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Evaluation of bread wheat (*Triticum aestivum*) genotypes under organic farming in north-west India

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ABSTRACT

The productivity of wheat (*Triticum aestivum* L.) generally remains low under organic farming in north-west India. Being a major crop under organic farming in in this region, the genetic variation among the wheat varieties/genotypes needs to be exploited for better nutrient use efficiency and higher productivity. The present experiment was conducted during winter (*rabi)* season 2018–19 and 2019–20 at research farm of Punjab Agricultural University, Ludhiana, Punjab to evaluate 9 bread wheat varieties, viz. PBW 1 Zn, PBW 175, PBW 660, Unnat PBW 343, Unnat PBW 550, PBW 1 Chapati, C-306, BWL 3498 and BWL 3500 for better profitability under organic farming. The highest grain yield was recorded with wheat variety Unnat PBW 550 which was statistically at par with PBW 1 Chapati, BWL 3498 and Unnat PBW 343 varieties but significantly better than PBW 1 Zn, C 306, BWL 3500, PBW 175 and PBW 660 varieties. The lowest grain yield was recorded with variety PBW 1 Zn. Similar trend was observed for biological yield and yields contributing characters, viz. effective tillers, number of grains/spike and test weight. The net returns and benefit-cost (B:C) ratios were also the maximum with variety Unnat PBW 550 as compared to all other varieties/ genotypes. The study concluded that wheat variety Unnat PBW 550 performed better than all other varieties under organic farming and can be recommended to organic growers of the state.

Keywords: Net returns, Organic farming, Productivity, Variety, Wheat

Organic agriculture has been and will always remain an integral part of agricultural production systems in India. The COVID-19 pandemic has again stressed the importance of food safety and food quality which can be ensured through organic farming. Wheat (*Triticum aestivum* L.), a major staple food in north-west India, is an important component of organic production systems (Panwar *et al.* 2021a). Due to availability of price premium (25–95% of minimum support price) and local market demand, the area under organic wheat is on the continuous rise. Most of the organic growers either use indigenous varieties (have low yield potential and susceptible to insect-pests) or varieties bred for conventional high-input sector under conventional breeding programmes (Bueren *et al.* 2011). The productivity of wheat under organic farming remains lower compared to conventionally grown wheat. The yield reduction is more during the initial years of organic farming and the differences diminish over the time but productivity rarely exceeds conventional farming. Modern high yielding varieties, responsive to chemical inputs, may not always be suitable for organic farming (Anastasi *et al.* 2019). Instead, the varieties having less pest and diseases occurrence, more weed suppression, better quality (chapati making in north-west India) and capable of giving acceptable yield are better suited under organic farming.

Productivities are generally low under organic production management systems as compared to chemical production systems (Sharma *et al.* 2018, Anastasi *et al.* 2019). There is a need to lay emphasis on selection of varieties under organic farming as it has a direct effect on yield and economics of a crop (Revilla *et al.* 2008). Suitability of varieties under organic production systems is one area which has not been given much importance under conventional breeding programmes that is why most of the conventional varieties do not perform well under organic cultivation. These varieties do not have traits required under organic management systems (Wolfe *et al.* 2008, Yadav *et al.* 2020). There is a need to develop/evaluate varieties/genotypes for organic crop production to boost the productivity. Thus, a field experiment was conducted to evaluate performance of bread wheat varieties/genotypes under organic management in respect to productivity and profitability.

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi)*

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season of 2018–19 and 2019–20 at the research farm of Punjab Agricultural University, Ludhiana, Punjab (30°54′N and 75°48′E) in the Indo-Gangetic plains of north-west India. The soil of the experimental field was loamy sand (Bouyoucos 1962) having EC-0.23 dS/m (Walkley and Black 1947), *p*H 7.10 (Jackson 1967), medium organic carbon (0.50%) (Walkley and Black 1947), available phosphorus (44.20 kg/ha) (Olsen *et al.* 1954) and high potassium (285.0 kg/ha) (Richards 1968). The experiment was laid out in randomized block design (RBD) with 9 wheat varieties/ genotypes (PBW 1 Zn, PBW 175, PBW 660, Unnat PBW 343, Unnat PBW 550, PBW 1 Chapati, C-306, BWL 3498 and BWL 3500) with three replications. The crop was grown with organic management practices as per the standards of National Programme on Organic Production (APEDA 2018) in basmati rice - wheat - green manure cropping system. The weather parameters especially temperature (maximum and minimum) during the crop growth period 2018–19 and 2019–20 are depicted in Fig 1. The meteorological data was obtained from the Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana, Punjab.

The crop was sown at row spacing of 20 cm using a seed rate of 100 kg/ha in the first fortnight of November except for variety Unnat PBW 550 for which 112.5 kg/ha seed was used. Well decomposed farmyard manure (FYM) having 1% nitrogen @12.5 t/ha was applied to supply 125 kg N/ha to the crop at the time of sowing, while vermicompost @125 kg/ha was broadcasted along the rows before first irrigation. Weeds were managed with two operations of wheel hand hoe. Three sprays of PAU homemade neem extract were applied at 70–100 days after sowing (DAS) for managing the insect-pests.

Agronomic observations and computation: The effective tillers (ear bearing tillers) were recorded from one meter row length from two sites in each plot and converted into effective tillers per square meter. Five randomly selected plants were used to record the number of grains/spike whereas the total biomass and grain yield (kg/ha) were calculated on the basis of total weight of harvested dry matter and grain yield of wheat from the experimental plot. Harvest index (HI) was calculated as:

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield (grain + straw)}} \times 100$$

RESULTS AND DISCUSSION

Plant height: Plant height of varieties/genotypes differed significantly (Table 1). The traditional wheat variety C-306 recorded significantly higher plant height at maturity during 2018–19, 2019–20 and on pooled basis (151.6 cm, 132.4 cm and 142.0 cm, respectively) followed by BWL 3498 and PBW 1 chapati. The comparison within bread wheat varieties/genotypes indicated a significant variation in plant height. In Organic farming, plant height is an essential trait in competing against weeds or diseases especially fusarium head blight, if ears are developed far above the canopy (Miko *et al.* 2014). This variation in plant height may be ascribed to the fact that nutrient requirement of plants varies with variety depending upon their photosynthetic rate, dry matter accumulation, roots characteristics and growing environments. The present findings are in conformity with the findings of Chadha *et al.* (2013) in pea and Lal and Singh (2016) in coriander. The variation in plant height among the varieties might be due to the differences in their genetic makeup. These results are in accordance with those of Das *et al.* (2012) who observed variable plant height among the rice varieties under organic farming.

Effective tillers/m^2: Number of effective tillers is considered to be one of the crucial determinants of grain yield of wheat. The maximum number of effective tillers was recorded in Unnat PBW 550, however it was statistically at par with PBW 1 Chapati, BWL 3498 and Unnat PBW 343 but significantly higher than all the other varieties/ genotypes. The traditional varieties recorded significantly lower effective tillers as compared to modern varieties under organic farming emphasizing the need for separate breeding programme. Wazir *et al.* (2019) also reported significant difference in number of effective tillers for different wheat varieties.

Number of grains/spike: Potential yield of a crop is determined during the early stage of differentiation of inflorescence which decides the number of spikelets formed on each spike (Reddy and Reddi 2016). The number of grains/spike did not differ significantly with varieties, however the Unnat PBW 550 recorded numerically maximum number of grains/spike (Table 1) followed by PBW 1 Chapati, BWL 3498 and Unnat PBW 343.

Test weight: Test weight of grains represents boldness of the grain and is governed by the genetic makeup of genotypes/varieties. Though, 1000-grain weight exerts an influence on grain yield but its

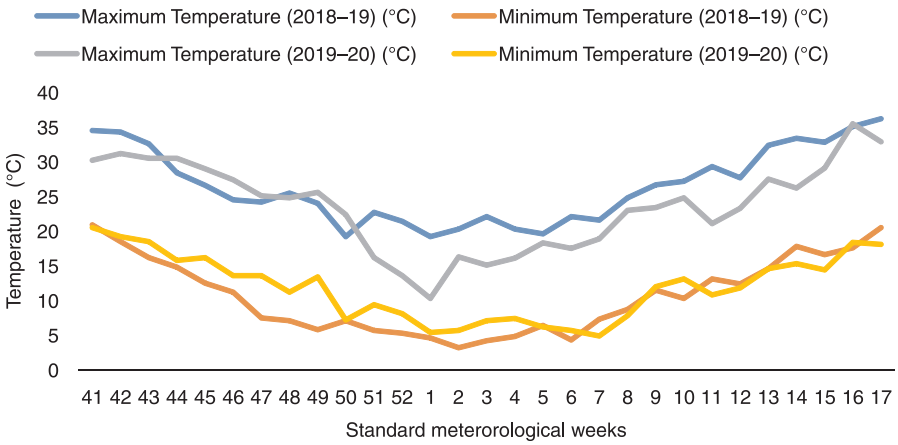

Fig 1 Weekly temperature during crop period (2018–19 and 2019–20).

Table 1 Growth and yield attributes of wheat varieties/genotypes

Variety	Plant height (cm)			Effective tillers/m^2			Number of grains/spike			Test weight (g)		
	2018–19	2019–20	Pooled	2018–19	2019–20	Pooled	2018–19	2019–20	Pooled	2018–19	2019–20	Pooled
PBW 1 Zn	111.5	106.3	108.9	264.2	270.3	267.3	38.0	37.5	37.8	39.5	38.8	39.2
C-306	151.6	132.4	142	272.4	277.0	274.7	39.1	39.3	39.2	39.8	39.1	39.5
BWL 3500	103.2	104.5	103.9	279.1	281.3	280.2	40.5	39.6	40.1	40.2	39.6	39.9
PBW 175	102.5	102.5	102.5	268.4	274.7	271.6	38.6	38.9	38.8	40.0	39.4	39.7
PBW 660	105.7	102.8	104.3	278.0	283.0	280.5	40.0	40.1	40.1	40.4	40.2	40.3
BWL 3498	116.6	110.5	113.6	285.2	287.0	286.1	43.0	42.5	42.8	40.8	40.5	40.7
Unnat PBW 343	99.8	99.6	99.7	281.4	284.3	282.9	41.6	40.8	41.2	40.5	40.2	40.4
Unnat PBW 550	88.6	91.2	89.9	292.4	294.3	293.4	46.1	44.8	45.5	41.3	41.3	41.3
PBW 1 Chapati	115.6	109.3	112.5	288.2	290.7	289.5	44.9	44.1	44.5	41.0	41.2	41.1
SEm±	1.6	2.1	1.3	4.1	3.7	3.6	0.8	1.3	1.5	1.1	0.7	1.0
CD (P=0.05)	5.1	6.5	4.2	13.0	10.8	9.8	NS	NS	NS	NS	NS	NS

effect is lower than panicle length and number of grains/panicle (Nadim *et al.* 2012). Test weight of different varieties varied from 38.8–41.3g during 2018–19 and 38.8–41.3 g during 2019–20 (Table 1). However, the highest test weight was observed in Unnat PBW 550 followed by PBW 1 Chapati, BWL 3498 and Unnat PBW 343. Similar results were reported by Ali *et al.* (2008) stated that larger variation in grain weight of different varieties under similar crop management conditions may be attributed to diverse genetic makeup of cultivars and their differential response to prevalent environment during grain filling stage.

Crop yield: In majority of the field crops, grain yield is the target of breeding programmes and the great integrator of genetics and environment. The cumulative effect of different treatments on growth and in turn on yield attributing characters is finally expressed in the grain yield which is of great economic importance.

The wheat grain yields varied from 22.1–37.7 q/ha among different varieties and the maximum per cent variation was 64.4% during 2018–19 (Table 2). The corresponding values for 2019–20 were 25.2–34.6 q/ha and 37.3%, respectively. The wheat variety Unnat PBW 550 gave significantly higher grain (37.7, 34.6 and 36.2 q/ha), straw (58.3, 59.6 and 59.0 q/ha) and biological yield (96.0, 94.2 and 95.0 q/ha) during 1st & 2nd year and on mean basis, respectively but it was statistically at par with PBW 1 Chapati, BWL 3498 and Unnat PBW 343. The lowest grain, straw and biological yields were recorded with PBW 1 Zn. Traditional varieties were out yielded by modern varieties. It is well known that the yield of a crop mainly depends on the yield attributing characters like number of spikelets/ear, ear length, number of grains/spike, number of effective tillers and test weight. The variety Unnat PBW 550 recorded significantly higher number of grains/spike and test weight in comparison to other varieties which resulted in higher grain yield of this variety.

Similarly, the straw yield was the highest in Unnat PBW 550 and was followed by PBW 1 Chapati, BWL 3498 and Unnat PBW 343 (Table 2). Grain yield differences due to varieties under organic farming have also been reported by Yadav *et al.* (2020) and Panwar *et al.* (2021b). Iannucci and Codianni (2016) evaluated durum wheat varieties for

Table 2 Grain, straw yield and economic analysis of wheat varieties/genotypes

Variety	Grain yield (q/ha)			Straw yield (q/ha)			Biological yield (q/ha)			Economics (pooled)	
	2018–19	2019–20	Pooled	2018–19	2019–20	Pooled	2018–19	2019–20	Pooled	Net returns (₹/ha)	B:C Ratio
PBW 1 Zn	22.1	25.2	23.7	38.5	40.3	39.4	60.6	65.5	63.1	23159	1.71
C-306	28.2	28.7	28.5	52.3	56.8	54.6	80.5	85.5	83.0	34385	2.06
BWL 3500	31.0	29.9	30.5	47.3	48.6	48.0	78.3	78.5	78.4	39049	2.20
PBW 175	25.4	28.6	27.0	39.8	46.3	43.1	65.2	74.9	70.1	31045	1.95
PBW 660	30.6	30.7	30.7	45.3	52.1	48.7	75.9	82.8	79.3	39551	2.21
BWL 3498	33.7	31.3	32.5	54.0	56.7	55.4	87.7	88	87.9	43838	2.35
Unnat PBW 343	32.9	30.9	31.9	50.2	53.2	51.7	83.1	84.1	83.6	42437	2.30
Unnat PBW 550	37.7	34.6	36.2	58.3	59.6	59.0	96	94.2	95.1	52408	2.61
PBW 1 Chapati	36.2	33.3	34.8	56.2	57.8	57.0	92.4	91.1	91.7	49119	2.51
SEm±	2.2	1.3	1.6	2.7	2.4	2.1	4.4	3.9	3.6	2328	0.09
CD (P=0.05)	6.4	3.8	4.6	8.1	7.0	6.5	13.2	12.0	11.2	7254	0.38

conventional and low input organic conditions based on variability in yield attributes and yield. Different varieties in different environments and breeding may contribute to the improvement of yield and baking quality to a certain extent (Baresel *et al.* 2008).

Economic analysis: The wheat variety Unnat PBW 550 recorded significantly higher net returns (54160, 50656 and 52408 ₹/ha) and benefit-cost (B:C) ratio (2.66, 2.55 and 2.61) during 1st & 2nd year and on mean basis, respectively) (Table 2). Yadav *et al.* (2020) also reported significant differences in net returns and benefit-cost (B:C) ratio among wheat varieties under organic management.

This study demonstrate the better performance of wheat variety Unnat PBW 550 under organic management. It produced significantly higher grain yield (>3.5 t/ha), net returns (₹0.50 lakh/ha) and B:C ratio (more than 2.5) in basmati-wheat cropping system. Thus, it can be concluded that Unnat PBW 550 can be promoted for organic cultivation in Punjab.

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