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Qualitative response of super basmati rice to different nitrogen levels under varying rice ecosystem

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Planting methods and nitrogen rates play pivotal role in the production and quality of fine grain rice. A field experiment was carried out at Rice Research Institute, Kala Shah Kaku, Pakistan during 2015 and 2016 using four planting methods namely drilling of dry seed in well prepared dry soil (DSR-drill), ridges made after broadcast of dry seed in dry soil (DSR-ridge), broadcast of dry seed in well prepared dry soil (DSR-broadcast), followed by irrigation and Puddled transplanted rice (PTR)-conventional transplanting. Four nitrogen levels viz. N_0: control, N_1: 133 kg N ha^{-1} (recommended), N_2: 166 kg N ha^{-1} and N_3: 199 kg N ha^{-1} were compared for a fine grain rice variety Super basmati. Data were collected on quality parameters namely brown rice (BR) %, total milled rice (TMR) %, head rice (HR) %, average grain length (AGL), length width ratio (LWR), cooked grain length (CGL) mm, bursting (%), elongation ratio (ER), amylose content %, protein content % and grain yield (t ha^{-1}). Results indicated that planting methods behaved the same with respect to the parameters BR %, TMR %, AGL, LWR, amylose and protein content %. However, HR % was the highest in DSR-ridge sowing as compared to other planting methods. AGL, CGL, and ER were more in PTR-conventional transplanting followed by DSR-ridge sowing and bursting % was more in DSR broadcast method. Nitrogen affected positively all the parameters under study up to maximum level of its application. So it can be concluded that PTR-conventional transplanting and DSR ridge sowing with nitrogen at the rate of 199 kg ha^{-1} gave better quality compared to other DSR methods and nitrogen doses.

Key words: Grain quality, Nitrogen levels, rice (*Oryza sativa* L.), sowing methods.

INTRODUCTION

Rice is a staple food of more than half population of the globe. In Pakistan, after wheat, rice (*Oryza sativa* L.) is the second largest cereal crop and an important exportable national commodity. It contributes 3.1% of value addition to agriculture and 0.6% of Gross Domestic Product (GDP). During the fiscal year 2016-17, rice was planted on an area of 2.72 million hectares showing a decline of 0.6% as compared to last year; it production was 6.85 million tonnes that was 0.7% lower than that of the last year (Anonymous, 2017).

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In Asian rice growing countries transplanting the rice seedling manually into puddled soil is most widely adopted method of rice planting but it consumes much water (Bouman and Tuong, 2001). As the water resources are declining thus judicious use of irrigation water has gained a pivotal importance to cope with the water and food needs of rapidly growing human population (Mahajan et al., 2012; Hanjar and Quereshi, 2010). Conventional method of transplanting the rice seedlings in puddled soil not only consumes more water but also involves intensive labour. It needs 25-50 man-days ha^{-1} as compared to direct seeded rice which requires about 5 man-days ha^{-1} (Dawe, 2005; Balasubramanian and Hill, 2002). Scarcity of labour and increasing wages resulting in an increase in cost of production is gradually replacing this conventional planting method with direct rice seeding (Dawe, 2003; Naklang et al., 1996).

With the availability of better quality rice, farmers can get ahead better income, as good quality rice can be priced higher (Maloles, 2008). The rice grain quality is a complicated term; there are many components involved such as appearance, hulling, milling, head rice recovery and protein contents, cooking and eating quality. However, more attention is paid to appearance of rice after cooking than the other properties by the ultimate consumers (Guo et al., 2011). The grain quality is equally important to quantity as it has a vital role in fetching the foreign exchange for Pakistan as indicated from the rice exports of 676,630 million tons pricing 681.55 million dollars in 2015 of basmati exported to over one hundred countries (REAP 2014-15). Quality of rice grain may be affected by several factors such as variety, production, and postharvest practices (Bandonill and Corpuz, 2015). Planting methods not only significantly affect yield, influence health and productivity of soil but also affect the grain quality (Iqbal, 2014; Sanjitha and Jayakiran, 2010). Bandonill and Corpus (2015) reported that transplanted rice had higher brown and head rice recovery than direct seeded rice, but did not find difference in terms of milling recovery. However, direct seeded rice had higher chalkiness and amylose contents as compared to transplanted rice which deteriorate the quality of rice grain.

Nitrogen is integral component of amino acids that are building blocks for protein and its availability in the soil solution and uptake at early growth stage determines the plant growth (Awan et al., 2011). In addition to that it also has impact on the quality of grain particularly of rice through amylose and protein content, grain length and width (Maqsood et al., 2013; Ahmad et al., 2009), cooking / eating quality (Hu-lin et al., 2007; Ya-Jie et al., 2009), milling recovery %, hulling % (Kandil et al., 2010) and head rice % (Saeed Firouzi, 2015). Protein contents become high in rice grains if nitrogen is applied at flowering stage (Perez et al., 1996). Gautam et al. (2008) reported that protein content increased significantly with increased nitrogen dose resulting in improved brown and head rice recovery. This is due to more resistance during the abrasive milling process owing to higher protein content (Cagampang et al., 1966). However, the physical parameters, amylose content and cooking quality decreased with increasing rate of nitrogen application. An appropriate nitrogen rate could lower the amylose content that is good for cooking quality which contributes to improving starch pasting properties (Da-wei et al., 2017). Maqsood et al. (2013) reported that transplanting with higher nitrogen application rates stimulates growth resulting in increased amylose content than direct seeded rice.

Different crop establishment methods have varying plant population, moisture availability conditions and may have different nitrogen requirements. Earlier study reports do not show the effect of varied doses of nitrogen application and different planting techniques on grain quality parameters in rice for Super Basmati. Therefore it is the dire need of today to investigate the quality parameters of rice under different planting methods and varied nitrogen levels.

MATERIALS AND METHODS

The study was conducted at experimental area of Rice Research Institute, Kala Shah Kaku, Pakistan during the year 2015 and 2016. Four rice establishment methods viz. drilling of dry seed in well prepared dry soil by drill (DSR-drill), broadcasting of dry seed in well prepared dry soil (DSR-broadcast), ridge sowing that is ridges made by tractor drawn ridger after broadcasting of dry seed in dry soil (DSR-ridge) and puddled transplanted rice were compared (PTR-conventional transplanting) and four nitrogen levels (viz N_0: Control, N_1:133 kg N ha^{-1}, N_2 166 kg N ha^{-1} and N_3: 199 kg N ha^{-1}) were studied. Randomized complete block design (RCBD), having planting methods in main plots and nitrogen levels in subplots, was used with three replications. The area of the main plot was 486 m^2 (18m × 27m). The physico-chemical characteristics of the experimental soil are given in Table 1. Super basmati rice variety was directly seeded on 14 June in both years. Drilling and broadcasting of dry seed was done in a well prepared dry seed bed. In ridge sowing ridges were made just after broadcasting of the seed on well prepared soil with a tractor drawn ridge. Irrigation was applied just after sowing of the direct seeded treatments and it was repeated 5 days after sowing (DAS) to enhance germination. Seed soaking for 24 h in fungicide (Topsin-M at the rate of 2.5 g kg^{-1} seed) dissolved water was done before sowing. Seed at the rate of 30 kg ha^{-1} was used in case of dry seeded of rice and 15 kg ha^{-1} was used for nursery raising for transplanting an area of one hectare. For weed control in DSR methods, Clover (Bispyribac sodium) 20% SC at the rate of 250 g ha^{-1} was sprayed at 20 days after seeding at saturated soil condition. The spray of Clover was repeated at 38 days after seeding as weeds again germinated in the field. Traditional rice transplanting was done on 18 July in each year with 9 inches row to row distance. Thirty days old rice nursery plants were used for transplantation in both years. Weed control in transplanted method was done by applying Butachlor 60% EC weedicide at the rate of 2000 ml ha^{-1} at 5 days after transplanting (DAT) in standing water with shaker bottle. Phosphate and Potash were used at the rate of 85 and 62 kg ha^{-1} respectively. All phosphorus and potash and 1/3rd nitrogen were applied as basal dose at the time of land preparation. Remaining 2/3rd of N was applied in two splits at 35 and 55 days after transplanting or seeding. In case of transplanting methods, continuous flooding of

Table 1. Physico-chemical properties of experimental field.

Parameter	Soil depth	
	0-6 inch	6-12 inch
EC (dS m^{-1})	1.40	0.93
Soil pH	8.19	8.05
Organic matter (%)	0.45	0.27
Nitrogen (%)	0.42	0.21
Available P (ppm)	5.1	4.95
Available K (ppm)	87	69
Saturation (%)	36	32
Texture	Clay loam	Clay loam
SAR (m mol $L^{-1})^{1/2}$	7.27	7.18

water was done for 30 DAT and after that irrigation was applied at about one week interval. Whereas, irrigation to direct sown rice was applied almost at 5-7 days interval till the crop matured. Other agronomic practices were same for all the treatments under study. For insects and disease control, recommended measures were adopted to save the crop from their ill effects. The crop was harvested at full physiological maturity, sun dried for 3 days and threshed manually.

Quality parameters

For the quality parameters, initially paddy samples taken from the field were sun dried and then drying was done on laboratory test dryer made by STAKE Japan, to reduce the moisture percentage up to required level for milling, that is, 12.0%.

De-husking the paddy and polishing the rice grains

Paddy samples were husked using SATAKE husking machine model No. THU-35 made by SATAKE Incorporation Tokyo, Japan. Whitening of husked rice was done for 35 s under 1 kg pressure by Seed Buro Whitening Mill (McGill Mill number 3) made by Seed Buro Incorporation, USA.

Measurement of Physical parameters

Rice grain length, width and thickness of 25 grains was measured by a dial gauge micrometer, provided and calibrated by Pakistan Council for Scientific and Industrial Research (PCSIR) Laboratory, Lahore and after that average was taken.

Amylose and protein were determined by Near Infra-Red Transmittance (NIRT) auto analyzer made by Kett Incorporation Japan No. AN 900 version 1.13. For internal calibration purpose, before analyzing unknown samples, there were determined reference samples of Basmati group and Non-Basmati long grain group. After measurement of values of amylose and protein of known reference samples on auto analyzer, experimental samples under study were determined for the amylose and protein content in the grains.

Statistical analysis

Statistical analysis of recorded parameters was carried out using the Statistix version 8.1 and MS Excel 2016.

RESULTS AND DISCUSSION

Brown rice (BR) %

In both years under study non-significant effect of crop establishing methods was found on brown rice (BR) %. These findings are in agreement with those of Yadav et al. (2014) who investigated five different crop establishment methods in Philippines and came with likewise findings and observed non-significant effect. Maximum BR (%) was found in the treatment DSR-ridge sowing and lowest in DSR-broadcast (Figures 1 and 3). This might be due to more retention of water in ridges facilitating higher availability of water throughout growing season and might be associated to more nutrient availability that promoted healthier grain formation. However, for nitrogen rates (Figures 1 and 3), BR (%) increased with increased nitrogen doses and maximum was observed at 199 kg N ha^{-1}. Nitrogen might have promoted more assimilate accumulation and probably led to lower husk formation. These findings coincide with those of Da-wei et al. (2017) who studied seven different nitrogen levels for two soft Japonica rice cultivars in China and found highest BR (%) value with maximum level of nitrogen application (337.5 N kg ha^{-1}). In case of interaction of both parameters (Table 2), maximum value was seen in DSR-ridge sowing with maximum nitrogen dose (199 kg ha^{-1}) and minimum value in DSR-broadcast along with no nitrogen application. Similar trend was found in the results of 2016 (Table 4).

Total Milled Rice (TMR) %

During 2015 and 2016 (Figures 1 and 3), total milled rice (TMR) % was found non-significant for different crop establishing techniques and more TMR % was found in DSR- ridge sowing in comparison with the other crop establishing methods; lowest TMR value was noted in PTR-conventional transplanting. The research outcomes agrees with those of Yadav et al. (2014) who investigated non-significant effect of establishing techniques in a different location of Philippines. Among the different nitrogen levels, TMR % increased with the gradual increment of nitrogen and highest value was recorded for the treatment where 199 kg N ha^{-1} was applied and lowest in those ones receiving no nitrogen at all. Similar findings are reported by Da-wei et al. (2017) who investigated TMR (%) is higher in the plots receiving 337.5 kg N ha^{-1}. While studying the interaction of the factors (Table 3), both year results revealed that DSR-ridge sowing with maximum dose of nitrogen application (199 kg N ha^{-1}) resulted in highest milling recovery and bottle rank was occupied by PTR-conventional transplanting along with no nitrogen application (Table 3

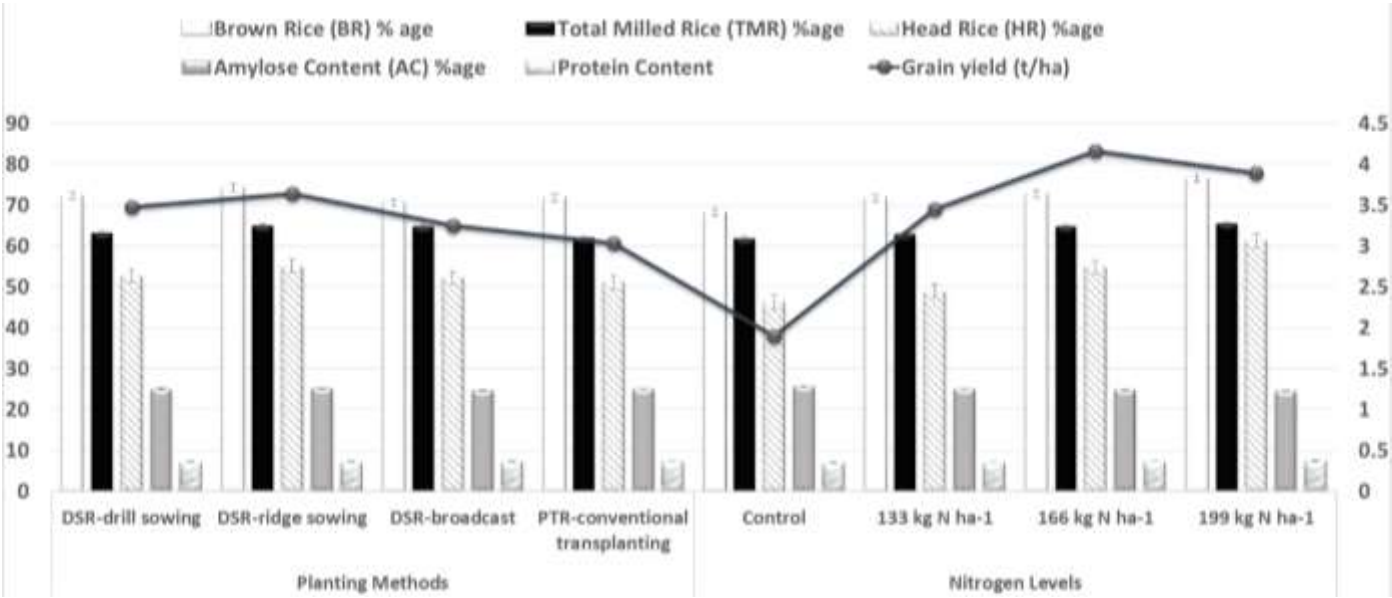

Figure 1. Effect of planting methods and nitrogen levels on grain yield and grain quality parameters of Super Basmati during 2015

and 5).

Head Rice (HR) %

Significantly higher HR % was recorded in DSR-ridge sowing as compared to other methods of rice establishment and minimum HR % was observed with PTR-conventional transplanting in both years (Figures 1 and 3). This might be due to the better performance of rice crop on that resulted into healthier grain, reducing breakage, more brown rice %, higher total milled rice % and at last giving high HR %. These observations are in conformity with those of Zein El-Din et al. (2008) who also found similar behavior of different planting methods on the head rice recovery of rice and found more head rice in DSR sown crop as compared to transplanting in ecological zone of Egypt. For nitrogen (Figures 1 and 3), maximum HR % was recorded with maximum dose of nitrogen (199 kg N ha^{-1}) and lowest value was seen in case of zero nitrogen application. The reason behind this might be that highest nitrogen rate enhanced vegetative growth producing more assimilates which could be utilized during grain formation stage. This led to healthier grains that resisted mechanical injury during milling ultimately resulting in higher HR %. Rice crop in the plots receiving nitrogen below the optimum level remained under fed producing relatively weaker grains more vulnerable to breakage. These findings are quite similar to those of Da-wei et al. (2017) who found maximum HR (%) at 337 kg N ha^{-1}. This is because of the reason that the gliadin content in rice grains is increased with the enhancement of nitrogen dose. In case of interaction highest value of this parameter (63.00 and 50.67) was observed in DSR-ridge sowing with nitrogen rate 199 kg ha^{-1} and lowest recorded (44.44 and 39.68) in PTR-conventional transplanting having no nitrogen application in 2015 and 2016 respectively.

Average grain length (AGL) mm

The AGL varied significantly from 7.47 to 7.55 mm (Figure 2) in all of the planting methods and the maximum value was observed in PTR-conventional transplanting and minimum in DSR- broadcast. However in the second year similar behavior was seen with non-significant effect (Figure 4). Such kind of results is also reported by Maqsood et al. (2013) who studied two planting methods dry seeded rice and transplanted rice by maintaining five different nitrogen levels in each and found more AGL in transplanted rice than DSR. These results are also supported by Ahmad et al. (2009) who maintained different plant population under this experimentation and noted higher AGL in transplanting than dry seeded rice crop. Different nitrogen levels significantly affected average grain length in both years (Figures 2 and 4). It was observed that increasing rates of nitrogen have more average grain length than the control. These findings are quite similar to those of Guatam et al. (2008) who investigated three nitrogen levels using three varieties and three plant spacing; they found maximum length where nitrogen was applied at the rate of 160 kg ha^{-1}. For the interaction (Tables 3 and 5), maximum AGL (7.73 and 7.63 mm) was recorded in PTR-conventional transplanting along with nitrogen dose of 199 kg N ha^{-1} and minimum

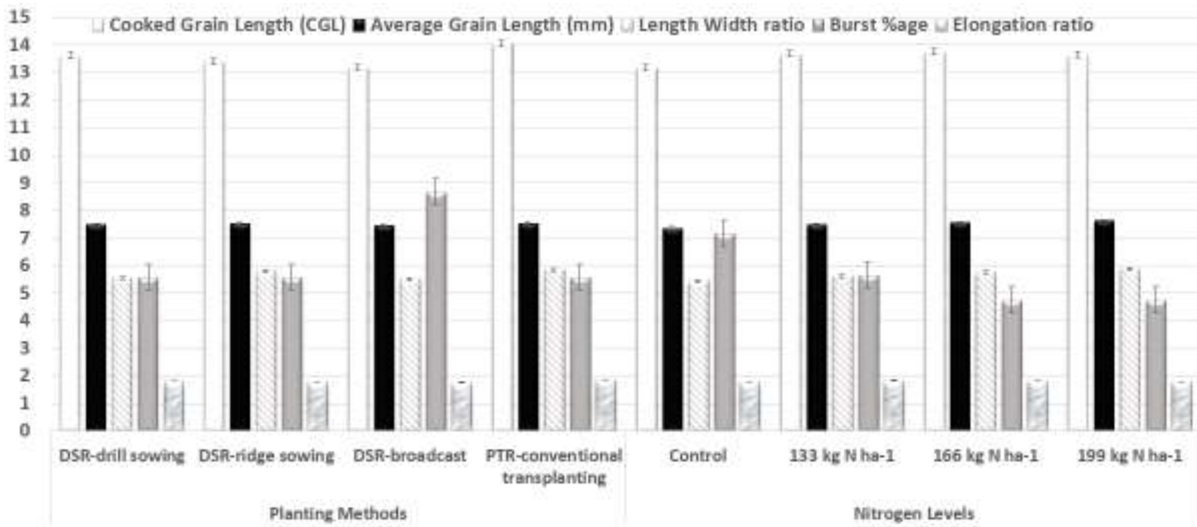

Figure 2. Effect of planting methods and nitrogen levels on grain quality traits of Super Basmati during 2015.

Table 2. Analysis of variance of different quality traits 2015.

Characters	MS (Rep.)	MS (Pm)	MS Error (Rep*Pm)	MS N Levels	MS Error (pm*nl)	MS Error (Rep*pm*nl)	CV (Rep*Pm)	CV (Rep*Pm*nl)
Brown Rice (BR) %	35.380	27.607	44.821	138.007	10.691	27.760	9.27	7.29
Total Milled Rice (TMR) %	87.3023	24.7146	20.1116	33.1400	1.3219	15.2754	7.05	6.14
Head Rice (HR) %	5.206	34.695	7.858	533.093	8.366	28.641	5.31	10.13
Average Grain Length (AGL) mm	0.00334	0.01629	0.00308	0.16031	0.00485	0.00143	0.74	0.50
Average Grain width (AGW) mm	0.13266	0.01936	0.00760	0.00801	0.00026	0.00103	6.57	2.42
Length Width ratio	2.04413	0.31727	0.12040	0.43533	0.00867	0.01985	6.12	2.49
Cooked Grain Length (CGL) mm	0.75724	1.67464	0.24682	0.84325	0.04227	0.16387	3.66	2.98
Bursting %	0.0208	52.7778	0.3819	15.6111	1.3148	1.0972	11.07	18.76
Elongation ratio	0.01069	0.02336	0.00420	0.00500	0.00084	0.00308	3.59	3.07
Amylose Content (AC) %	5.93453	0.72815	2.39964	3.25495	0.28278	2.09024	6.22	5.81
Protein Content (PC) %	0.16673	0.05732	0.05645	0.31763	0.03145	0.13185	3.27	5.00
Grain yield (tons/ha)	0.7186	0.8269	0.1877	12.1677	0.2996	0.1426	12.92	16.51

Table 3. Interactive effect of planting methods and nitrogen levels on rice grain quality for the year 2015.

Treatment	Brown Rice (BR) %	Total Milled Rice (TMR) %	Head Rice (HR) %	Average Grain Length (AGL) mm	Length Width ratio	Cooked Grain Length (CGL) mm	Bursting %	Elongation ratio	Amylose Content %	Protein Content %	Grain yield (tons/ha)
P1N0	68.650	60.757	45.773	7.35	5.39	13.200	6.000	1.797	25.517	7.050	2.01
P1N1	72.583	61.750	48.667	7.43	5.47	13.867	5.000	1.863	25.300	7.150	3.50
P1N2	72.880	64.827	55.607	7.56	5.62	13.717	4.000	1.813	54.983	7.350	4.33
P1N3	75.383	65.047	60.793	7.60	5.69	13.667	3.667	1.797	24.250	7.367	4.05
P2N0	73.110	63.777	47.457	7.44	5.57	13.150	5.333	1.779	25.750	7.017	2.45
P2N1	73.250	64.167	51.553	7.52	5.72	13.400	3.667	1.783	24.990	7.150	3.45
P2N2	73.333	65.167	58.667	7.57	5.86	13.633	3.667	1.800	24.900	7.207	4.45
P2N3	77.063	66.220	63.000	7.64	5.99	13.467	3.333	1.763	24.817	7.450	4.21
P3N0	63.150	62.260	47.407	7.34	5.26	12.833	9.667	1.745	25.813	7.100	1.65
P3N1	70.237	64.777	50.000	7.44	5.41	13.367	9.000	1.797	24.200	7.200	3.73
P3N2	72.083	65.463	52.443	7.56	5.66	13.300	7.333	1.760	24.180	7.300	3.60
P3N3	76.667	66.250	59.283	7.58	5.74	13.233	8.667	1.747	24.000	7.433	4.05
P4N0	67.947	59.983	44.443	7.34	5.55	13.517	7.667	1.843	25.350	7.050	1.51
P4N1	70.280	60.427	45.470	7.56	5.80	14.117	5.000	1.867	25.083	7.283	3.11
P4N2	72.393	63.137	52.650	7.58	5.88	14.367	4.000	1.897	24.717	7.550	3.11
P4N3	76.667	63.673	61.960	7.73	6.10	14.250	3.333	1.840	24.450	7.567	3.25
	*	Ns	*	*	*	*	*	*	Ns	Ns	*
SE	4.6206	3.3151	3.9535	0.0350	0.1732	0.3508	0.0.7825	0.473	1.2021	0.2745	0.3203
LSD 0.05	10.156	7.2292	8.2865	0.0778	0.4018	0.7690	1.6461	0.1033	2.6085	0.5796	0.6985

P1= DSR-drill sowing; P2= DSR-ridge sowing; P3=DSR-broadcast; P4= PTR- conventional transplanting; N0=Control; N1=133 kg N ha^{-1}; N2= 166 kg N ha^{-}1; N3=199 kg N ha^{-}1; ns= Non-significant; *= Significant at P< 0.05.

(7.34 and 7.35 mm) in DSR-drill sowing and DSR-broadcast in 2015 and 2016 respectively.

Length width ratio (LWR)

The length width ratio (LWR) did not vary significantly among different planting methods during both years under study (Figures 2 and 4). However, in 2015 highest LWR (5.83) was recorded in PTR-conventional transplanting, DSR-ridge (5.79) and minimum (5.52) in DSR-broadcast. The results are similar to those of Naresh et al. (2014) who investigated eight sowing techniques and observed that transplanted rice had better LWR as compared to all direct seeding techniques. Varying nitrogen levels were also affected LWR in both years (Figures 2 and 4). Increasing rates of nitrogen enhanced LWR over the control. In 2015, maximum LWR (5.88) was noted in the treatment having 199 kg N ha^{-1} whereas minimum (5.44) was observed in control. These findings are in line with that of Ya-Jie et al. (2009) who studied two varieties Zhonghan 3 and Yangjing 9538 and three nitrogen levels viz. low (100 kg N ha^{-1}), normal (200 kg N ha^{-1}) and high (300 kg N ha^{-1}) in China. They recorded maximum LWR for variety Yangjing 9538 cultivated under both dry and moist cultivation methods at nitrogen level of 200 kg ha^{-1}. These results are also confirmed by Singh et al. (2011) who maintained four nitrogen levels for three rice cultivars under this experimentation in India. He found that nitrogen has positive role in the LWR and its highest value was recorded in the treatment with maximum nitrogen level (60 kg $ha^{-1)}$. For the interaction (Tables 3 and 5), maximum LWR (6.10) was recorded in PTR-recommended conventional transplanting along with 199 kg N ha^{-1} and minimum (5.26) receiving no nitrogen.

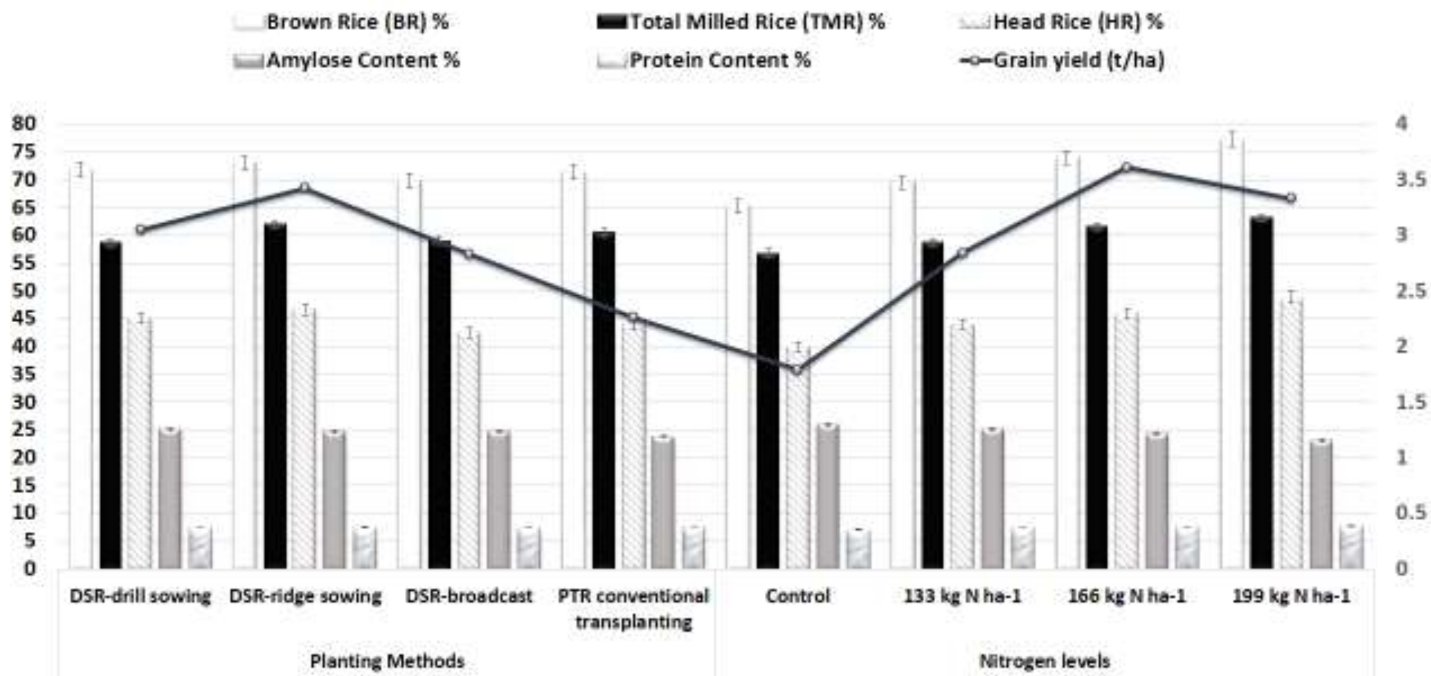

Figure 3. Effect of planting methods and nitrogen levels on grain yield and grain quality parameters of Super Basmati during 2016.

Table 4. Analysis of Variance 2016.

Characters	MS (Rep.)	MS (Pm)	MS Error (Rep*Pm)	MS N Levels	MS Error (pm*nl)	MS Error (Rep*pm*nl)	CV (Rep*Pm)	CV (Rep*Pm*nl)
Brown Rice (BR) %	105.943	20.740	49.354	332.622	3.819	25.163	9.83	7.02
Total Milled Rice (TMR) %	5.6262	27.5775	27.6070	96.5978	8.2505	29.2957	8.76	9.02
Head Rice (HR) %	3.461	36.918	10.775	171.739	3.142	28.161	7.36	11.89
Average Grain Length (AGL) mm	0.00930	0.01619	0.01886	0.08308	0.00205	0.01986	1.83	1.88
Length Width ratio	0.03366	0.62728	0.08324	0.67970	0.01054	0.05777	5.15	4.29
Cooked Grain Length (CGL) mm	0.20146	1.70583	0.17646	0.23139	0.27639	0.42326	3.20	4.96
Bursting %	0.4375	18.7431	1.6597	7.4097	0.1505	1.7153	19.63	19.96
Elongation ratio	0.00250	0.02193	0.00223	0.00565	0.00481	0.01005	2.70	5.73
Amylose Content (AC) %	2.0626	3.5201	0.4803	16.4073	0.4572	0.9635	2.82	4.00
Protein Content (PC) %	0.10974	0.08783	0.07793	0.98172	0.06190	0.07644	3.75	3.71
Grain yield (tons/ha)	0.00028	2.80917	0.06838	7.68542	0.18020	0.03058	9.05	6.05

Table 5. Interactive effect of planting methods and nitrogen levels on rice grain quality for the year 2016.

Treatment	Brown Rice (BR) %	Total Milled Rice (TMR) %	Head Rice (HR)	Average Grain Length (AGL) mm	Length Width ratio	Cooked Grain Length (CGL) mm	Burst %	Elongation ratio	Amylose Content (AC) %	Protein Content (PC) %	Grain yield (tons/ha)
P1N0	65.910	56.903	40.383	7.42	5.213	12.833	7.333	1.727	26.483	7.100	1.86
P1N1	69.800	57.607	44.333	7.43	5.383	13567	7.000	1.827	25.683	7.400	3.19
P1N2	75.053	59.300	45.760	7.50	5.583	13.133	6.667	1.750	24.450	7.500	3.58
P1N3	76.500	60.617	50.220	7.59	5.853	12.967	5.667	1.707	23.500	7.600	3.56
P2N0	66.000	60.000	40.667	7.44	5.450	13.033	7.000	1.753	26.183	7.000	1.95
P2N1	70.667	60.667	47.333	7.46	5.573	13.267	6.333	1.780	25.467	7.283	3.26
P2N2	75.610	62.807	48.080	7.57	5.793	13.400	5.667	1.767	24.183	7.633	4.33
P2N3	79.607	64.153	50.667	7.61	5.830	13.700	5.000	1.800	22.850	7.800	4.13
P3N0	63.883	52.763	38.600	7.35	5.060	12.267	9.333	1.670	25.717	7.033	1.86
P3N1	68.513	58.687	40.193	7.41	5.247	12.700	8.667	1.713	24.700	7.250	2.78
P3N2	70.200	60.423	44.230	7.53	5.447	13.100	7.667	1.737	24.917	7.550	3.54
P3N3	76.573	64.000	47.113	7.59	5.693	12.333	7.333	1.627	23.750	7.773	3.16
P4N0	65.027	57.333	39.683	7.47	5.607	13.633	6.333	1.827	24.933	7.100	1.47
P4N1	69.097	57.693	43.700	7.54	5.853	13.467	5.333	1.787	24.533	7.550	2.13
P4N2	75.140	63.327	45.520	7.58	5.957	13.233	5.000	1.743	23.300	7.800	2.98
P4N3	76.420	63.660	47.383	7.63	6.170	13.433	4.667	1.763	22.367	7.850	2.46
	*	*	*	*	*	*	*	*	*	*	*
SE	4.5615	4.3874	3.9845	0.1143	0.2068	0.4910	1.0650	0.0735	0.7495	0.2263	0.1634
LSD 0.05	10.105	9.4568	8.3962	0.2465	0.4525	1.0362	2.2976	0.1536	0.4890	73.249	0.3639

P1= DSR-drill sowing; P2= DSR-ridge sowing; P3=DSR-broadcast; P4= PTR- conventional transplanting; N0=Control; N1=133 kg N ha^{-1}; N2= 166 kg N ha-1; N3=199 kg N ha-1; ns= Non-significant; *= Significant at P< 0.05.

Similar trend was observed in 2016 (Table 5).

Cooked grain Length (CGL) mm

PTR-conventional transplanting produced best cooked grain length (CGL) (14.06 mm and 13.44 mm) and minimum CGL (13.18 mm and 12.60 mm) was seen in DSR-broadcast in 2015 and 2016 respectively (Figures 2 and 4). Ali et al. (2012) reported the same and recorded maximum CGL (14.4 mm) in transplanting in puddled soil as compared to broadcast of pre-germinated seed in wet puddled soil (13.8 mm) in Pakistan. Whereas for nitrogen application best CGL (13.75 mm and 13.25 mm) was observed at 166 kg N ha^{-1} in 2015 and 2016 respectively and CGL decreased with further increase of nitrogen. For the interaction (Table 3) best CGL was noted in PTR-conventional transplanting (14.36 mm) with nitrogen application of 166 kg ha^{-1} and minimum CGL (12.83 mm) was seen in DSR-broadcast along with zero nitrogen level in 2015; similar trend was recorded in 2016 (Table 5).

Bursting %

In 2015 (Figures 2 and 4), DSR-broadcast gave maximum bursting % whereas PTR-conventional

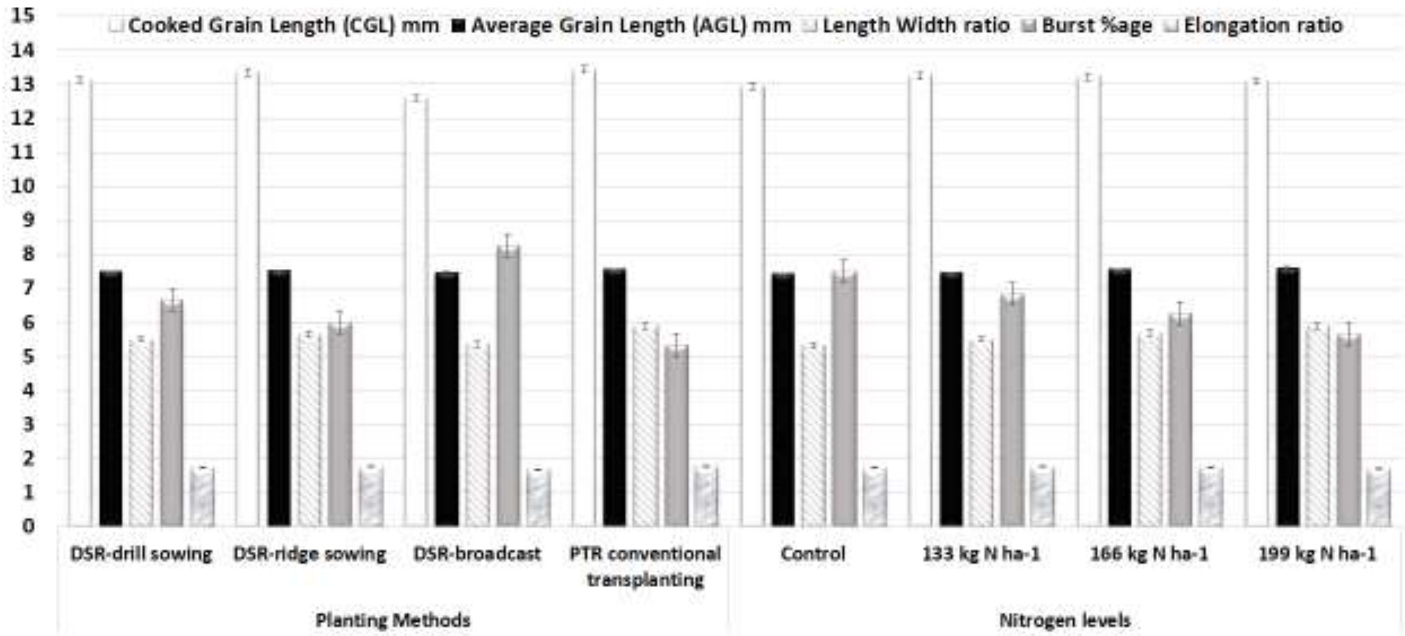

Figure 4. Effect of planting methods and nitrogen levels on grain quality traits of Super Basmati during 2016

transplanting had lower bursting. This might be due to more nitrogen uptake in transplanted rice and ultimately leading to more protein content that increased compactness and resisted bursting at high temperature while boiling. Ali et al. (2012) also found lower bursting in rice crop established through seedling transplanting as compared to broadcast of pre-germinated seed in wet puddled soil in Pakistan. However for different doses of nitrogen, bursting decreased with its increments. Maximum bursting was recorded in the plots where no nitrogen was applied and at 199 kg N ha^{-1} level minimum bursting was recorded. This can be strengthened by the argument that grain developed with maximum nitrogen level might be thick having higher protein content than resisted bursting. For the interaction (Table 3), highest bursting (9.67 %) was seen in DSR-Broadcast with no nitrogen application. On the other hand, lower was found in PTR-conventional transplanting (3.33 %) and DSR-ridge sowing (3.33 %) with nitrogen application of 199 kg ha^{-1}. Similar results were found in 2016 (Table 5).

Elongation ratio (ER)

The ER varied significantly among different planting methods during both years under study (Figures 2 and 4). In 2015, higher ER was recorded in PTR-conventional transplanting (1.86), DSR-drill sowing (1.82) and DSR-ridge sowing (1.78) whereas minimum (1.76) was in DSR-broadcast. The ER was maximum in case of 133 kg N ha^{-1} and below and above that level ER decreased. Among different nitrogen treatments, maximum ER (1.90) was recorded in PTR-conventional transplanting along with nitrogen rate of 166 kg N ha^{-1} and minimum in DSR-broadcast (1.74) with no nitrogen.

Amylose content (%)

Amylose content is among the important physicochemical parameters that determine the quality of cooked rice. Amylose content differed significantly among different planting methods during 2016. The DSR-planted rice through drill sowing consistently had higher amylose content (25.03%) compared with PTR- conventional transplanted rice (23.78%). These finding are in accordance with that of Ya-Jie et al. (2009) who studied dry and moist cultivation methods for upland and lowland rice receiving different doses of nitrogen fertilizer and found more amylose content in dry cultivation than moist cultivation. In case of nitrogen application, the amylose content declined with the increment of nitrogen fertilizer. This might be due to the enhanced photosynthetic activity affecting negatively amylose content and boosting the other parameters. Hu-lin et al. (2007) maintained three nitrogen levels for two cultivation methods in their study and found that amylose content decreased when nitrogen dose was enhanced. From the interaction of both factors, it was revealed that DSR-drill sown crop receiving no nitrogen gave highest amylose content in the grains whereas lowest value was recorded in the transplanted rice with 166 kg N ha^{-1}. Similar findings were in 2015 for nitrogen application whilst for the planting method and interaction non-significant effect was recorded.

Protein content (%)

Different planting methods have non-significant effect on the protein content in the grains during both years though PTR-conventional transplanting produced more protein content in the rice grains as compared to the other three treatments of DSR sown crop consistently in both years. This is because of the reason that in standing water position, plant takes nutrients more efficiently especially nitrogen, integral part of the amino acid and protein and eventually resulted in higher protein content. These findings are confirmed by Maqsood et al. (2013). On the other hand, during 2016 highest protein content was found where nitrogen was applied at the rate of 199 kg N ha^{-1} and minimum value was noted where no nitrogen was applied. The reason for declining of protein content at higher rates seems to be higher vegetative growth and less photosynthate assimilation in the grains, ultimately lowering protein content. Findings match those of Hu-lin et al. (2007); Ya-Jie et al. 2009) and Kandil et al. (2010) and found that nitrogen increases the protein content in rice grains. For the interaction maximum protein content was observed in PTR-recommended conventional transplanting having nitrogen at the rate of 133 kg ha^{-1} and lowest value was recorded in DSR- ridge sowing receiving no nitrogen at all. During 2015 non-significant effect was seen.

Grain yield (t ha^{-1})

Grain yield varied significantly among different planting methods and nitrogen levels during both years (Figures 1 and 3). The maximum biological yield during 2015 was achieved with the planting method of DSR-ridge (3.64 t ha^{-1}) that was statistically similar with drilling of dry seed (DSR-drill) (3.48 t ha^{-1}). Broadcast of seed (DSR-broadcast) in well prepared seed bed produced 3.36 t ha^{-1} that was similar with PTR-conventional transplanting which produced the lowest grain yield of 3.04 t ha^{-1}. For application of different levels of nitrogen, maximum grain yield (4.16 t ha^{-1}) was harvested from the treatment in which N was applied at the rate of 166 kg ha^{-1} and it was statistically similar with the treatment in which maximum dose of N at the rate of 199 kg ha^{-1} was applied (3.89 t ha^{-1}). The lowest grain yield (1.91 t ha^{-1}) was observed in the control treatment receiving no nitrogen. In case of interaction of both the factors under trial (Tables 3 and 5), it was found the highest value for grain yield (4.45 t ha^{-1}) was achieved in the DSR-ridge sowing method of rice cultivation and receiving nitrogen dose at the rate of 166 kg ha^{-1} while lowest yield (1.52 t ha^{-1}) was recorded from the treatment PTR-conventional transplanting along with no nitrogen application. Our outcomes are in agreement with the research studies of Farooq et al. (2008) who observed poor yield in transplanted rice and more in directly sown crop. For nitrogen application, our results are confirmed by Yosef (2013) and Chen et al. (2014) who investigated three nitrogen levels viz 0, 150 and 225 kg N ha^{-1} for different rice cultivars using two establishing methods and found that at 225 kg N ha^{-1} highest yield was found.

Conclusıon

Direct seeded rice is gaining popularity in the agro climatic zones of Pakistan and is replacing the conventional transplanting. Among different crop establishment techniques, DSR ridge sowing produced better milling recovery parameters along with maximum grain yield. Though conventional transplanting exceeded in cooking and chemical traits but it was almost similar with DSR ridge sowing. So, DSR ridge sowing can be best alternative option to conventional transplanting that can be adopted. Nitrogen application at the rate of 199 kg ha^{-1} resulted in good quality parameters over all other applied doses. However, quality traits evaluation of rice was limited by time and space, so there is a need to evaluate multi locations and multi years. There is also a need to measure the grain quality parameter using the DSR along with manual transplanting of rice at different location.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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