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Research Articles

Agronomic interventions for high seed productivity and quality of wheat (*Triticum aestivum*)

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ABSTRACT

An experiment was carried out at the ICAR- IISS, Mau, Uttar Pradesh, India during winters of 2013-14 and 2014-15, to assess the effect of seed rate on growth, seed yield, yield attributes and seed quality for wheat crop in split plot design (SPD) with three replications. The genotype HD-2733 had significantly higher seed and seedling traits,viz. germination (97.04%), root length (21.64 cm), seedling length (35.54 cm), seedling dry weight (0.208g), vigour index I (3453.8) and vigour index II (20.19). Among the PGRs, the IAA (Indole acetic acid) significantly increased germination (97.11%), root length (22.19 cm), shoot length (14.19cm), seedling length (36.38 cm), seedling dry weight (0.205g), vigour index I (3534.4) and vigour index II (19.95). The seeding rate (75 kg/ha) produced significantly higher tillers/plant at harvest (6.76), enhanced the spikelet/spike (19.33). The variety PBW 502 showed significantly higher number of tillers/plant at harvest and number of tillers /m row length at harvest than HD 2733 and PBW 550. The different seed rates (50, 75, 100 kg/ha) were tested, among the seed rate (75 kg/ha) significantly enhanced biological yield, seed yield and economics of wheat seed production. Among the genotypes, the significantly highest processed seed yield (3.77 t/ha), biological yield (11.08 t/ha) was obtained with PBW 502. Among the PGRs, the IAA significantly increased processed seed yield (3.77 t/ha). Therefore, IAA was found more promising PGR for enhancement of yield potential in wheat crops compared to Gibberellic acid (GA_3). Higher net return (₹ 90×103), B:C ratio (>3.0) were realized in PBW 502 at 75 kg/ha seed rate with use of plant growth hormones.

Key words: Growth hormones, Seed productivity, Seed quality parameters, Seed yield and Yield attributes

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of India and abroad. Area, production and productivity of wheat in India are 30.6 Mha, 98.38 MT and 3216 kg/ha respectively (Anonymous 2018). The massive increase in production of wheat became possible mainly by improved production technologies and varieties (Singh *et al.* 2007). However, national average wheat yield is only 3.12 t/ha. In India, wheat production has to be enhanced upto 109 MT by 2025 AD from the present level of 92.46 MT. Ensuring timely availability of quality seed to the farmers is one of the potential option to achieve this target. Area coverage under quality seed can be enhanced either through increased production of quality seed or by reducing the seed rate for sowing of wheat.The poor seed replacement rate (32%) for wheat necessitates to effectively reduce seed rate through suitable agro-techniques manipulations. The improved varieties respond well to growth regulators, like auxins and GA, which have shown their effect on several physiological and developmental processes (Swarup *et al.* 2002). However, to our knowledge, the interaction of exogenously applied GA_3 (GA-priming) on endogenous auxins is still not reported adequately. Recommended seed rate for wheat sowing varies from 100 to 120 kg/ha. However, precise sowing with seed drills effectively saves 25-30% of the seed by uniform placement of seeds at proper depth in the soil. Further, if effective tillers/hill could be raised to 3-4 from existing 1-2 through the use of growth regulators, at par yields can be achieved even at half of the recommended seed rate. Hence, a study was conducted to harness maximum seed productivity through adjustment of seed rate and use of growth regulators of newly released varieties in eastern Indo-Gangetic Plains of India.

MATERIALS AND METHODS

An experiment was conducted at the ICAR- IISS, Mau, Uttar Pradesh, during the winter season of 2013-14 and 2014-15, to assess the effect of seed rate on growth, seed yield, yield attributes and seed quality for wheat crop. It was laid out in split plot design (SPD) with three replications.

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There were 27 treatment combinations that comprised of three seed rates (50, 75 and 100 kg/ha) and three genotypes (HD 2733, PBW 550 and PBW 502) in the main plots. In sub-plots, three growth regulators viz. control, 100 ppm GA_3 and 100 ppm IAA were taken. The sandy loam soil of the experimental field had 0.24 and 0.33% organic carbon, 215 and 245 kg/ha available nitrogen, 13.5 and 15.0 kg/ha available phosphorus and 184 and189 kg/ha available potassium with pH 7.7 and 7.9during 2013-14 and 2014-15, respectively. These seeds were thoroughly washed after surface sterilization. After completing the period of priming the seeds were taken out from the container and allowed for shade drying. The recommended dose of NPK fertilizer for wheat crop was 120:60:50:25 kg/ha. Full dose of P, K and $ZnSO_4$ along with half of N were applied as a basal at the time of sowing and remaining N was applied in 2 splits at crown root initiation (CRI) and ear initiation (EI) stages of the crop during the year of experimentation. Wheat varieties were sown manually in rows at 4-5 cm depth on last week of November during both the years. Seed rate was fixed as per treatments (50, 75 and 100 kg/ha) at 22.5 cm row to row spacing. It was harvested in second fortnight of April during both years. The irrigation was scheduled as per standard recommendations. All the other recommended package of practices was adopted during the crop growth period. The field observations were recorded from ten plants in each plot selected randomly and tagged and seed yield was determined by net area basis after boarder rows removed. Processed seed yield was computed based on the data on seed yield and expressed in t/ha. The cost of cultivation and net returns were calculated by taking into account the prevailing cost of inputs, seed price (grain MSP+20% higher) and local market price of straw. Observations on seed quality parameters were observed as per standard procedure (ISTA, 1993). One hundred seeds were put for germination in three replication, using top of the paper method. For determination of the seedling dry weight, ten normal seedlings from each replication of the germinated seeds were selected at randomly and kept for oven drying, overnight at 80°C temperature (ISTA, 1993). All the data were statistically analyzed using the analysis of the variance (ANOVA) technique (Cochran and Cox 1957). The critical differences at 0.05% level of probability were calculated to assess the significance between treatments.

$$\text{Germination \%} = \frac{\text{Number of normally germinated seeds}}{\text{Total number of seeds}} \times 100$$

Seedling length: Root and shoot length of five fresh seedlings was measured in centimeters up to one decimal. Total seedling length was calculated by adding root and shoot length.

Seedling dry weight: The seedlings used for recording were dried in an oven at 103°C$\pm$10°C for 12 hours. Measurement of dried samples was record on an electronic balance upto three decimals in mg.

Vigour Index (I) = Germination percentage×Mean seedling length (cm)

Vigour Index (II) = Germination percentage×Mean seedling dry weight (mg)

Seedling vigour index I = Germination (%)× Mean seedling length (cm)

Seedling vigour index II = Germination (%)× Mean seedling dry weight (mg)

RESULTS AND DISCUSSION

Seed quality traits: The seed quality parameters (Germination percentage, root length, shoot length, seedling length, seedling dry weight, vigour index I and vigour index II) were significantly influenced by seed rate, genotypes and growth regulators (Table 1). Significantly higher ($P \leq 0.05$) germination (97.04%), root length (21.64 cm), seedling length (35.54 cm), seedling dry weight (0.208 g), vigour index I (3453.8) and vigour index II (20.19) were in genotype HD-2733, but the shoot length was not affected by seed rate, genotypes. However the growth regulators (GA_3 and IAA) significantly increased the shoot length over control (Table 1). Among the PGRs, the IAA significantly increased germination (97.11%), root length (22.19 cm), shoot length (14.19 cm), seedling length (36.38 cm), seedling dry weight (0.205 g), vigour index I (3534.4) and vigour index II (19.95) were high compared to other treatments and control. Similarly, the GA_3 was significantly higher for the traits such as seed weight/spike (1.90 g), test weight (35.43 g), number of seed/spike (53.12) and harvest index (36.85) compared to the rest of the treatments. As the seed germination process starts with imbibition of water, reinitiates metabolic processes and emergence of the radicle, PGR play vital role in these processes. The seed germination vigour is basically determined by the ability of the plant embryo within the seed, to resume its metabolic activity in a perfectly normal way (Nonogaki *et al*. 2010). Tetracyclic diterpenes, the Gibberellins (GAs) are essential germination activators (Groot and Karssen 1987). Also the ABA/GA ratio regulates the metabolic transition required for germination, imbibed dormant seeds retain high levels of bioactive ABA (Ali-Rachedi *et al*. 2004). The plant hormones/regulators regulate cell division, growth and differentiation (Hooley, 1994) and also plant hormones can affect different plant activities including seed dormancy and germination (Graeber *et al*. 2012).

Effect on wheat growth and yield attributes: In the present investigation it was clear that the effect of seeding rates was significant for all the growth and yield attributing traits. Seeding rate (75 kg/ha) significantly produced higher tillers/ plant at harvest (6.76), enhanced the spikelet/spike (19.33). Similarly, the lower seed rates 50 kg/ha significantly enhanced spike length (10.55cm), seed weight/spike (1.99 g), number of seed/spike (53.90), but the traits like test weight, did not differ significantly. The present finding is in agreement with Laghari *et al.* (2011) who reported that the higher seed rates leads to more susceptibility to lodging due to tall plants, thus reduced 1000 grain weight and yield and he also reported that, lower seed rates leads to highly vigorous crop growth and produce better yield.Among the

Table 1 Effect of seed rate, genotypes and growth regulators on seed quality parameters of wheat

Treatment	Germination (%)		Root length (cm)		Shoot length (cm)		Seedling length (cm)		Seedling dry weight (g)		Vigour index I		Vigour index II	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Seed rate (kg/ha)														
50 kg/ha	95.78	97.00	21.36	23.24	13.71	14.78	35.06	37.21	0.199	0.207	3365.5	3617.5	19.07	20.1
75 kg/ha	94.48	95.15	20.60	22.46	14.00	14.11	34.60	36.37	0.197	0.203	3277.6	3462.1	18.67	19.3
100 kg/ha	94.74	95.93	20.37	21.89	13.52	13.79	33.89	35.48	0.195	0.201	3217.1	3420.9	18.56	19.3
SEM±	0.53	0.63	0.27	0.38	0.16	0.28	0.31	0.42	0.003	0.003	41.31	56.43	0.30	0.30
LSD (P=0.05)	NS	NS	0.79	1.13	NS	0.84	0.94	1.26	NS	NS	123.86	169.17	NS	NS
Genotypes														
HD 2733	97.04	97.78	21.64	23.35	13.89	14.50	35.54	37.39	0.208	0.214	3453.8	3664.8	20.19	20.99
PBW 550	92.15	94.00	20.02	21.93	13.56	13.99	33.57	35.39	0.184	0.190	3098.9	3342.8	16.96	17.88
PBW 502	95.81	96.30	20.66	22.30	13.77	14.18	34.43	36.29	0.200	0.206	3307.5	3492.9	19.15	19.90
SEM±	0.53	0.635	0.27	0.376	0.16	0.28	0.31	0.42	0.003	0.003	41.31	56.43	0.30	0.30
LSD (P=0.05)	1.57	1.90	0.79	1.13	NS	NS	0.94	1.26	0.009	0.009	123.86	169.17	0.88	0.91
Growth regulators														
Control	91.30	92.63	18.04	20.12	13.08	13.27	31.13	32.90	0.182	0.188	2841.9	3052.6	16.62	17.44
GA3 (100ppm)	96.59	97.37	22.09	23.66	13.95	14.45	36.04	37.96	0.204	0.210	3483.9	3705.1	19.73	20.48
IAA (100ppm)	97.11	98.07	22.19	23.80	14.19	14.96	36.38	38.20	0.205	0.212	3534.4	3742.8	19.95	20.84
SEM±	1.14	1.05	0.84	0.74	0.21	0.31	1.04	1.06	0.005	0.005	136.50	137.21	0.66	0.66
LSD (P=0.05)	3.26	3.00	2.40	2.12	0.59	0.88	2.98	3.03	0.013	0.014	391.52	393.54	1.89	1.90

seed rate (100 kg/ha) significantly produced maximum tillers/m row length at harvest (69.67). The variety PBW 502 has shown significantly higher maximum tillers/plant at harvest than HD 2733 and PBW 550. This result is in agreement with Nizamani *et al.* (2014), who have also reported that different varieties respond differently in growth and yield attributes. Variation in tillers count might be due to differences in genetic makeup of wheat genotypes.

The different genotypes were recorded significant variation for all the traits under study, except for test weight, harvest index and shoot length (Tables 1, 2 and 3).Among the genotypes, PBW-502 was observed with maximum plant height (81.97cm), tillers/plant at harvest (5.85), tillers /m row length at harvest (66.60), spike length (10.69cm), seed weight/spike (2.07g), seeds/ spike (58.76), spikelet/ spike (19.32) compared to other genotypes (Table 1). The differences in plant height amidst various genotypes are in general, due to genetic variance. The genotypes of the wheat respond well to IAA for traits like growth and development contributing traits, yield, yield attributing traits and seed and seedling traits, but few traits like seed weight/spike, test weight, number of seed/spike and harvest index showed lower response with IAA foliar spray than GA_3. Plant growth regulators (PGRs) play crucial role to enhance yield potential of different crops (Nickell (1982) and Bakhsh *et al.* (2011). Among the PGRs, the IAA significantly increase plant height (80.03 cm), enhance the number of tillers/plant at harvest (5.96), number of tillers/m row length at harvest (63.27), spike length (10.43 cm), spikelet/spikes (19.10). PGRs play important roles in the grain filling process of wheat crop and determining the level of proteins, which respond differently to the external environmental stimuli (Bano *et al.* 1993). Gibberellins have been widely reported that regulates the duration of grain filling in crops (Yang *et al.* 2013).

Effect on seed, biological yield and economics: The seeding rates showed significant difference in seed yield (Table 1, 2 and 3). The different seed rates (50,75,100 kg/ha) were tested, among the seed rate (100 kg/ha) significantly enhanced straw yield (7.26t/ha) and biological yield (11.11t/ha) compared to rest of the treatments. The optimum seeding rate is one of key important production factors for higher grain yield and quality crop. Harrison and Beuerlein, 1989 reported that if optimal seeding rates exceed, yield reductions often occur, optimum plant densities vary greatly between areas, climatic conditions, soil, sowing time and varieties. Many researchers were reported that seeding rates significantly affect biological yield, achieved stands, spike number and weight (Ozturk *et al.* 2006).

Among the genotypes, PBW-502 significantly increased processed seed yield (3.77 t/ha) and biological yield (11.08 t/ha). The genotype PBW-550 had produced the highest straw yield (7.05 t/ha) among the genotypes. Harvest index did not differ significantly among different genotypes under study (Table 2). The PBW- 502 performed better with 100 kg/ha seed rates than the HD-2733 and PBW-550. Bairwa *et al.* (2000) reported that grain and straw yields, and N, P

Table 2 Growth and yield attributes of wheat affected by different seed rates, genotypes and growth regulators

Treatment	Plant height (cm) at harvest		No. of tillers/ plant at harvest		No. of tillers/m row length at harvest		Spike length (cm)		Seed weight/spike (g)		Test weight (g)		No. of seeds/ spike		Spikelets/ spike	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Seed rate (kg/ha)																
50 kg/ha	76.19	77.22	5.76	6.76	53.83	70.92	10.55	12.08	1.99	2.10	35.45	38.38	53.90	56.43	18.88	21.01
75 kg/ha	78.03	79.10	5.20	6.24	59.59	61.11	10.21	11.44	1.87	1.99	34.89	37.34	51.85	53.40	19.33	21.92
100 kg/ha	80.86	81.97	5.08	6.16	69.67	56.18	10.03	11.27	1.71	1.83	34.75	36.86	51.03	52.77	18.81	20.89
SEM±	0.99	1.01	0.17	0.17	1.47	1.36	0.10	0.14	0.05	0.05	0.75	0.87	0.75	1.09	0.15	0.17
LSD (P=0.05)	2.94	3.01	0.49	0.51	4.41	4.07	0.29	0.42	0.16	0.16	NS	NS	2.24	3.25	0.46	0.51
Genotypes																
HD 2733	74.83	75.93	5.00	6.04	54.66	55.93	9.51	10.92	1.68	1.80	35.31	37.69	46.39	49.40	19.01	21.40
PBW 550	78.28	79.40	5.19	6.19	61.83	64.19	10.59	11.90	1.82	1.93	34.27	36.74	51.63	53.89	18.69	20.73
PBW 502	81.97	82.96	5.85	6.92	66.60	68.09	10.69	11.97	2.07	2.19	35.51	38.15	58.76	59.32	19.32	21.70
SEM±	0.98	1.01	0.17	0.17	1.47	1.36	0.10	0.14	0.05	0.05	0.75	0.87	0.75	1.09	0.15	0.17
LSD (P=0.05)	2.94	3.01	0.49	0.51	4.41	4.07	0.29	0.42	0.16	0.16	NS	NS	2.24	3.25	0.46	0.51
Growth regulators																
Control	76.79	77.71	4.19	5.23	56.57	59.69	9.98	10.99	1.81	1.92	34.48	36.75	51.02	49.91	18.89	20.40
GA_3(100ppm)	78.26	79.41	5.88	6.92	63.25	63.72	10.39	11.70	1.90	2.01	35.43	38.15	53.12	57.24	19.04	22.05
IAA(100ppm)	80.03	81.17	5.96	7.00	63.27	64.80	10.43	12.09	1.87	1.98	35.18	37.68	52.65	55.46	19.10	21.37
SEM±	0.58	0.61	0.35	0.35	1.37	0.95	0.09	0.20	0.02	0.02	0.17	0.25	0.39	1.35	0.04	0.29
LSD (P=0.05)	1.65	1.76	1.01	1.01	3.91	2.73	0.25	0.56	0.05	0.05	0.50	0.72	1.12	3.88	0.11	0.84

Table 3 Yield and harvest index of wheat affected by different seed rates, genotypes and growth regulators

Treatment	Processed seed yield (t/ha)		Biological yield (t/ha)		Harvest index (HI)		Net return (₹ 10^3/ha)		B:C ratio	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Seed rate (kg/ha)										
50 kg/ha	3.50	3.80	9.67	10.20	36.10	37.19	75.5.	84.5	2.56	3.86
75 kg/ha	4.14	4.31	10.97	11.26	37.85	38.19	93.9	99.0	3.11	4.27
100 kg/ha	3.86	4.12	11.11	11.51	34.58	35.76	84.8	92.6	2.74	3.99
SEM±	1.26	0.90	1.74	1.80	0.94	0.52	3.1	3.5	0.10	0.15
LSD (P≤0.05)	3.77	2.71	5.23	5.38	NS	1.56	7.2	8.1	0.21	0.30
Genotypes										
HD 2733	3.58	3.80	9.79	10.19	36.33	37.18	77.2	83.8	2.55	3.77
PBW 550	3.8.3	40.09	10.89	11.31	35.20	36.14	83.8	92.8	2.77	4.07
PBW 502	4.09	4.34	11.08	11.47	37.01	37.83	92.5	99.9	3.06	4.30
SEM±	1.26	0.90	1.74	1.80	0.94	0.52	3.5	4.6	0.10	0.10
LSD (P≤0.05)	3.77	2.71	5.23	5.38	NS	NS	8.9	9.4	0.29	0.32
Growth regulators										
Control	3.60	3.65	10.19	10.17	35.53	35.97	77.8	79.3	2.57	3.62
GA3(100ppm)	3.94	4.29	10.68	11.28	36.85	37.74	87.5	97.9	2.84	4.19
IAA (100ppm)	3.96	4.32	10.89	11.51	36.16	37.44	88.0	98.9	2.86	4.21
SEM±	0.73	1.30	1.27	2.53	0.23	0.33	3.9	4.6	0.15	0.20
LSD (P≤0.05)	2.10	3.72	3.64	7.27	0.67	0.96	8.8	9.4	0.29	0.40

and K uptake differed within varieties and increased with increased seed rates from normal.

Among the PGRs, the IAA significantly increased processed seed yield (3.77 t/ha), straw yield (6.92 t/ha), biological yield (10.89 t/ha), hence the genotypes of the wheat response well with IAA (Fig. 1 and 2). Therefore, the IAA is the most promising PGR for enhancement of yield potential in wheat crops compared to GA_3. In addition, GAs interacts with other hormones to regulate various metabolic processes in the plants. Plants respond to stress especially water stress and adapt to drought stress through various endogenous hormone levels. Therefore, better plant adaptations are also the reason for higher seed productivity with application of PGR. Maximum net return was obtained from 75 kg/ha seed rate in PBW-502 variety with application of IAA (100 ppm), while the effect of growth regulators (GA_3 and IAA) was statistically at par but significantly higher over control. Similarly highest B:C ratio was obtained from 75 kg/ha seed rate (>3.0) during both the years. Among the varieties PBW-502 had higher B:C ratio. Enhanced profitability is mainly because of higher seed yield.

The optimum seeding rates is the prime requirement for the uniform establishment of various field crops, including wheat. The potential genotypes are required to adapt the vagaries of environment condition possessing the inherent

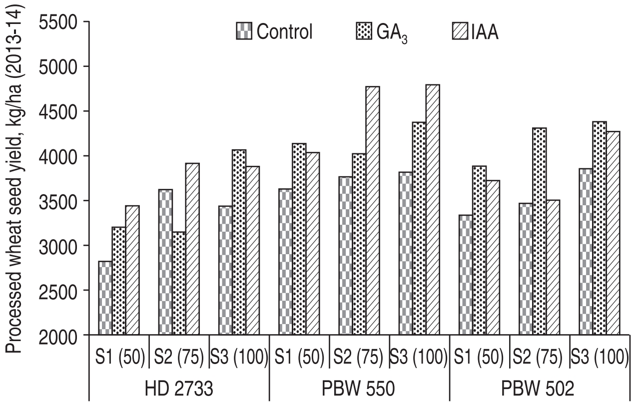

Fig 1. Processed seed yield of different varieties of wheat as influenced by seed rate and growth hormones during 2013-14.

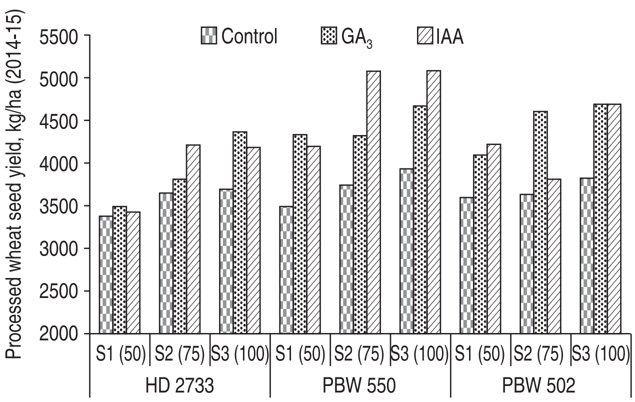

Fig 2. Processed seed yield of different varieties of wheat as influenced by seed rate and growth hormones during 2014-15.

ability to response to any exogenous application. The rationalizing seed rate assists these plant types to respond well to the agronomic manipulations and optimum plant population. Likewise, the application of plant growth regulators aids in improving the seed quality characteristics also. The improved variety (PBW 502) resulted in higher quality seed productivity at optimum seed rate, i.e.75 kg/ha with treatment of PGRs (IAA). Further, higher profitability was also achieved with the use of IAA. This information could be useful where over-use of seeding rates is often practised, which not only increases production costs but may also decrease wheat grain yield.

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