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Response of system of barley intensification and organic manures on grain quality of organic barley (*Hordeum vulgare* L.)

Victor Debbarma and Niranjani Chaurasia

Abstract
The experiment was carried out during *Rabi* season 2015-16 and 2016-17 at Crop Research Farm, SHUATS Model of Organic Farm (SMOF), Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.) to study the 'Response of System of Barley Intensification and organic manures on grain quality of organic barley (*Hordeum vulgare* L.)'. The pooled data recorded that highest carbohydrate contain of 74.58% in the treatment M_3 (Furrow Irrigated Raised Bed) and highest protein contain of 10.57% in the treatment M_1 (System of Barley Intensification technique), though it was found non-significant. Considering Farm yard manure (12 t/ ha) pooled data showed highest percentage in carbohydrate content of 74.57% and protein contain of 10.58%, though there was no significance difference.

Keywords: SBI, planting methods, organic sources of nutrient, quality parameters in barley grain

Introduction
Barley can be grown successfully in temperate, tropical and subtropical climatic condition of the world. It's mainly grown for food products as well as animal feed in the globe. The world barley production in 2017-18 was 142.37 m t cultivated over an area of 55.9 m ha with the productivity of 2.54 t/ ha (The Statistics Portal, 2020b) [8]. India stands twenty second in production among barley growing countries. It produces 1.78 m t of barley in an area of 0.66 m ha with the productivity of 2.67 t/ ha (The Statistics Portal, 2020c) [9].
The energy value of barley mainly depends on its starch content and less on indigestible fibre components, such as cellulose, lignin and non-starch polysaccharides, arabinoxylan (hemicellulose) and β-glucan (Newman and Newman, 1992a) [6]. Starch constitutes the largest part of endosperm and usually amounts to about 62% of barley grain dry matter (Evers *et al.*, 1999) [3] and varies in the range from 53 to 67% (Aman, 1985) [1]. Starch is composed of polymers — amylose and amilopectin (Mauro, 1996) [5]. The amylose/amylopectin ratio in starch is determined by genetic factors.
Protein can be divided into four groups, depending on their solubility in different solvents. Protein solubility fractions are named albumin, globulin, glutelin and hordein. The hordein fraction represents the major group of storage protein in the grain. Hordein can be classified into three groups of polypeptides called B, C, D hordeins based on their electrophoretic mobility (Evers *et al.*, 1999) [3]. The B and C fractions account for 70–80% and 10–12%, respectively, of the total hordein, while the D fractions are a minor component (about 5%). Each group of hordein is synthesised from a family of structural genes.
The nutrients required by the plants can be supplied through organic sources of nutrients such as farm yard manure, poultry manure, *vermicompost*, *bokashi* manure, green manure and foliar spray of organics such as cattle urine. Therefore, the present investigation entitled, "Response of System of Barley Intensification and organic manures on quality of organic barley (*Hordeum vulgare* L.)', was carried out at SHUATS Model Organic Farm, Crop Research Farm of Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology & Sciences, Prayagraj during *Rabi* season 2015-16 and 2016-17 for Barley crop.

Materials and Methods
The experiment was carried out during *Rabi* season 2015-16 and 2016-17 at Crop Research Farm, SHUATS Model of Organic Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj (U.P.).

SHUATS Model Organic Farm (SMOF) with 2 hectares (5 acres) area has been Certified by Lacon Quality Certification (P) Ltd. [Accreditation No. NPOP/NAB/006, Ministry of Commerce, Govt. of India] till 2017 the field was in its 9th year of conversion. The soil of the experimental plot was sandy loam in texture, low in available nitrogen, medium in available phosphorus and high in available potash with 7.68 soil pH. The experiment was laid out in split plot design with three replications, having three planting methods, *viz.*, System of Barley Intensification (20 × 20 cm) technique, *Kera* method (22.5 × 10 cm) and Furrow Irrigated Raised Bed (FIRB, 22.5 × 10 cm); three organic sources of nutrient, *viz*., Poultry manure (2 t/ ha), Farm yard manure (12 t/ ha) and *Bokashi* manure (2 t/ ha) were studied. There were total 9 treatment combinations in all. The net plot size was 5 × 4 m and net experimental area 540 m^2. The agronomic practices, *viz*., weeding with cycle weeder in SBI technique, manual and hand weeding in *Kera* method and Furrow Irrigated Raised Bed (FIRB) methods were done and irrigation was given according to the schedules for all treatments. The barley variety 'RD2035' was sown. Data on carbohydrate (%), protein (%), fat (%), ash (%) and moisture (%) were recorded. Data recorded on qualitative parameters were tabulated and subjected to statistical analysis as per Gomez and Gomez, 1976 [4].

Carbohydrate (%) in barley grain

The carbohydrates content of grain can be determined by calculating the percent remains after the entire component have been measured, *viz.*, moisture, protein, fat and ash. The following formula was used for calculation (Ranganna, 2003) [7].

Carbohydrate (%) = 100 - [Protein (%) + Moisture (%) + Fat (%) + Ash (%)]

Protein (%) in barley grain

It is calculated by the formula, Protein (%) = N (%) × power factor [barley (5.83)]. The nitrogen content of grains was analyzed by micro-Kjeldahl digestion and distillation method (Amma, 1989) [2].

The micro-Kjeldahl's method for total nitrogen content (%) essentially involves digestion of the sample to convert N compounds in the sample to NH_4 form. The 200 mg of plant sample and an equal amount of catalyst mixture (prepared by mixing 25.0 g K_2SO_4 + 5.0 g $CuSO_4$. $5H_2O$ + 0.5 g of metallic selenium) is transferred to a micro Kjeldahl digestion flask. On adding 3 ml of conc. H_2SO_4 the digestion flask is transferred to digestion assembly with a fume hood. The contents are first heated slowly. When the initial vigorous reaction is over, the contents are heated briskly until it become clear. Organic N is transformed into ammonium sulphate during the digestion process.

The digestion contents are transferred to distillation flask of a micro Kjeldahl distillation unit which has water filled large flask with round bottom for generating steam to boil the contents placed in distillation flask. The distillation flask is connected to a condenser, and the condenser outlet is dipped in 25 ml of 2% boric acid containing mixed indicator. On adding of 10 ml of 40% NaOH into distillation flask, the feeding funnel is closed and water in large round flask is heated to boil for generating steam for boiling the contents in distillation flask. In 9 minutes of distillation about 55 ml of distillate is collected in boric acid forming ammonium borate which makes the weak boric acid alkaline.

The ammonium borate is back titrated by adding 0.02N HCl until the reaction mixture changes its colour from green to pink. The standard acid used in back titration of ammonium borate is a masure of N content of the plant sample. Similar procedure for blank sample was followed.

$$\% \text{ Nitrogen in plant sample} = \frac{(S - B) \times 0.02\ N \times ME \times 100}{W}$$

Where,

S is ml of standard acid used in the titration of the sample distillate

B is the ml of standard acid used in the titration of the blank distillate

N is the normality of the acid used in the titration of the distillate

ME is the milligram equivalent weight of nitrogen, *i.e.*, 0.014

W is the mass of plant sample taken in gram for the preparation of the sample digest.

Fat (%) in the barley grain

The extractor and extract flask were cleaned and dried. The extract flask was weighed on chemical balance up to 2 decimal. Two gram of prepared sample was placed on whatman paper number 42 which was folded in to a shape of thimble and was placed inside the extractor. Two hundred fifty (250) ml of ether solvent was added in the extractor flask and to avoid overheating, the intensity of heat from electric coil was lowered with the help of regulator. For the complete removal of fat of grain sample, four cycles of siphoning was needed and 1000 ml of ether solvent were used. The solvent was kept in flask and only the fat content was heated gently till the smell of ether was not there. It was taken out and kept for cooling and the weight was taken. It was represented in percentage. The following formula was used for calculation (Ranganna, 2003) [7].

$$\text{Fat percentage} = \frac{(X - Y)}{\text{Weight of sample (g)}} \times 100$$

Where,

X is final weight of flask

Y is initial weight of flask

Moisture (%) in the barley grain

This method consists in measuring the weight lost by prepared sample. The moisture content was determined by the air oven method and the methodology was used as follows. The temperature of the oven was set at 80 °C and samples were placed inside the oven and the final weights of samples were measured after the 8 hours (Ranganna, 2003) [7].

$$\text{Moisture Percentage} = \frac{(X - Y)}{X} \times 100$$

Where,

X = Initial weight of grain sample

Y = Final weight of grain sample

Ash (%) in the barley grain

The ash content in rice was determined by the Bunsen burner and muffle furnace. Two g sample was prepared and put in the crucible and the initial weight was taken. The samples were kept over the Bunsen burner for 5 to 6 minutes. Samples were put inside the muffle furnace at 525 ºC for 4 hours samples and thereafter it was cooled and the final weight recorded. The difference in weights gave the total ash content and was expressed as percent (Ranganna, 2003) [7].

$$\text{Ash percentage} = \frac{(X - Y)}{X} \times 100$$

Where,
X = Initial weight of grain sample
Y = Final weight of grain sample

Results and Discussion

Carbohydrate content in grain (%)

The result regarding the effect of different planting methods and organic sources of nutrients on qualitative parameter namely carbohydrate content (%) in grain of barley is given in the table 1 and 2.

Highest carbohydrate of 74.58% with exactly same values was registered in the treatment M_3 (Furrow Irrigated Raised Bed) during both the years of experiment and in pooled, though it was found to be non significant. Further, M_1 (System of Barley Intensification technique) was also registered with exactly same values with M_3 (Furrow Irrigated Raised Bed) in 2015-16. The mean data also registered lowest carbohydrate percentage in the treatment M_2 (*Kera* method) during both the years and in pooled.

Data pertaining to organic sources of nutrient showed highest in carbohydrate percentage. It further registered that S_2 (Farm yard manure, 12 t/ ha) has highest percentage in carbohydrate content during both the years and pooled, though it was found non significant. Further, data also revealed that statistically lowest values by S_3 (*Bokashi manure*, 2 t/ ha) during both the years and pooled. The highest percentage in carbohydrate content recorded with farm yard manure, which may have provided more nitrogen accumulation, more starch may be because of higher nitrogen uptaken by the plant. Similar findings reported by Takahashi *et al.* (1959) [10].

Appraisal of the data on carbohydrate percentage remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Protein content in grain (%)

The data regarding the effect of different planting methods and organic sources of nutrient on qualitative parameter namely protein content (%) in grain is given of barley in the table 1 and 2.

Highest protein (10.56% and 10.59%) was registered in the treatment M_1 (System of Barley Intensification technique) during both the years of evaluation and pooled, though it was found non significant. Data also envisage that M_3 (Furrow Irrigated Raised Bed) had lowest protein percentage during both the years of experiment and in pooled.

Data pertaining to organic sources of nutrient showed highest in protein percentage. It further registered that S_1 (Poultry manure, 2 t/ ha) has highest percentage in protein content (10.54% and 10.61%) in both the years and pooled compared to other organic sources of nutrient, though it was found no significance difference in protein percentage. Data also envisage that S_3 (*Bokashi manure*, 2 t/ ha) had lowest protein percentage during both the years and in pooled.

Appraisal of the data on protein percentage remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Fat content in the grain (%)

The performance regarding the effect of different planting methods and organic sources of nutrients on qualitative parameter namely fat content (%) in grain of barley is given in the table 1 and 2.

Highest fat content of 1.26% and 1.24% was registered in the treatment M_2 (*Kera* method) in 2015-16 and pooled; and by M_1 (System of Barley Intensification technique) in 2016-17, and found non significant. The mean data also registered with exactly same values by M_1 (System of Barley Intensification) with M_2 (*Kera* method) in pooled analysis.

Data pertaining to organic sources of nutrient showed highest percentage in fat content. It further registered that S_3 (*Bokashi manure*, 2 t/ ha) has highest percentage in fat content (1.28% and 1.23%) in both the years and pooled compared to other organic sources of nutrients, and found to be non significant. Further, it was registered with exactly same values by S_1 (Poultry manure, 2 t/ ha) with S_3 (*Bokashi manure*, 2 t/ ha) in 2016-17.

Appraisal of the data on fat percentage remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Ash content in grain (%)

The finding regarding the effect of different planting methods and organic sources of nutrients on qualitative parameter namely ash content (%) in grain of barley is given in the table 1 and 3.

Highest ash content of 1.32% with exactly same values was registered in the treatment M_2 (*Kera* method) in 2015-16 and pooled; and by M_3 (Furrow Irrigated Raised Bed) in 2016-17, though it was found to be non significant.

Data pertaining to organic sources of nutrient showed highest percentage in ash content. It further registered that S_3 (*Bokashi manure*, 2 t/ ha) has highest percentage in ash content in 2016-17 and pooled; and by S_1 (Poultry manure, 2 t/ ha) in 2015-16, though it was found to be no significance difference. The mean data also registered the lowest value by S_2 (Farm yard manure, 12 t/ ha) during both the years and in pooled.

Appraisal of the data on ash percentage remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Moisture content in grain (%)

The observation regarding the effect of different planting methods and organic sources of nutrients on qualitative parameter namely moisture content (%) in grain of barley is given in the table 1 and 3.

Highest moisture content (12.43% and 12.39%) was registered in the treatment M_3 (Furrow Irrigated Raised Bed) in 2015-16 and pooled; and by M_2 (*Kera* method) in 2016-17, though it was found to be non significant. Further, statistically lowest value was registered by M_1 (System of Barley Intensification technique) in both the years and pooled.

Data pertaining to organic sources of nutrient showed highest

percentage in moisture content. It further registered by S_1 (Poultry manure, 2 t/ ha) in 20f15-16; and by S_3 (*Bokashi manure*, 2 t/ ha) in pooled has highest percentage in moisture content compared to other organic sources of nutrient; though it was recorded non significant. The mean data also registered with exactly same values by S_2 (Farm yard manure, 16 t/ ha) and S_3 (*Bokashi manure*, 3.2 t/ ha) in 2016-17.

Appraisal of the data on moisture percentage remained unchanged with planting methods and organic sources of nutrient during both the years and in pooled.

Table 1: Response of System of Barley Intensification and organic manures on quality parameters of organic barley

Treatment	Qualitative percentage														
	Carbohydrate content in grain (%)			Protein content in grain (%)			Fat content in grain (%)			Ash content in grain (%)			Moisture content in grain (%)		
	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
Planting methods															
M_1	74.58	74.52	74.55	10.56	10.59	10.57	1.22	1.26	1.24	1.31	1.32	1.32	12.36	12.34	12.35
M_2	74.53	74.51	74.52	10.50	10.57	10.53	1.26	1.23	1.24	1.32	1.32	1.32	12.39	12.37	12.38
M_3	74.58	74.58	74.58	10.46	10.56	10.51	1.23	1.19	1.21	1.29	1.33	1.31	12.43	12.34	12.39
SE(d) ±	0.05	0.04	0.03	0.11	0.08	0.04	0.04	0.03	0.02	0.03	0.04	0.02	0.03	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Organic sources of nutrient															
S_1	74.56	74.54	74.55	10.51	10.59	10.55	1.20	1.23	1.22	1.33	1.31	1.32	12.42	12.32	12.37
S_2	74.59	74.56	74.57	10.54	10.61	10.58	1.23	1.21	1.22	1.29	1.30	1.29	12.34	12.37	12.36
S_3	74.54	74.51	74.53	10.46	10.51	10.48	1.28	1.23	1.26	1.30	1.37	1.33	12.41	12.37	12.39
SE(d) ±	0.04	0.04	0.02	0.09	0.07	0.04	0.04	0.03	0.02	0.04	0.03	0.02	0.03	0.02	0.02
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M_1 – System of Barley Intensification (SBI) technique; M_2 – *Kera* method; M_3 – Furrow Irrigated Raised Bed (FIRB); S_1 – Poultry manure (2 t/ ha); S_2 – Farm yard manure (12 t/ ha); S_3 – *Bokashi manure* (2 t/ ha) (at 25, 35 and 50 DAS); DAS – Days after sowing; NS – Non-significant; S.Ed (±): Standard error of deviation; CD: Critical difference

Table 2: Interaction response of System of Barley Intensification and organic manures on quality parameters of organic barley

Planting Methods	Carbohydrate content in grain (%)				Protein content in grain (%)				Fat content in grain (%)			
	Organic sources of nutrient				Organic sources of nutrient				Organic sources of nutrient			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
2015 – 16												
M_1	74.57	74.60	74.57	74.58	10.60	10.60	10.47	10.56	1.17	1.20	1.30	1.22
M_2	74.53	74.57	74.50	74.53	10.50	10.53	10.47	10.50	1.23	1.27	1.27	1.26
M_3	74.57	74.60	74.57	74.58	10.43	10.50	10.43	10.46	1.20	1.23	1.27	1.23
Mean	74.56	74.59	74.54		10.51	10.54	10.46		1.20	1.23	1.28	
Interaction		SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)	
(PM × OS)		0.07	NS			0.15	NS			0.06	NS	
2016 – 17												
M_1	74.53	74.57	74.47	74.52	10.63	10.63	10.50	10.59	1.23	1.23	1.30	1.26
M_2	74.53	74.50	74.50	74.51	10.60	10.60	10.50	10.57	1.23	1.23	1.23	1.23
M_3	74.57	74.60	74.57	74.58	10.53	10.60	10.53	10.56	1.23	1.17	1.17	1.19
Mean	74.54	74.56	74.51		10.59	10.61	10.51		1.23	1.21	1.23	
Interaction		SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)	
(PM × OS)		0.08	NS			0.12	NS			0.05	NS	
Pooled												
M_1	74.55	74.58	74.52	74.55	10.62	10.62	10.48	10.57	1.20	1.22	1.30	1.24
M_2	74.53	74.53	74.50	74.52	10.55	10.57	10.48	10.53	1.23	1.25	1.25	1.24
M_3	74.57	74.60	74.57	74.58	10.48	10.55	10.48	10.51	1.22	1.20	1.22	1.21
Mean	74.55	74.57	74.53		10.55	10.58	10.48		1.22	1.22	1.26	
Interaction		SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)	
(PM × OS)		0.04	NS			0.07	NS			0.03	NS	

M_1 – System of Barley Intensification (SBI) technique; M_2 – *Kera* method; M_3 – Furrow Irrigated Raised Bed (FIRB); S_1 – Poultry manure (2 t/ ha); S_2 – Farm yard manure (12 t/ ha); S_3 – *Bokashi manure* (2 t/ ha) (at 25, 35 and 50 DAS); DAS – Days after sowing; NS – Non-significant; S.Ed (±): Standard error of deviation; CD: Critical difference

Table 3: Interaction response of System of Barley Intensification and organic manures on quality parameters of organic barley

Planting Methods	Ash content in grain (%)				Moisture content in grain (%)			
	Organic sources of nutrient				Organic sources of nutrient			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
2015 – 16								
M_1	1.33	1.27	1.33	1.31	12.40	12.33	12.33	12.36
M_2	1.30	1.33	1.33	1.32	12.43	12.30	12.43	12.39
M_3	1.37	1.27	1.23	1.29	12.43	12.40	12.47	12.43
Mean	1.33	1.29	1.30		12.42	12.34	12.41	
Interaction		SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)	
(PM × OS)		0.07	NS			0.06	NS	

2016 – 17								
M_1	1.23	1.33	1.40	1.32	12.37	12.33	12.33	12.34
M_2	1.33	1.27	1.37	1.32	12.30	12.40	12.40	12.37
M_3	1.37	1.30	1.33	1.33	12.30	12.37	12.37	12.34
Mean	1.31	1.30	1.37		12.32	12.37	12.37	
Interaction		SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)	
(PM × OS)		0.05	NS			0.04	NS	
Pooled								
M_1	1.28	1.30	1.37	1.32	12.38	12.33	12.33	12.35
M_2	1.32	1.30	1.35	1.32	12.37	12.35	12.42	12.38
M_3	1.37	1.28	1.28	1.31	12.37	12.38	12.42	12.39
Mean	1.32	1.29	1.33		12.37	12.36	12.39	
Interaction		SE(d) ±	CD (P=0.05)			SE(d) ±	CD (P=0.05)	
(PM × OS)		0.04	NS			0.04	NS	

M_1 – System of Barley Intensification (SBI) technique; M_2 – *Kera* method; M_3 – Furrow Irrigated Raised Bed (FIRB); S_1 – Poultry manure (2 t/ ha); S_2 – Farm yard manure (12 t/ ha); S_3 – *Bokashi manure* (2 t/ ha) (at 25, 35 and 50 DAS); DAS – Days after sowing; NS – Non-significant; S.Ed (±): Standard error of deviation; CD: Critical difference

Conclusion

The findings of two year study of organic barley demonstrate that System of Barley Intensification is more beneficial than other planting methods. The application of farm yard manure has been found to be the best for obtaining higher grain quality percentage of organic barley.

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