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Effect of Karnal bunt incidence on quality parameters in wheat

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Fungal pathogens are the leading biotic stresses of wheat (*Triticum aestivum* L.). Among these, Karnal bunt (KB) caused by the smut fungus *Tilletia indica* Mitra (Syn. *Neovossia indica* (Mitra) Mundkur), is an important disease of wheat with restricted occurrences in Asia, Africa, North America and South America (Emebiri *et al*., 2019a; Emebiri *et al*., 2019b; Gurjar *et al*., 2019; Singh *et al*., 2020). Since, the disease is characterized by the replacement of a part of the seed with a black powdery mass of spores thereby, affecting both the quality and quantity of the wheat grains. Yield losses caused by fungal diseases are influenced by the severity, the initiation of the epidemic and the duration (Teng, 1983; Oerke, 2006). Very often, yield losses due to Karnal bunt are insubstantial. But the presence of the pathogen in a region or country results in quarantine restrictions that prevent international trading of wheat grains from the disease affected regions (Carris *et al*., 2006; Figueroa *et al*., 2018; Pandey *et al*., 2019). As a result, most wheat-importing countries insist on an additional declaration from the exporting countries that the wheat consignment being traded is produced in a KB-free area (Gurjar *et al*., 2019). Thus it is very important to survey the disease incidence to establish the general occurrence of KB as well as to identify KB-prone and KB-free areas. Over the years, it has been established that the disease incidence and severity vary across years as well as locations (Bala and Kaur, 2020; Bala *et al*., 2022)

Therefore, survey of grain markets in Punjab is undertaken and status of the disease is determined every year. The survey of the Karnal bunt-infected grains from grain markets in various wheat-growing areas of the state during 2023 was conducted in April. This survey consisted of a determination of Karnal bunt infection in 2521 wheat samples collected from 147 grain markets across Punjab. The sampling of grains was random and was carried out according to current ISTA (International Seed Testing Association) rules. Most of the samples were taken from the open heaps, lying on the floors of the grain markets, before their putting and packing into gunny bags by the dealers. Each sample consisted of 1-2 kg wheat grains sampled appropriately from five places of the heaps or storage and mixed thoroughly to make it a composite representative sample. The samples were labeled with reference to grain market, locality, district, and brought to the laboratory. At the time of determination of the incidence of Karnal bunt disease, a composite sub-sample of 500 g of the grains was drawn from each of the 1-2 kg sample, and the numbers of bunted and total grains in the sub-sample were counted and the per cent incidence of Karnal bunt infection of the grains of each wheat sample was determined.

A total of 188 samples (7.46%) out of 2521 were found to be infected with Karnal bunt during 2023. District Pathankot showed the maximum KB infected samples followed by Gurdaspur and Amritsar. The range of per cent KB infected samples was 0.83% (Fazlika) to 70.31% (Pathankot) as depicted in Table 1. As far as severity is concerned, the highest KB infection was in the Tarntaran and Kapurthala districts followed by Gurdaspur. An overall infection in districts ranged between 0.00 (Malerkotla) to 0.292 (Tarntaran) with an average infection of 0.076 in the state. Out of 188 samples, 50 samples were taken for quality assessment. The samples selected had a KB infection of 0.1 or more and ranged from 0.1% to 3.1%. Fig. 1 revealed the distribution of these Karnal bunt infected wheat samples from grain markets of Punjab. The KB infection was found to be on the

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Table 1. Karnal bunt spectrum in grain markets of Punjab during the crop season 2022-23

S. No.	District	Total samples	Infected samples	Infected samples (%)	Average infection (%)
1	Amritsar	47	7	14.89	0.130
2	Barnala	158	3	1.90	0.004
3	Bathinda	177	22	12.43	0.023
4	Faridkot	95	3	3.16	0.025
5	Fatehgarh Sahib	107	2	1.87	0.000
6	Fazilka	120	1	0.83	0.003
7	Ferozepur	221	7	3.17	0.027
8	Gurdaspur	108	32	29.63	0.190
9	Hoshiarpur	167	22	13.17	0.125
10	Jallandhar	100	3	3.00	0.172
11	Kapurthala	56	2	3.57	0.270
12	Ludhiana	261	3	1.15	0.117
13	Malerkotla	38	0	0.00	0.000
14	Mansa	110	12	10.91	0.016
15	Moga	131	2	1.53	0.040
16	Mohali	36	3	8.33	0.006
17	Muktsar	150	6	4.00	0.054
18	Pathankot	64	45	70.31	0.094
19	Patiala	88	0	0.00	0.003
20	Ropar	80	2	2.50	0.104
21	Sangrur	78	6	7.69	0.009
22	Nawanshar	69	0	0.00	0.178
23	Tarantarn	60	5	8.33	0.292
	Total	2521	188	7.46	0.076

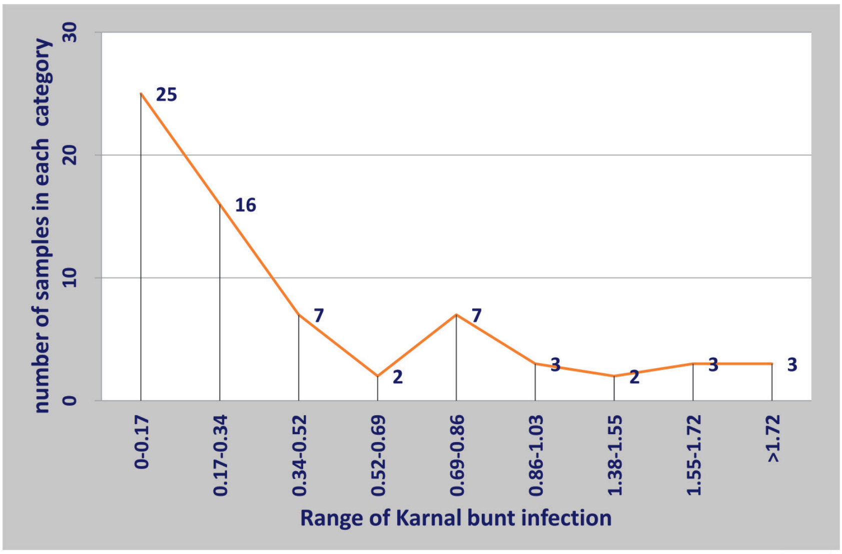

Fig. 1. Distribution of Karnal bunt infected wheat samples used for quality analysis

lower side as the weather parameters during the year 2022-23 were not conducive for higher KB infection (Anonymous*,* 2023).

The Karnal bunt has assumed great significance because of widespread inoculum and its adverse effect on grain quality (Bedi, 1989). Wheat becomes unfit for human consumption beyond 3 % level of infection due to a fishy odor, perceptible blackening, and altered organoleptic attributes (Mehdi *et al*., 1973). The presence of diseased Kernels in small proportions not only threatens the acceptability of the wheat, but the very cultivation in a particular area becomes questionable.

Therefore, there is a need to understand how this post-harvest disease affects the quality in the various grain markets. In the present investigation impact of KB on grain quality parameters of grain samples collected from grain markets across Punjab during harvesting season was assessed. To decipher these interactions, 50 samples varying in KB infection (having KB infection of 0.1 or more) were selected for quality parameters assessment, along with some KB-free samples as well. The quality parameters analyzed were protein content, sedimentation value, test weight, and grain hardness. The per cent protein content was determined from wheat grains using Infratech 1241 whole grain analyzer M/S FOSS by non-destructive method. Sedimentation values of flours were determined (Axford *et al.,* 1979). Test weight was determined using the apparatus developed by the Directorate of Wheat Research (DWR) Karnal, which employs a standard container of 100 ml capacity (Mishra, 1998). The grains were weighed and the test weight was expressed in kg/hl. The grain hardness was measured by using the grain hardness test supplied by M/S Ogawa Seiki Co. Ltd., Japan by crushing randomly taken ten grains one by one. The mean force (kg) required to crush the grain was recorded.

The protein % at 12 per cent moisture in the analyzed samples ranged between 9.33 -12.78 per cent with an overall mean of 11.29 per cent. The correlation analysis between Karnal bunt infection and protein content was found to be negative and non-significant. The results were in agreement with the study of Bhat *et al.* (1980) who stated that the nutrient composition of KB-affected grains does not differ much from the healthy grains but the protein quality of the infected grains deteriorates as reflected by the decreased content of lysine and thiamine. The infected samples, ash and phosphorus content were also found to be elevated. Gopal and Sekhon (1988) reported that infection in the range of 1% to 5% results in the weakening of the dough strength as a result of lower flour recovery and gluten strength of the infected samples.

An appraisal of Fig. 2 revealed that SDS was found to be in the range of 30-47 with an overall mean of 39. It was also negatively correlated with KB. As desirable, with a decrease in protein content, protein quality also gets altered subsequently decreasing the SDS sedimentation value in the infected seeds. The wheat processing for different end products requires medium SDS sedimentation values in the range of 35-50. Swelling of the gluten fraction of flour in a lactic acid solution affects the rate of sedimentation of a flour suspension in the lactic acid medium. Higher gluten content and better gluten quality both give rise to slower sedimentation and higher sedimentation test values. Sedimentation value is directly related to the grain protein content and its functional quality.

Test weight, bushel weight or hectoliter weight (kg/hl) are synonyms for the determination of the weight of a fixed volume of grain, which is directly proportional to the density of the grain. Uniform, dense and plump grains fit in properly with each other so accommodating a larger number of grains in a fixed volume, thus showing higher test weight. Test

Table 2. Analysis of variance for different quality traits and Karnal bunt infection

	Per cent KB	Protein (At 12 % moisture)	Sedimentation value (cc)	Test weight (Kg/ hl*)	Hardness (Kg)
Min	0.00	9.33	30	67	8.35
Max	3.10	12.78	47	77	12.5
Mean	0.49	11.29	39.27	72.76	10.70
Std. error	0.079	0.087	0.50	0.24	0.10

hl=Hectoliter

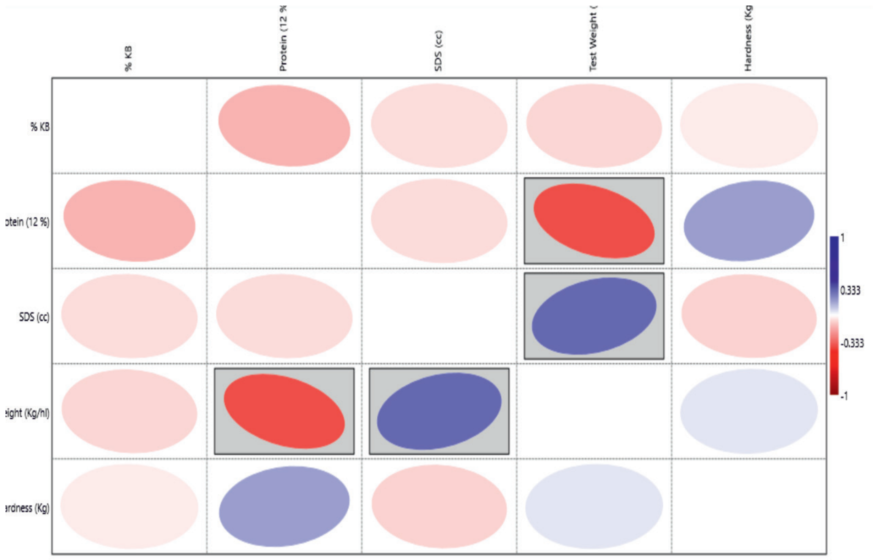

Fig. 2. Correlation matrix of Karnal bunt infection with different wheat quality traits

weight determination is the primary quality parameter to forecast the flour yield. Immature and shriveled wheat seeds are usually low in test weight and give correspondingly poor yields of flour. As per Table 2, weight was found to be in the range of 67-77 with an overall average of 72.76. The correlation analysis between KB and hardness was found to be negatively correlated and non-significant with the KB infection (Fig. 2). Due to KB infection, the infected seeds become shriveled and thus reflect lower test weight. The weight of the grains decreased with Karnal bunt infection (Table 2). A loss of 3% in kernel weight was found in the samples having 10% infected grains. The results are in agreement with the report of Bedi (1989). There are two distinct classes of wheat as soft and hard. The most important physical difference between the endosperm of hard and soft wheat is that soft wheat contains attached starch granules with a protein matrix surrounding these granules (Simmonds *et al*., 1973). Less damaged starch is produced by kernels of soft wheat. These kernels easily break down yielding fine powder-like flour having less damaged starch. Hard kernels are difficult to crush and grind and produce coarser-textured flour with higher levels of starch damage (Jolly *et al*., 1993; Ikeda *et al*., 2005). Grain hardness is an important character for determining the quality of wheat flour. The grain hardness of the genotypes ranged from 8.35 to 12.5 with an overall mean of 10.7 kg. The correlation analysis between KB and hardness was found to be negatively correlated and non-significant with the KB infection which is desirable. As the fungus feeds on the carbohydrate content of the seed, it would have direct implications on hardness, as the protein and starch network decide the hardness of any particular variety. Karnal bunt infected kernels are damaged, shriveled, shrunken, and lightweight showing a tendency towards a decrease in the endosperm to bran ratio due to fungal carbohydrate consumption.

The study can be concluded with the fact that since the mean KB infection (0.49%) as well as its range is low; therefore, none of the traits are affected by KB in this study and minor KB infection does not affect the quality of wheat. The quality aspects of wheat, particularly the gluten quality have been much worked upon lately, but information on how KB affects the gluten concentration and quality are lacking in the available literature. In addition to this data, the comparative micronutrient analysis studies of healthy and KB-infected grains and the physicochemical and rheological properties of flour are also not available. More information is also needed on the possible human health effects associated with the consumption of KB-infected and trimethylamine-contaminated wheat kernels. Such studies could stimulate further efforts on the management of KB and minimizing the economic losses to the growers.

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