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Yield performance and economics of wheat varieties under organic farming

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ABSTRACT

Area under organic cultivation of wheat is increasing in India. Information on the yield performance and economic suitability of wheat varieties for organic farming in different agro climatic conditions is lacking. The present two year study was carried out during 2015 and 2016 to observe the yield performance of different varieties of bread, durum and local wheat under sub-humid conditions of southern plains and Aravalli Hills of Rajasthan. Results revealed that among the 12 varieties of wheat tested under organic production system, the maximum grain yield (56.39 q/ha) was obtained from durum wheat variety HI-8713 having 53.50 grains/ear followed by bread wheat variety MP-3288 (45.74 q/ha grain yield) bearing 51.67 grains/ear during both the years. Under organic production system the durum wheat variety HI-8713 recorded maximum net profit of ₹ 170700/ha which was higher by ₹ 68247, ₹ 79436 and ₹ 85055 over the commonly grown wheat varieties Raj-4037, Raj-3765 and Raj-4120, respectively.

Key words: Net return, Organic farming, Variety, Wheat, Yield, Yield attributes

Area under organic cereals was 4.5 million ha during 2017 in the world which was 0.6 % of the total cereal area in the world (718 million ha in 2016; FAOSTAT). The organic cereal area has more than tripled since 2004 (1.3 million ha). In 2017, the area under organic wheat was increased by 6 %. Organic cultivation of wheat is increasing in India in terms of total export value realization (₹ 3453 crore) cereals and millets contributed 10.4 % during 2017-2018 (APEDA 2019).

Wheat is the important crop of organic farming systems in India. However, 20-40 % yield reduction in organic wheat have been observed in comparison to wheat grown with chemical farming. Modern high yielding varieties which respond well to chemical inputs, may not be always suitable for organic farming (Ceccarelli 1996, Murphy *et al*. 2007). Instead, varieties which are hardy with less pest and diseases occurrence and capable of giving acceptable yield especially in the early phase of conversion are ideal.

In organic management system, grain yield is generally low compared to conventional production systems (Poutala *et al.* 1993, Mason *et al*. 2007, Reid *et al.* 2009, Sharma *et al.* 2018), while a great deal of confusion exists around the selection of a suitable variety of a crop for high yield under organic management as in case of chemical farming. Selection of a variety under organic farming has a direct effect on yield and economics of a crop than conventional farming (Revilla *et al.* 2008).

Keeping this in view, a field experiment was carried out to evaluate improved and local varieties of wheat under organic farming with respect to yield and economics.

MATERIALS AND METHODS

Field experiment was conducted during *rabi* seasons of 2015-16 and 2016-17 on Entisol soil, low in organic carbon (0.55%) and nitrogen (220 kg/ha), medium in available phosphorus (34.20 kg/ha), high in potassium (235.50 kg/ha), low in DTPA extractable iron (3.05 ppm) and zinc (0.45 ppm) at Organic Farming Unit, Rajasthan College of Agriculture, MPUAT, Udaipur (24°35' N latitude and 72°42' E longitude and at an elevation of 582.17 m above mean sea level). The experiment was laid out in a randomized block design (RBD) with 12 treatments and three replications. The experiment comprised 12 wheat varieties, *viz*. bread wheat; HI-1531, MP-3288, Raj-4037, Raj-3765 and Raj-4120, *durum* wheat; HI-8627, HI-8663, HI-8713, MPO-1215 and HI-1500 and local; Lok-1 and C-306. The characteristics of different wheat varieties are mentioned in Table 1.

The wheat varieties were grown with organic management practices as per standards of National

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Table 1 Varieties of wheat and their characteristics

Varieties	Duration (Days)	Year of release
Triticum aestivum (Bread wheat)		
HI-1531	110-120	2006
MP-3288	115-120	2012
Raj-3765	110-120	1996
Raj-4037	115-120	2005
Raj-4120	117-124	2009
Triticum durum (Durum wheat)		
HI-8627	125-130	2005
HI-8663	115-118	2007
HI-8713	130-135	2012
MPO-1215	125-130	2009
HI-1500	115-120	2003
Local		
Lok-1	100-110	1981
C-306	136-140	1969

Programme on Organic Production (NPOP) (APEDA 2018). The weather parameters especially temperature (maximum and minimum) during growth period of wheat during 2015 and 2016 are depicted in Fig 1. The organic nutrient and pest management practices followed in organic production of wheat varieties are given in Table 2.

Soil physical properties, *viz.* texture, bulk density and hydraulic conductivity and chemical properties, *i.e.* pH, EC, OC, available N, P, K, Fe and Zn of experimental field were determined up to 15 cm soil depth. The sand, silt and clay contents were determined with Hydrometer method, (Bouyoucos 1962), bulk density with Core sampler method (Piper 1950), EC by Conductivity bridge meter (Walkley and Black 1947), pH with Glass electrode pH meter (Jackson 1967), soil organic carbon by Walkley and Black's rapid titration method (Walkley and Black 1947), available nitrogen by Alkaline permanganate method (Subbiah and Asija 1956), phosphorus by Olsen's method (Olsen *et al.* 1954), potassium by Flame photometer (Richards 1968), zinc and iron by DTPA-extract with AAS (Lindsay and Norvell 1978). Daily weather data on maximum and minimum temperature, maximum and minimum relative humidity, wind speed and rainfall during the crop growth period were recorded at meteorological observatory, situated at the experimental site.

The crop was sown at a spacing of 22.5 cm × 10 cm distance. Nitrogen @ 90 kg/ha was applied to the crop through organic sources. For the nutrient management, NADEP compost @ 8000 kg/ha and vermicompost @ 4000

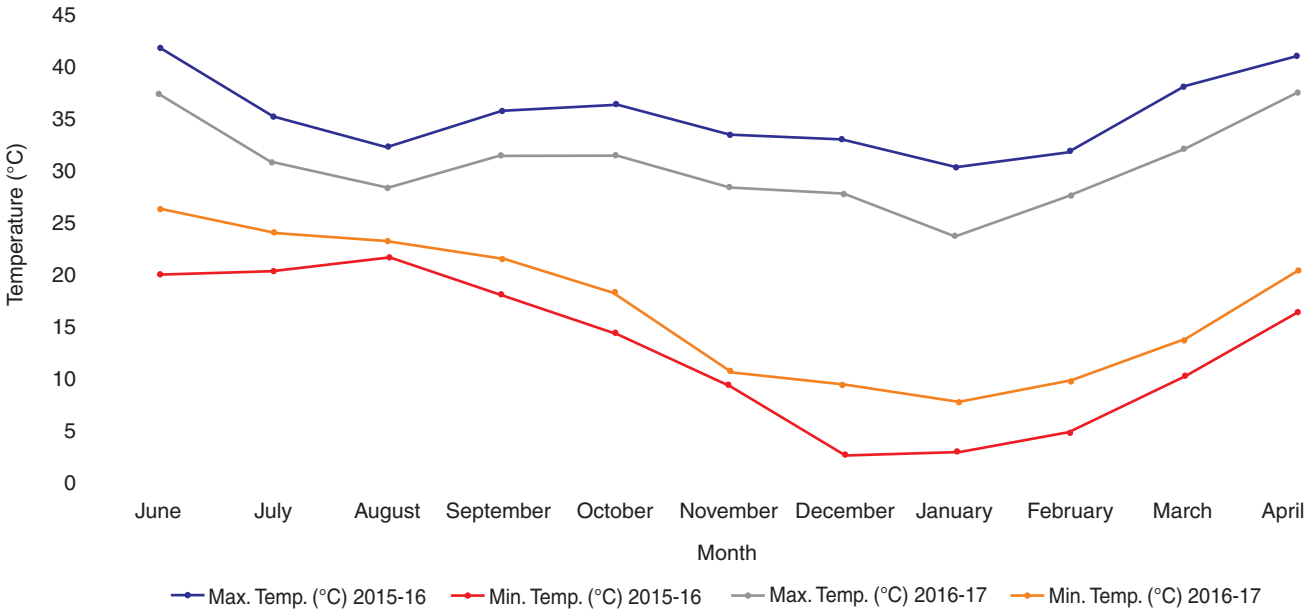

Fig 1 Monthly temperature during crop period (2015-16 and 2016-17).

Table 2 Nutrients and pest management practices used in organic farming of wheat

Wheat (90:60:30 NPK kg/ha)	NADEP	At the time sowing	8000 kg/ha	Nutrient management
	Vermicompost	At the time sowing	4000 kg/ha	
	Neem cake	1/2 at the time sowing+ 1/2 at tillering	200 kg/ha	Pest and nutrient management
	Vermiwash	25 DAS and 45 DAS	10 %	Nutrient management
	BD 500	Days before sowing	75 g/ha	Soil and plant health
	Yellow mataka trap (No.)	15 DAS	16 /ha	Pest monitoring
	Neem oil	20 DAS	0.3%	Pest management

kg/ha were applied at the time of sowing while neem cake @ 200 kg/ha was applied in two splits; ½ at the time of sowing and remaining ½ quantity at tillering. Weeds were controlled manually with hand hoe (4 times). Two sprays of vermiwash (10%) were applied at 25 and 45 DAS. Neem oil (0.3%) was applied as foliar spray for controlling of insect-pests. Plant phenological stages and climatic factors were recorded during the crop season.

Agronomic observations and computation

The yield and yield attributing parameters such as number of spikelets/ear, number of grains/ear, test weight, grain yield, straw yield, total biomass were recorded. Five randomly selected plants were used to record the number of spikelets/ear and number of grains/ear, whereas the total biomass and grain yield (kg/ha) were calculated on the basis of total weight of harvested dry matter and grain of wheat from the experimental plot. Harvest index is the ratio of grain yield to above ground biomass yield, i.e.

$$\text{Harvest Index} = \frac{\text{Economic yield}}{\text{Biological yield}}$$

RESULTS AND DISCUSSION

Crop growth-plant height at 90 DAS

Plant height of wheat varieties grown under organic farming differed significantly (Table 3). Durum wheat variety HI-1500 recorded significantly higher plant height at 90 DAS during 2015-16, 2016-17 and on pooled basis (138.00 cm, 142.67 cm and 140.33 cm, respectively) followed by C-306 of local wheat and HI-1531 bread wheat. The comparison within bread and durum wheat varieties indicated a significant variation in plant height.

This variation in plant height may be attributed to the fact that nutrient requirement of plants varies from variety to variety depending upon their photosynthetic rate, dry matter accumulation androots characteristics and growing environments. The present findings were in conformity with the findings of Chadha *et al*. (2010) in pea, Moslemi *et al.* (2012) in coriander, 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 Khatun (2001), Das *et al.* (2012) who observed variable plant height among the rice varieties under organic farming.

Dry matter accumulation at 90 DAS

The findings of the study indicated significant dry matter accumulation in wheat varieties at 90 DAS in both the years as well as in pooled data. Results revealed significantly maximum dry matter accumulation (84.67 g/plant) was recorded in variety HI-8713 at 90 DAS during 2015-16 and on pooled basis (84.67 g/plant and 81.33 g/plant, respectively) as compared to other varieties and it was found at par with variety HI-1500 (78.33 g/plant and 79.17 g/plant, respectively). However, during 2016-17, variety HI-1500 recorded significantly higher dry matter at 90 DAS (80.00 g/plant) as compared to other varieties and it was found at par with HI-8713 (79.00 g/plant), MPO-1215 (78.67 g/plant) and C-306 (76.00 g/plant) (Table 3). The higher total dry matter production was directly related to LAI. Accumulation of dry matter during the crop growth and its partitioning has a correlation with leaf area and other growth parameters (Bharadwaj and Kalindi 1986). This was in agreement with the findings of Kudachikar *et al*. (1999).

Number of spikelets/ear

Number of spikelets/ear varied from 13.67 to 19.67 during 2015-16 and 2016-17. A significant difference in terms of number of spikelets/ear was recorded among the bread, durum and local wheat varieties. During 2015-16 and on pooled basis significantly highest number (18.67 and 19.00) of spikelets/ear were recorded in bread variety HI-1531 over the other varieties, but during 2016-17, durum variety HI-8713 recorded significantly higher number of spikelets/ear (19.67) as compared to other varieties (Table 3).Tahir *et al*. (1995), who all reported that number of spikelets per spike differed significantly in various genotypes of wheat.

Number of grains/ear

The variety HI-8713 having the maximum number of spikelets/ear, also recorded significantly higher number of grains/ear during both the year as well as in pooled data analysis (52.33, 54.67 and53.50, respectively) as compared to other wheat varieties (Table 3).

Test weight

Test weight of seed is governed by genetic factors and is influence by the genotypes/varieties grown. Test weight of different varieties of wheat grown under organic farming varied significantly from 43.67g to 60g during 2015-16 and 2016-17 (Table 3). The durum variety MPO-1215 recorded significantly higher test weight during both the year and on pooled basis (60.00g, 58.67g and 59.33g, respectively) as compared to other varieties. However, the test weight of this variety was found at par with variety HI-8627 (58.67g, 57.33g and 58.00g, respectively) and HI-8713 (57.33g, 57.67g and 57.50g, respectively).

Among the different wheat varieties, the maximum test weight on pooled basis (58.00g) was recorded in variety MPO-1215 followed by HI-8627, which might be due to its larger grain size showing its genetic character and its positive response under organic farming conditions (Fig 2). Whereas the lowest test weight (46.00g) was found in bread variety MP-3288 which might be due to its smaller grain size and shrink in nature.

Similar results were reported by (Gupta and Sharma 1991). Ali *et al*. (2008) also 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.

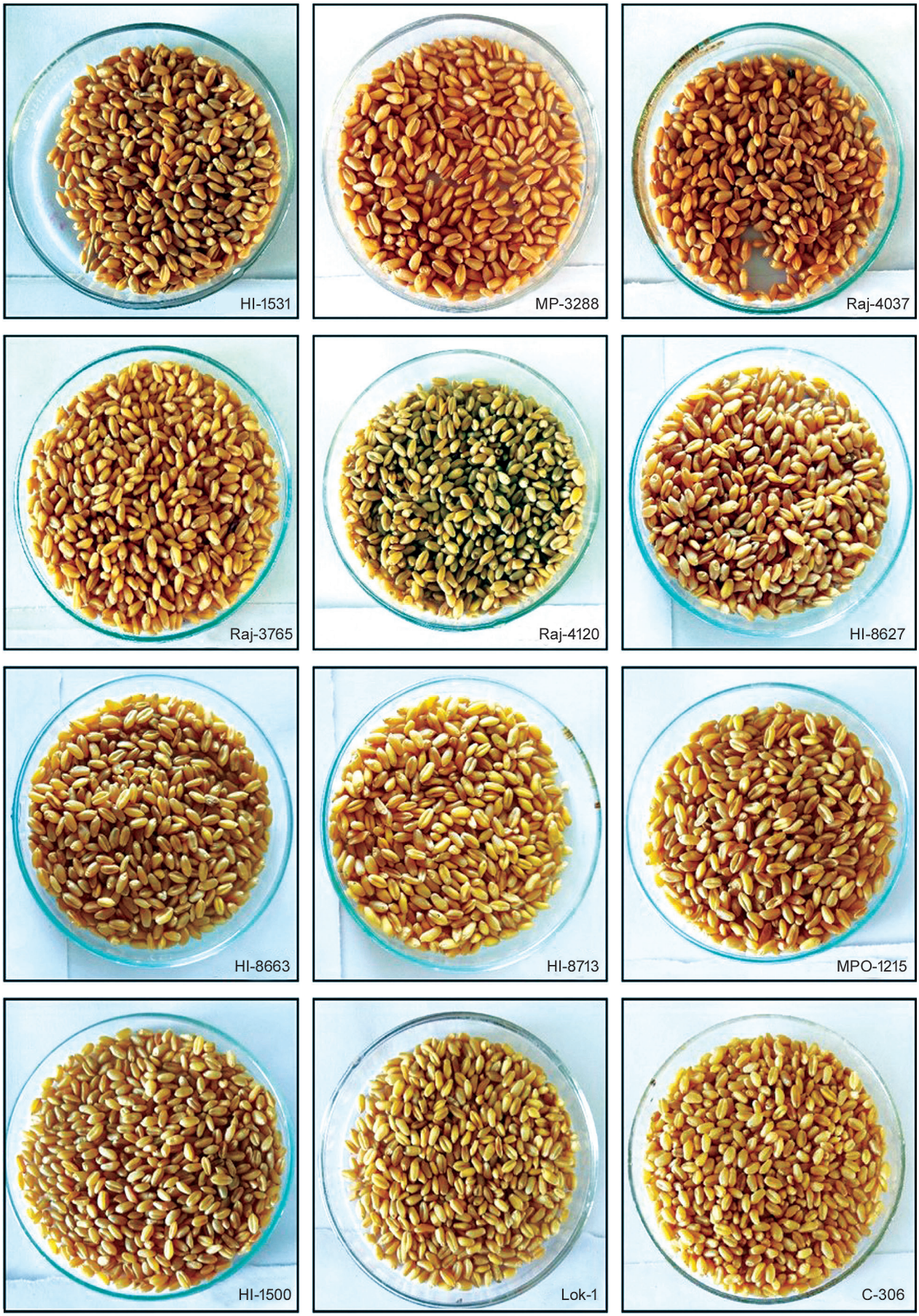

Fig 2 Grains of bread, durum and local wheat varieties

Table 3 Growth and yield attributes of wheat varieties grown under organic farming

Variety	Plant height at 90 DAS (cm)			Dry matter accumulation at 90 DAS (g/plant)			Number of spikelets/ ear			Number of grains/ ear			Test weight (g)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Triticum aestivum (Bread wheat)															
HI-1531	106.00	100.33	103.17	45.00	47.00	46.00	18.67	19.33	19.00	47.33	48.33	47.83	47.80	47.27	47.53
MP-3288	92.00	92.00	92.00	72.50	68.00	70.25	18.33	17.33	17.83	51.00	52.33	51.67	46.17	45.83	46.00
Raj-3765	68.00	68.67	68.33	47.30	51.00	49.15	17.67	19.00	18.33	46.67	46.00	46.33	49.30	48.50	48.90
Raj-4037	71.00	74.00	72.50	60.30	60.00	60.15	14.00	13.67	13.83	34.67	35.33	35.00	51.67	52.33	52.00
Raj-4120	81.50	79.00	80.25	69.00	72.00	70.50	13.67	13.33	13.50	40.67	42.00	41.33	50.67	50.00	50.33
Triticum durum (Durum wheat)															
HI-8627	85.50	88.00	86.75	75.67	71.25	73.46	17.00	17.00	17.00	49.67	50.67	50.17	58.67	57.33	58.00
HI-8663	80.50	81.33	80.92	65.00	64.00	64.50	17.33	18.00	17.67	51.33	48.33	49.83	51.33	51.00	51.17
HI-8713	78.50	81.67	80.08	84.67	79.00	81.83	17.67	19.67	18.67	52.33	54.67	53.50	57.33	57.67	57.50
MPO-1215	77.00	82.67	79.83	75.00	78.67	76.83	17.33	16.33	16.83	40.33	41.67	41.00	60.00	58.67	59.33
HI-1500	138.00	142.67	140.33	78.33	80.00	79.17	17.33	16.67	17.00	41.00	40.00	40.50	44.33	45.67	45.00
Local															
Lok-1	75.00	65.67	70.33	65.00	63.00	64.00	14.33	13.67	14.00	32.00	31.67	31.83	49.00	43.67	46.33
C-306	104.00	111.00	107.50	74.70	76.00	75.35	15.33	15.33	15.33	44.33	44.33	44.33	48.33	49.33	48.83
SEm ±	2.843	2.656	1.945	2.316	2.119	1.570	0.550	1.046	0.591	1.660	2.318	1.426	1.133	1.147	0.806
CD at 5 %	8.337	7.789	5.544	6.793	6.215	4.473	1.612	3.069	1.685	4.870	6.798	4.063	3.324	3.365	2.298

Table 4 Grain and straw yield of bread and durum wheat varieties under organic farming

Variety	Grain yield (q/ha)			Straw yield (q/ha)			Biological yield (q/ha)			Harvest index (%)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Triticum aestivum (Bread wheat)												
HI-1531	44.07	42.96	43.52	76.30	84.81	80.56	120.37	127.78	124.07	36.67	34.32	35.49
MP-3288	43.33	48.15	45.74	72.41	68.52	70.46	115.74	116.67	116.20	37.58	41.93	39.75
Raj-3765	31.11	41.11	36.11	65.19	75.56	70.37	96.30	116.67	106.48	32.27	36.95	34.61
Raj-4037	33.80	44.07	38.94	73.61	80.00	76.81	107.41	124.07	115.74	31.98	36.14	34.06
Raj-4120	29.91	37.41	33.66	64.54	81.11	72.82	94.44	118.52	106.48	32.02	31.62	31.82
Triticum durum (Durum wheat)												
HI-8627	42.41	46.48	44.44	76.11	90.56	83.33	118.52	137.04	127.78	35.72	35.61	35.66
HI-8663	38.24	51.85	45.05	69.17	81.48	75.32	107.41	133.33	120.37	35.74	38.66	37.20
HI-8713	44.81	67.96	56.39	81.11	104.26	92.69	125.93	172.22	149.07	35.33	39.92	37.62
MPO-1215	33.39	45.00	39.19	59.20	66.11	62.66	92.59	111.11	101.85	36.40	41.42	38.91
HI-1500	29.26	35.37	32.31	72.59	75.74	74.17	101.85	111.11	106.48	28.90	31.74	30.32
Local												
Lok-1	29.81	37.04	33.43	66.48	70.37	68.43	96.30	107.41	101.85	30.88	37.03	33.95
C-306	42.78	42.78	42.78	73.89	79.81	76.85	116.67	118.52	117.59	37.11	36.47	36.79
SEm ±	3.098	4.488	2.727	6.485	12.172	6.896	8.194	10.193	6.539	2.217	5.089	2.776
CD at 5 %	9.087	13.162	7.771	19.020	35.698	19.654	24.032	29.895	18.637	NS	NS	NS

Crop yield

Grain yield of different wheat varieties under organic farming varied from 29.81 to 67.96 q/ha. In both the years the trend of response was same but yield was comparatively higher during second year (2016-17) (Table 4). Durum HI-8713 gave significantly higher grain, straw and biological yield during both the year and on pooled basis (44.81 q/ha, 67.96 q/ha and 56.39 q/ha grain yield, 81.11 q/ha, 104.26 q/ha and92.69 q/ha straw yield and 125.93 q/ha, 172.22 q/ha and 149.07 q/ ha biological yield, respectively) as compared to other varieties (Table 4 and Fig 3). There was no significant difference was found among the grain yield of HI-1531, MP-3288, HI-8627, HI-8663 and C-306 during both the years.

It is well known that the yield of a crop mainly depends on the yield attributing characters of plant like number of spikelets/ear, ear length, number of grains/ear, number of effective tillers and test weight. The variety HI-8713 recorded significantly higher number of grains/ ear and test weight in comparison to other varieties which resulted the higher yield of this variety in comparison to other varieties.

Similarly, straw yield of wheat was higher in the variety HI-8713 followed by HI-8627, HI-1531 and C-306 (Table 4). This might be attributed to significantly LAI and dry matter accumulation of variety HI-8713 in comparison to the other varieties. Grain yield differences due to varieties were also reported by Biswas *et al.* (1998). Iannucci and Codianni (2016) evaluated durum wheat varieties for 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 (Tarakanovas and Ruzgas 2007, Baresel *et al.* 2008).

Harvest index

No significant difference in the harvest index of different varieties of wheat was observed during 2015, 2016 and on pooled basis (Table 4).

Net return and BC ratio

Variety HI-8713 of durum wheat recorded significantly higher net return and benefit-cost ratio (B:C ratio) during 2015-16, 2016-17 and on pooled basis (130075 ₹/ha, 211325 ₹/ha and 170700 ₹/ha net return and 2.84, 4.62 and 3.73, respectively) as compared to other varieties. The net return and B:C ratio of durum varieties was comparatively higher than bread and local varieties (Table 5).

Ozberk *et al.* (2011) also reported the better net return and B:C ratio of durum wheat as compared to other varieties. This might be due to higher test weight of durum wheat varieties than bread wheat varieties. Highly significant correlation coefficient between 1000 kernel weights vs. marketing price as indicated earlier

Table 5 Economics of bread and durum wheat varieties grown under organic farming

Variety	Net return (₹/ha)			B:C ratio		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Triticum aestivum (Bread wheat)						
HI-1531	116583	117816	117199	2.55	2.58	2.56
MP-3288	112525	124023	118274	2.46	2.71	2.59
Raj-3765	74620	107908	91264	1.63	2.36	2.00
Raj-4037	86435	118471	102453	1.89	2.59	2.24
Raj-4120	70919	100371	85645	1.55	2.19	1.87
Triticum durum (Durum wheat)						
HI-8627	120303	139892	130097	2.63	3.06	2.84
HI-8663	104261	151375	127818	2.28	3.31	2.79
HI-8713	130075	211325	170700	2.84	4.62	3.73
MPO-1215	84625	122981	103803	1.85	2.69	2.27
HI-1500	79064	99003	89033	1.73	2.16	1.95
Local						
Lok-1	71651	93857	82754	1.57	2.05	1.81
C-306	111725	114747	113236	2.44	2.51	2.48
SEm ±	10722.73	10682.75	7567.99	0.234	0.234	0.165
CD at 5 %	31448	31331	21569	0.688	0.685	0.472

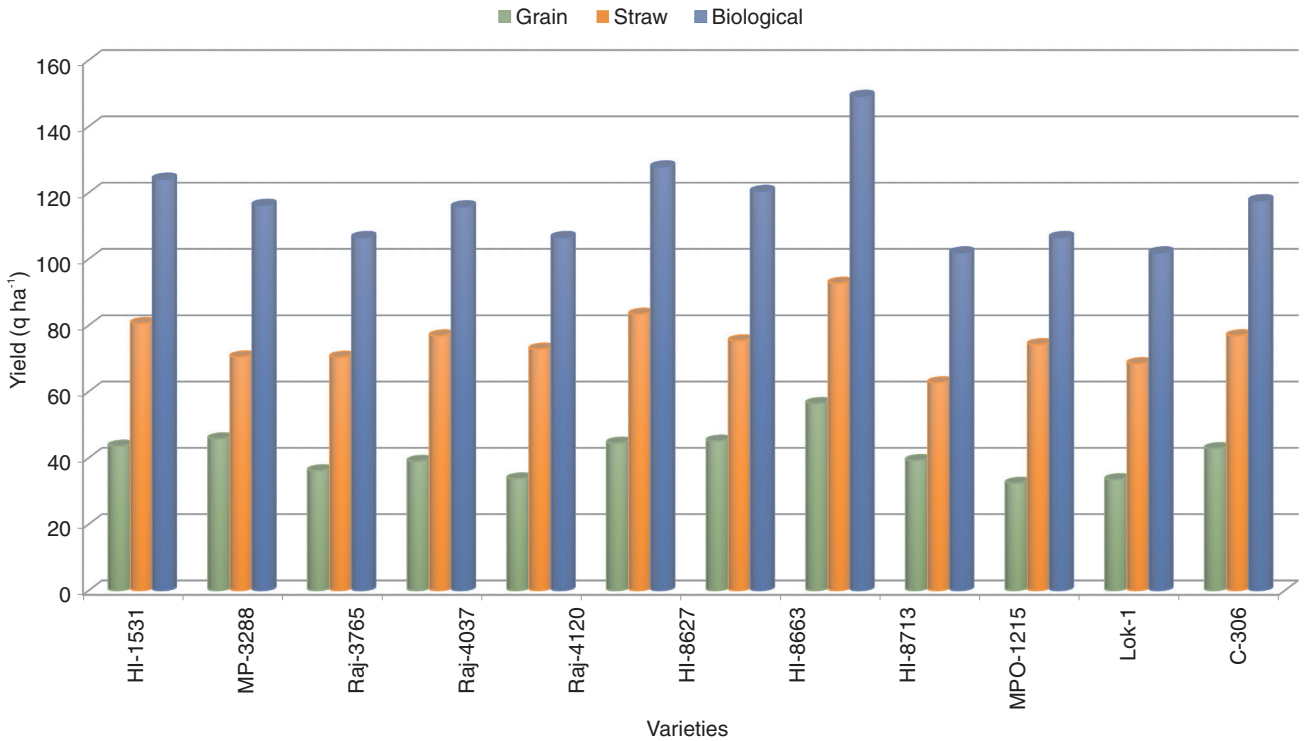

Fig 3 Grain, straw and biological yield of different wheat varieties grown under organic farming (Mean of pooled data of 2015-16 and 2016-17).

visual characteristics of grains in commodity market are main criteria for high market price offers.

Hence, the present study demonstrates that the performance of durum variety is significantly better than the bread varieties under organic production system. Durum variety HI-8713 produced significantly higher grain yield (>5 t ha^{-1}) and biological yield (14.9 t ha^{-1}) by registering higher values of growth and yield attributes. Under organic farming, durum variety HI-8713 followed by HI-8627 and HI-8663 recorded the higher net return of more than ₹ 1.25 lakh ha^{-1} and also B:C ratio more than 3.0 in maize-wheat cropping system. Thus it can be concluded

that according to prevailing cropping system, durum variety HI-8713 can be promoted for organic cultivation in South and East region of Rajasthan.

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