Improving grain yield and quality of wheat grown in Haryana (NW India)

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Abstract

Here we report on practices that farmers can adopt as part of an integrated system for enhancing both wheat yield and quality in Haryana, NW India. Data are presented from a large site at the experimental farm of Haryana Agricultural University where wheat was grown in rotation with cotton, pearl millet and cluster bean. The experiments were an evaluation of wheat varieties with time of sowing, conventional tillage and no-till, N fertiliser and irrigation treatments. Varieties C 306 and WH 283, which have good chapatti characteristics (hardness and good grain size), were lower yielding (21 and 5% respectively) than varieties like PBW 343, PBW 502, DBW17 and PBW550. For the sowing times, there was no yield difference between the early and mid-November sowings but December was always lower. Protein was higher with the later sowing and with cluster bean in the rotation. Highest yield and protein was achieved when N-fertiliser was applied in three equal splits. Wheat yield did not differ with sowing method but protein was improved with the wheat sown with no-till. These results are now being used to guide and extend 'best practice' agronomy for optimising both wheat quality and productivity, with the goal of rewards for targeting quality outcomes.

Key Words

Double-crop rotations, sowing time, zero till, split N rates, chapatti quality

Introduction

In Haryana state in NW India, wheat is grown sequentially in an irrigated double-cropping pattern; in SW Haryana it is mostly grown in rotation with cotton, pearl millet and clusterbean, whereas in NE Haryana it is mainly grown in an annual rotation with rice. To date most studies on wheat management in Haryana and neighbouring Punjab have focused on the rice-wheat rotation where issues such as herbicide resistant weeds, tillage management and optimising crop nutrition have been well studied (Hobbs and Gupta 2004). For example, in the rice-wheat production areas farmers have adopted zero tillage of wheat with the area rising from zero in 1997 to 300,000 ha in 2002. Soils with this intensive crop system are often deficient in N and split application systems are recommended for wheat. Most wheat is used for traditional Indian flat bread (chapatti). In this paper, we examine management of varieties, time of sowing, tillage, and N-fertiliser and irrigation management in wheat crops grown with 3 common rotations of SW Haryana, with a view to optimising grain production as well as trying to establish a management protocol that will achieve chapatti quality.

Methods

Three separate experiments with either 3 or 4 replicates were undertaken on the experimental farm (sandy loam texture) of Haryana Agricultural University (Hisar) to evaluate various agronomic practices with wheat (2008-09 winter crop). The wheat crop was sown following one of cotton (*Gossypium hirsutum*), pearl millet (*Pennisetum glaucum*) or cluster bean (*Cyamopsis tetragonoloba*) (all preceding monsoon sown crops were in adjacent blocks, thus a split-plot design).

Wheat varieties and time of sowing

Eight wheat varieties (Table 1) were sown at 3 sowing dates (5th November, 20th November and 5th December 2008) using a 11-tyne seeder and no tillage, with row spacing 18 cm and seed rate 125 kg/ha.

Basal fertilizer was used at 50 kg N/ha, 24 kg P/ha and 25 kg K/ha at seeding and urea was also top dressed twice with100 kg N/ha (? at 22 DAS and ? at 45 DAS) and irrigations were applied at 22, 45, 65, 85, 105, 120 DAS. The plot size was 2.0 x 4.0 m.

Tillage and N rates

Two systems of sowing the wheat, conventional and zero tillage were used in a split arrangement with N-fertiliser rates (Table 3). These were the PK (as above) plus N-fertiliser applied at 3 rates (120:60:30 kg/ha; 150:60:30 kg/ha; 180:60:30 kg/ha). The full amount of PK and 1/3rd of the N-fertiliser was applied as basal at the time of seeding, a second split of 1/3rd N-fertiliser was applied at the first irrigation and the remaining 1/3rd N-fertiliser was applied with the second irrigation.

Nitrogen input and irrigation

Split applications of N and irrigation schedules were evaluated with main plots consisting of 4 irrigation treatments (I1: 3 irrigations -22, 65, 105 DAS; I2: 4 irrigations -22, 45, 85,105 DAS; I3: 5 irrigations - 22, 45, 65, 85,105 DAS, and I4: 6 irrigations - 22, 45, 65, 85,105, 120 DAS). The sub-plot consisted of 4 N schedules (N1: 1/3 basal + 2/3 at 45/65 DAS; N2: 1/3 basal +1/3 at 22 DAS + 1/3 at 65/85 DAS; N3: no basal + ? at 22 DAS + ? at 45/65 DAS; N4: ? basal + ? at 22 DAS.

The variety used was PBW-502 for the latter 2 experiments and planting occurred on 6th November following cotton and cluster bean and 23rd November following pearl millet. At harvesting, crop biomass was recorded before threshing, and after threshing yield was recorded and a random sample was taken to evaluate 1000 grain weight (TGW) and for protein and other quality attributes.

Results

Varieties C 306 and WH 283, which are preferred by some farmers for having good chapatti characteristics, had yield reductions of 21% and 5% compared to PBW-343 (Table 1). There were mostly no difference in grain weight (WH-1025 lowest) and no difference between the varieties in protein. All the varieties had higher yields and protein following cluster bean, and there was no difference between PM-W and C-W rotations in yield and protein (Table 1).

Table 1.Grain yield, TGW and protein for 8 varieties following different rotations.

?	Grain yield (t/ha)			TGW (g)			Protein (%)		
?	C-W[1]	PM-W	CB-W	C-W	PM-W	CB-W	C-W	PM-W	CB-W
DBW-17	4.52	4.54	5.20	42.01	41.45	44.32	9.16	9.17	10.03
PBW-502	4.45	4.60	5.25	43.23	43.67	45.43	8.88	9.15	9.78
PBW-343	4.65	4.56	5.17	43.66	42.34	43.95	8.73	9.28	9.89
PBW-550	4.53	4.66	5.16	42.32	42.21	42.61	9.27	9.31	10.38
WH-283	4.50	4.46	4.79	44.31	43.11	43.89	8.98	9.49	10.04

Raj-3765	4.41	4.38	4.66	43.30	43.83	45.40	9.12	9.25	9.86
C-306	3.79	3.69	3.94	42.92	42.09	44.78	9.11	9.28	9.97
WH-1025	3.83	3.82	3.91	38.75	38.18	40	9.00	9.53	9.68
Variety[2]	0.08			1.02			ns		
Rotation	0.05			0.63			0.17		
VxR	0.12	?	?	ns	?	?	ns	?	?

[1] Rotation: C-W cotton-wheat, PM-W pearl millet-wheat, CB-W cluster bean-wheat; [2] lsd (P<0.05)

TOS1 gave the highest straw DM, except with wheat sown following C-W and, overall, there was less biomass with C-W. There were no differences in yield with TOS 1and 2, and the highest protein was with TOS3, where there was an interaction with CW. All varieties except Raj-3765 had their highest yields at the 2 early sowings (data not shown).

There was an additive response at each N rate with PM-W and CB-W but with C-W there was no difference at the highest rate (N3) compared with N2 (Table 3). Grain yield showed no differences between N2 and N3. With all 3 rotations wheat yield did not differ (P=0.05) with sowing method but protein was improved in each case with the wheat sown with no-till (data not shown).

With each irrigation the 3 way split of N-fertiliser application (treatment N2) gave the highest yield and protein (Table 4). This treatment had N-fertiliser applied at seeding, tillering (22DAS) and first node stage (65/85 DAS). With N application at 22 DAS (treatments N3, N4) included in a 2-way split the yield outcomes were better than where 22 DAS was not included in the split (treatment N1).

Table 2. DM, grain yield and protein for 3 times of sowing (TOS) following different rotations.

TOS	Straw dry matter (kg/ha)			Grain yield (t/ha)			Protein (%)		
	C-W	PM-W	CB-W	C-W	PM-W	CB-W	C-W	PM-W	CB-W
1	5327	5588	7827	4.43	4.36	4.87	8.93	9.10	10.18
2	5167	5187	7308	4.42	4.38	4.87	8.52	9.01	9.63
3	4985	5086	6771	4.15	4.28	4.54	9.65	9.81	10.05
rotation	lsd (P<0.05)		110			0.05			0.17
TOS			110			0.05			0.17

RxTOS	190	?	?	0.86	?	?	0.3

Table 3. DM, grain yield and protein with 3 N rates following different rotations.

?	Rotation	Nitrogen rate		?	lsd	(P<0.05)	
		N1	N2	N3	Rotation	N rate	RxN
Straw DM	C -W	5464	6252	6345	98	139	240
kg/ha	PM -W	5823	6252	6396			
	CB -W	7166	8169	8330	?	?	?
Yield	PM -W	4.49	5.46	5.47	0.08	0.12	0.2
t/ha	C -W	4.74	5.18	5.24			
	CB -W	4.69	5.54	5.61	?	?	?
Protein	PM -W	8.13	8.31	8.41	0.14	0.2	ns
%	C -W	8.46	8.46	8.70			
?	CB -W	8.38	8.39	8.66	?	?	?

There was an interaction with rotation and irrigation, with CB-W more responsive to additional irrigation (Table 5). With protein there was no difference between PM-W and C-W, with both less than CB-W where irrigated (Table 5), but there was an N x Irrigation interaction, with no differences in protein with the N4 treatment (Table 4). There was no response with irrigation in TGW; the only response with TGW was with rotation with CB-W>C-W>PM-W and with hectolitre weight with PM-W>CB-W>C-W.

Table 4. Grain yield and protein with N split-timings of N application and irrigation timing.

?	Irrigation	Nitrogen				lsd (P<0.05)?		
		N1	N2	N3	N4	Irrigation	Nitrogen	IxN
grain yield	I1	4.31	4.72	4.59	4.44	0.1	0.1	ns
t/ha	I2	4.43	4.89	4.69	4.58			

	I3	4.71	5.15	4.91	4.84			
	I4	4.81	5.14	5.11	5.01			
protein	I1	9.10	8.96	9.08	8.56	0.15	0.15	0.3
%	I2	8.77	9.29	8.68	8.74			
	I3	8.83	8.84	8.86	8.64			
?	I4	8.77	8.91	8.69	8.67	?	?	?

Discussion

The optimum yields obtained in these experiments were about 5.5 t/ha and these yields are consistent with a decade-long yield barrier, mostly for the rice-wheat rotation, identified for Haryana and the Punjab (Hobbs et al. 1998). In these experiments grain protein was mostly low, and even though there were responses with extra DM produced with additional N-fertiliser, this did not translate into additional grain yield. Whilst raising the N-fertiliser rate *per se* does not necessarily increase grain yield, delaying of some part of the application of N does result in both higher grain yield and protein. The inclusion of the pulse crop, cluster bean, as the preceding rotation crop has also additively increased yield and protein. It is possible from the results given here to guide ‘best practice' agronomy recommendations for optimising grain yield for these 3 non-rice wheat rotations. This would involve sowing in the first 2 weeks of November, zero-till practice for sowing, N-fertiliser at least at 150kg/ha and this applied as a 3-way split at seeding, tillering and first node in stem elongation. However an overarching aim of the experiments described here was to establish if optimising yield can be maintained plus, at the same time, achieving desirable chapatti quality. High grain hardness is the key measure for realising chapatti quality and, although not measured here, this attribute is likely to be improved with the agronomy package advocated here. Further the variety WH-283, which is a recognised preferred chapatti quality wheat, has not suffered much yield penalty in this experiment. With opportunities for selling better chapatti quality wheat developing with the availability of substantial premiums for such wheat, improving wheat quality should be an on-going and concurrent objective alongside targeting sustainable increases in wheat yield.

Table 5. DM, grain yield, TGW, hectolitre weight (V) and protein with 4 irrigation timings.

Rotation		DM(kg/ha)	Yld t/ha	TGW g	V Kg/ h	Protein%
C-W	I1	5606	4.56	47.47	73.48	8.87
	I2	5724	4.63	48.32	73.33	8.63
	I3	5962	4.86	48.76	73.31	8.65
	I4	6033	4.89	48.86	73.36	8.62

PM-W	I1	4771	4.19	43.32	76.12	8.73
	I2	5122	4.31	44.34	77.10	8.63
	I3	5306	4.51	42.99	76.40	8.54
	I4	5441	4.63	42.68	76.32	8.63
CB-W	I1	6936	4.78	48.93	75.03	9.18
	I2	7108	5.01	50.13	75.62	9.35
	I3	7328	5.34	49.79	74.72	9.19
	I4	7440	5.54	50.56	74.89	9.03
lsd	rotation	85	0.09	0.66	0.31	0.13
(P<0.05)	irrigation	98	0.11	ns	0.35	ns
	RxI	ns	0.17	ns	ns	ns

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