatinization. Genotypes, JW-3336, HD-2864, HD-2932 and 31ESWYT-107 belonging to cluster V showed maximum value of starch (%). In case of moisture percentage genotypes of cluster IV MP-3368/MP-4669 and 31ESWYT-123 showed maximum moisture as compared to normal percentage moisture required for soft to hard wheat i.e., 12 to 14 %, these genotypes suffer from terminal heat stress therefore having less moisture in flour. Whereas, the genotypes MP-3368/MP-4669 and 31ESWYT-123 are highest yielder genotypes belonging to superior cluster IV and considered as very important in developing heat tolerant variety with good quality index and other plant breeding strategies. Similar results and findings were also supported by other researcher's also for association among genotypes and their quality traits which were grouped together in same cluster in wheat crop (Mirela *et al.,* 2018 & Mutwali *et al.,* 2016).

4. Conclusion

Above identified genotypes were found as promising in the above late sown experiment conducted on wheat crop. Further, research may be carried out in this flow by selection of suitable genotypes for heat stressed environment along with good quality. Genotypes with maximum grain yield falls under cluster IV, were found most tolerant to terminal heat stress. The genotypes MP-3368/MP-4669 and 31ESWYT-123 are highest yielder genotypes belonging to superior cluster IV and considered as very important in developing heat tolerant variety with good quality index and other plant breeding strategies.

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Compliance with ethical standards

NA

Conflict of Interest

Authors declare that they have no conflict of interest

Author contributions

Concept of research and designing of experiments (MS), Conduction of experiment (MS, RSS), Preparation of manuscript (MS, VK), Quality assessment (MS, SP).

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