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Evaluation of Comparative Performance of Hydroponically raised wheat nurseries of Varieties DBW-173, DBW-187 and DBW-222

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ABSTRACT

Wheat (Triticum aestivum L.) is the second most important crop after rice in India. Wheat crop is affected by high terminal heat stress. The available varieties does not offer high yields. Disease Infestation at vegetative and growth phase is often observed which affects the yield and hence income of the farmers. Thus development of short duration, heat tolerant, high yielding, and disease resistant varieties is seen as a viable option for preventing yield losses in this region. ICAR-Indian Institute of Wheat and Barley Research, Karnal- Haryana has developed 3 high yielding varieties DBW-173, DBW-187 and DBW-222 which offers yield per acre in the range 24- 27q/acre. These varieties offer resistance to different diseases. Through our research trial we have evaluated the agronomic performance of these high yielding varieties. The trial was conducted at our R&D centre located at, Chidana, Sonipat. The experiment had 3 treatments, Treatment 1 Wheat Nursery of these varieties were raised hydroponically and transplanted in soil. In treatment 2 mycorrizal compost was added while transplantation in soil and in Treatment 3 wheat was sown with traditional broadcasting method. We observed that the highest yield was observed in DBW- 187 follwoed by DBW-222& DBW-173. The results of treatment 1 and 2 were better than treatment 3 in terms of maturity, lodging, disease infestation and crop yield.

1. Introduction

Varieties play a pivotal role in increasing the production and productivity of the heat crop in our country. During the year 2018-19 new varieties of Wheat were released by ICAR-Indian Institute of Wheat and Barley Research, Karnal. New varieties were released / developed keeping in view the limiting availability of resources required for the crop to flourish, without altering the crop yield (FAO, 2016); Kumar *et al.*, 2021; Thapa *et al.,* 2019; Mohan *et al.,* 2020; Bainsla *et al.,* 2018).

Brief description of the varieties selected for the trial
Variety DBW 187 (Karan Vandana)

DBW 187 (Karan Vandana) is a high yielding wheat variety which has been developed by ICAR-Indian Institute of Wheat & Barley Research, Karnal. It was released and notified by the 'Central Sub-Committee on Crop Standard Notification and Release of Varieties for Agricultural Crops' Govt. of India on 01.04.2019 for commercial cultivation under timely sown, irrigated conditions in NEPZ which covers Eastern Uttar Pradesh, Bihar, Jharkhand, West Bengal (excluding hills), Odisha, Assam and plains of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura.

DBW187 has shown over all yield superiority over all the checks, HD 2733, K 0307, DBW 39, K 1006 and HD 2967. The average yield of DBW187 is 48.8q/ha in NEPZ with a potential yield of 64.7q/ha. In agronomic trials under recommended conditions DBW 187 was highest yielder compared to its checks. It showed less yield reduction under late sown condition than the best check DBW 39. It is having desirable plant architecture with robust stem and a large compact spike. DBW 187 is highly resistant to important and prevalent pathotypes of brown rust. It is resistant to most foliar diseases and wheat blast. It also showed high level of adult plant resistance to brown rust (ACI 4.3), yellow rust (ACI 8.9) and black rust (ACI 8.0). Resistance gene Yr^{2+} (yellow rust), Lr10, Lr23 (brown rust resistance) and Sr5, Sr11 (black rust resistance) have been postulated in this variety through multipathotype testing for seedling

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resistance (Gupta *et al*., 2019)

Variety DBW-173

Bread wheat variety DBW 173 was developed at the ICAR-Indian Institute of Wheat and Barley Research, Karnal-Haryana and was released for cultivation by the Central Sub-committee on Crop Standards, on 27th March, 2018 for the irrigated late sown conditions of the North Western Plains Zone of the country. The NWPZ includes states of Punjab, Haryana, Delhi, and Rajasthan (excluding Kota and Udaipur division), western Uttar Pradesh (except Jhansi division), Jammu and Kathua district of Jammu & Kashmir, Paonta Valley and Una district of Himachal Pradesh and Tarai region of Uttarakhand. DBW 173 is an indigenously developed variety.DBW 173 showed average yield of 47.2q/ha and a potential yield of 57.0q/ha. It was significantly superior in yield to the popular check varieties HD 3059 (4.8%) and DBW 90 (4.9%). The variety is having confirmed heat tolerance since it had Heat Susceptibility Index (HSI) of 0.98 during two years of testing in MLHT trial. DBW 173 also performed better in the agronomic trials and was higher yielding than checks under late sown conditions.

It also showed minimum reduction in grain yield, grain number and 1000-gr.wt. under very late sown conditions indicating its better adaptation under late sowing. Among the agro-morphological trails DBW 173 had average days to heading value of 81 with an average of 65-94 days. Similarly, the days to maturity average was 122 with a range of 106-138 days. It had an average plant height of 90 cm with a range of 65-108 cm and average 1000-grains weight of 37 g with a range of 25-43 g (Gupta *et al*., 2019).

Variety DBW-222

Scientists of the Indian Institute of Wheat and Barley Research (IIWBR) have developed DBW-222 high yielding variety, for the areas where the water resourses are declining at an alarming rate. Although the production remains the same with the existing high yielding varieties but these require only 4 cycles of irrigation for cultivation in comparison to six for normal wheat varieties; Days to Maturity – 125-130 days. The DBW-222 produce 45q/ha. This variety is yellow rust resistant (IIWBR, 2019).

Brief Introduction to Hydroponics

Hydroponics is a soil- less agriculture where nutrients required for the plants to flourish are provided directly to the root zone of the plants in the form of liquid nutrient solution. It is a highly efficient technology which saves water (upto 95%), land (as practiced in vertical system), and time (as plant flourishes early due to easy availability of the nutrients). The promotes effective utilisation of natural resources. Raising Wheat nursery through hydroponics saves seed upto 30% and offers yield gain upto 10% , fetching an additional income benefit (Sambo *et al*., 2019). This research paper presents the agronomic evaluation of high yielding Wheat varieties in the environmental conditions of Sonipat Haryana. We have also introduced the Hydroponics factor for ensuring effective utilisation of available natural resources like water, land and seeds.

Experimental details

The field experiment was conducted during Rabi (winter) season of year 2019-2020. In the experiment the Wheat crop of 3 high yielding Wheat varieties DBW-187, DBW-173 & DBW-222 was grown with 3 treatments. Treatment 1 consists of raising Wheat nurseries hydroponically and its transplantation in soil, Treatment 2 consists of rising, Wheat nursery hydroponically and its transplantation in soil with mycorrhizal compost. Treatment 3 involves Wheat cultivation through broadcasting method. The experiment details are as follows:

Experimental Location	R&D Centre , Ayurvet Research Foundation Village – Chidana District- Sonipat Block- Mundlana		
Variety	DBW 187, DBW 222, DBW 173.		
Experimental Area	8550 sq feet (0.2 acre)		
Dimensions (LXB)	114' X 75'		
No. of Plots	27		
Treatments	27 (3 Varieties X 3 Treatments X 3 Replications)		
Experimental design	Paired Comparison		
Analysis Software	OPSTATs		
Treatment 1- Wheat Nursery raised Hydroponically +Nutrient solution used in Hydroponics system + Transplantation in soil			
Date of Soaking	21-12-2019		
Date of putting in APH-360	23-12-2019		
Nursery for Acclimatization	4-1-2020 (12 days)		
Date of transplantation in soil	6-1-2020		
Plot size	316.6 sq ft		
Plots under this treatment	9		
Variety	Trials		
DBW- 173	V1T1R1	V1T1R2	V1T1R3
DBW-187	V2T1R1	V2T1R2	V1T1R3
DBW-222	V3T1R1	V3T1R2	V3T1R3

Treatment 2- Wheat Nursery raised Hydroponically + Hydroponics Nutrient solution + Mycorrizal Compost + Transplantation in soil	
Date of Soaking	21-12-2019
Date of putting in APH-360	23-12-2019
Nursery for Acclimatization	4-1-2020 (12 days)
Date of transplantation in soil	6-1-2020

Plot size	316.6 sq ft		
Plots under this treatment	9		
Mycorrhiza Compost (Dry)	55g mycorrhiza/ plot @ 5-10 Kg / acre		
Variety	Trials		
DBW- 173	V1T2R1	V1T2R2	V1T2R3
DBW-187	V2T2R1	V2T2R2	V1T2R3
DBW-222	V3T2R1	V3T2R2	V3T2R3

Treatment 3- Control (Grown with Standard Practices)			
Date of Sowing	23-12-2019		
Plot size	316.6 sq ft		
Plots under this treatment	9		
Variety	Trials		
DBW- 173	V1T3R1	V1T3R2	V1T3R3
DBW-187	V2T3R1	V2T3R2	V1T3R3
DBW-222	V3T3R1	V3T3R2	V3T3R3

First irrigation was given at the Crown Root initiation stage i.e., 20-25 days after sowing followed by irrigation at late tillering, late jointing, milk and dough stages. Same practices were used for both the treatments. Observations on Growth characters and yield parameters like plant height (cm), number of grains per panicle, panicle length (cm) , plants per square meter, 1000 seed wt (gm) , yield (qt/acre) and number of irrigations were recorded for both the treatments. Data has been analyzed for growth and yield parameters. Paired comparison analysis was done. Analysis was performed using OPStats (HAU) statistical software at 1% level of significance to test the significance of difference among the treatment and control.

Results

Data for growth & Yield parameters was recorded as per the ICAR Standards. The details are as follows:

DBW- 187

Table 1- Comparative analysis for Growth parameters of variety DBW-18**7**

S.No	Parameters	Plant Height (cm)	Plant Thickness(mm)	Spike Length(cm)	No. of Spikelets/ Spike	Lodging %
Treatments – Variety 1						
1.	T_1	98.1±4	5.1±0.2	9±0.6	19±0.4	20
2.	T_2	94±10	4±0.2	9±0.8	18±1	0
3.	T_3	100±3.7	5±0.4	10±0.2	19±0.2	0

Table 2- Comparative analysis for Yield parameters of variety DBW-187

S.No	Parameters	Number of grains/ spikes	Effective number of tillers	1000 seed wt(g)	Biomass/sqm(g)	Yield per acre(kg)
Treatments – Variety 1						
1.	T_1	54.5±1.6	377±5.8	43.4±1.8	1933±57.8	3053±175
2.	T_2	52.5±3	367±6.2	43±1	1390±446.5	2892±243
3.	T_3	56.3±2	368±8	43±1.5	1747±162	2927±243

Discussions

VARIETY 1- DBW 187

In accordance to our experiment conducted at our Experimetal field in Chidana, Sonipat following are the observations on different growth and yield parameters. The experimental details are mentioned above. Average Plant height at maturity was reported to be 98.1 cm in T_1 and 94 in T_2 which were lower than the T_3 (control). There was no significant difference in the height (Table 1). Average Number of tillers in T_1 and T_2 are 13, 13 respectively which were significantly higher than T_3 (12). The treatments have significantly affected the number off tillers per plant. This increase may be being due to use of efficient hydroponically raised Wheat Nursery (Table 1).

Spike length was recorded to be 9, 9.1 in T_1, and T_2 respectively. However, it as 10 in T_3. The treatments have slightly affected the spike length. No significant increase is observed. It was observed that the spike was large and compact (Table 1). 30% lodging as recoded in T_1 and T_2 however no lodging was recoded in T_3. May be this is due to the less strength of the stem or because the plots where the lodging is observed are on the outskirts of the experimental plot (Table 1). Effective number of tillers per square meter found out to be higher in T_1 (377) followed by T_3 (368) and T_2 (367). The average number of tillers per plant lies in standard range i.e., 350-370 per square meter. The treatments have significant effect on the effective number of tillers per sq. m (Table 2).

The yield parameter 1000 seed weight was recorded to be 43.4 and 43 in T_1 and T_2 respectively, which was evidently higher than T_1 (42). This is because the hydroponics nursery was highly nutritive and offers better grain quality (Table 2). The per acre yield was significantly higher in T_1 (3053kg/ acre). This is the calculated yield, which is calculated on the basis of yield per square meter. The yield per acre was recorded as 2892kg/ acre in T_2 and 2927kg/acre in T_3. The yield is on higher side because of use of hydroponics nursery, use of Mycorrhiza as dry compost and other effective crop inputs. As per standard Average yield per acre fall in the range 21q/acre to 27q/acre (Table 2). No significant effect of dry mycorrizal compost was observed. No disease

DBW-173

Table 3- Comparative analysis for Growth parameters of variety DBW-222

S.No	Parameters	Plant Height (cm)	Plant Thickness(mm)	Spike Length(cm)	No. of Spikelets/ Spike	Lodging %
Treatments – Variety 2						
1.	T_1	92±1.5	5±0.3	9±0.5	18±1.2	0
2.	T_2	94±0.8	5±0.2	9±0.2	18±0.2	0
3.	T_3	95±4.2	5±0.6	9±0.2	19±0.5	0

Table 4- Comparative analysis for Yield parameters of variety DBW-222

S.No	Parameters	Number of grains/ spikes	Effective number of tillers	1000 seed wt(g)	Biomass/sqm(g)	Yield per acre(kg)
Treatments – Variety 1						
1.	T_1	52±2	373±4	35±1	1870±61	3020±120
2.	T_2	53±3	379±6	38±2	1733±31	3090±118
3.	T_3	53±3	357±7	36±2	1400±340	2509±227

DBW-222

Table 5- Comparative analysis for Growth parameters of variety DBW-173

S.No	Parameters	Plant Height (cm)	Plant Thickness(mm)	Spike Length(cm)	No. of Spikelets/ Spike	Lodging %
Treatments – Variety 3						
1.	T_1	94±5.7	5±0.3	8±0.1	17±1	0
2.	T_2	96±3.5	5±0.2	8±0.6	18±1	0
3.	T_3	99±2.6	5±0.3	8±0.2	18±1	0

Table 6- Comparative analysis for Yield parameters of variety DBW-173

S.No	Parameters	Number of grains/ spikes	Effective number of tillers	1000 seed wt(g)	Biomass/sqm(g)	Yield per acre(kg)
Treatments – Variety 1						
1.	T_1	54±4	371±5	38±0.4	1827±110	2879±140
2.	T_2	53±7	370±4	38±1.4	1680±72	2874±101
3.	T_3	54±4	372±4	38±0.3	1833±115	2882±61

infestation was observed. No pesticide was used throughout the experiment. No evidence of brown rust/ wheat rust/ foliar diseases/ black rust /yellow rust was seen. The variety is suited for timely sown irrigated conditions. However, it performed well in the late sown conditions because of time decreased at nursery preparation stage. It took 112 days to mature and 101 days for 80% maturity. Dry Mycorrizal compost had significant effect on some of the growth and yield parameters.

VARIETY 2- DBW 222

In accordance to our experiment conducted at our Experimental field in Chidana, Sonipat following are the observations on different growth and yield parameters. The experimental details are mentioned above.

Average plant height was at par in all the 3 treatments. The results were significant; however, It is lower than the standard i.e., 103 (Table 3). Average number of tillers per plant as significantly higher in T_1 (13) followed by T_2 (12) and T_3 (11). The reason mainly is the use of hydroponically raised Wheat nursery in T_1 and T_2.

Spike length in all the treatments is 9 which shows the treatments has no significant effect on the spike length of the experimental crop under study.

Lodging was not observed in any of the plot off this variety because of the strong lodging tolerance tendency of the variety and strong stem strength. No variation in grains per spike was observed as it was same in all the three treatments i.e., T_1 (53), T_2 (53) and T_3 (53). This is evident that the treatments do not have significant effect on the

number of grains per spike (Table 4).

Effective number of tillers per square meter is higher in T_2 (379) as compared to T_1 (373) and T_3 (357). The treatments have shown significant impact on effective number of tillers per square meter.

1000 seed weight was recorded to be highest in T_2 (38) followed by T_3 (35) and T_1 (36) respectively. Grain yield per acre was calculated as per $1m^2$ and is recorded to be 25q/acre in T_3, 3020kg/acre in T_2 and 3090kg/acre in T_1. The reason for higher yield in T_2 and T_1 is evidently the use of hydroponically raised Wheat nursery. However T_2 has some effect of Mycorrizal compost too. The study shows treatments have affected the crop yield significantly.

Disease infestation was not observed. No evidence of stripe and leaf rust, karnal bunt and loose Smut. This shows that the variety offers resistance to the following diseases. It took 112 days to mature and 101 days for 80% maturity. The crop has matured way too early because of the time reduced at the nursery level since hydroponically raised crop nursery was used.

VARIETY 3- DBW 173

In accordance to our experiment conducted at our Experimental field in Chidana, Sonipat following are the observations on different growth and yield parameters. The experimental details are mentioned above. Average plant height at maturity was highest in T_3 (99) as compared to T_1 (94) and T_2 (96). Also, the plant height was in the standard range of the variety i.e., 65-108cm. There was a significant effect of the treatments on the plant height this may be due to the sowing under late conditions (Table 5).

The numbers of tiller per plant was at par in all the three treatment and have come out to be 13 in all the treatments. When analyzed statistically it was evident that the treatments have no significant effect on the number of tillers per plant. Number of grains per spike was recorded to be at par in the three varieties i.e., 54 in T_1, 53 in T_2 and 54 in T_3. The analysis proved that the treatments have no effect on the number of grains per spike.

Effective number of tillers per square meter was recorded to be competitive in all the three treatments i.e., T_1 (371), T_2 (370) and T_3 (372). There is no significant difference in the effective number of tiller (Table 6).

The yield per acre (calculated) was found out to be 2879kg/ acre in T_1, 2874kg/acre in T_2 and 2882 kg/ acre in T_3. There was no significant difference in the yields which shows that the treatments have not affected the crop yield. However, the yield is higher than the standard. The crop is ideal for late sown conditions. Dry Mycorrizal compost does not have any significant effect on growth and yield parameters. The crop of V_1 i.e., DBW-173 had offered complete tolerance to heat as no browning / yellowing of leaves / tip burning was observed in vegetative or growth phase. It took 112 days to mature and 102 days for 80% maturity which falls in the range i.e., 106-138 days. Standard average number of days required for maturity is 122 however our crop has matured early because of use of hydroponically raised wheat nursery.

Conclusion

The performance of all the three varieties was good. Significant difference in most of the growth and yield parameters were observed. According to the results obtained theses varieties i.e., DBW-173, DBW-187 and DBW-222 are superior to the other commonly used heat varieties like HD-3967, HD- 2733, DBW-39 etc. The introduction of hydroponically raised Wheat nursery has significantly affected the crop yield and has made the crop effective even in late sown conditions (as DBW-187 and DBW-222 are timely sown irrigated varieties). Hydroponics technology has also saved water and land at nursery stage. Another positive aspect is the lodging tendency, which makes these three varieties different from the others. During the experimentation no pesticides were used and there was no evidence of any sort of disease infestation in any of the three varieties. Only three irrigations ere provide during the whole crop cycle.

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Declaration of interest statement

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We confirm that the manuscript has been read and approved by all named authors.

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