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Quantification of informal spread of high yielding wheat (*Triticum aestivum*) seeds among farmers of National Capital Region

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ABSTRACT

Over decades, the total wheat (*Triticum aestivum* L.) production of the country has been able to meet the domestic consumption and export considerable amount of it. APEDA reports the export of 2.26 lakh MT of wheat for the worth of ₹424.94 crores/60.55 USD Millions during 2018–19. Further increase in production is only possible through varietal replacement with varieties having higher productivity potential in the existing production area through horizontal spread. Two reputed wheat varieties of ICAR-IARI, viz. HD 2967 and HD 3086 with good nutrient content and resistance as well as tolerance to major fungal diseases were distributed among 572 farmers of two villages of Haryana and western Uttar Pradesh respectively, with predominant rice-wheat cropping cycle to assess their acceptance level over space and time among villagers through assessment trials from winter (*rabi*) season 2014–15 to 2019–20. In selected, Haryana and Uttar Pradesh villages the relative yield advantage of HD 2967 was 21.7% and 19.9%, respectively and of HD 3086 was 17.5% and 14.3%, respectively over the local check. HD 3086 additionally reported bold grain, less lodging and less quality loss in the situation of repeated rainfall in maturity stage. The popularity and acceptance of the varieties were evident by the horizontal spread for HD 2967 i.e. 468.2 ha (Haryana) and 383.2 ha (Uttar Pradesh) from 6 and 6.4 ha, respectively from the winter (*rabi*) season of 2014–15 to 2019–20. The study re-affirms the philosophy of Farmer-to-Farmers spread of modern technologies including the HYV seeds

Keywords: Horizontal spread, Seed diffusion, Wheat

India is one of the main wheat (*Triticum aestivum* L.) producing and consuming countries of the world. The major states that are involved in the cultivation of wheat are those located in the plains like Uttar Pradesh, Punjab, Haryana and Rajasthan. They account for nearly 80% of the total wheat produced in the country (Meena B S 2012). Thus, there is further need to enhance wheat production by adopting improved production practices. Presently, the area under wheat is almost stagnant and there is no scope for horizontal expansion. Thus, there is a need to improve production technologies of the crop and same have to be adopted by the wheat growers to obtain higher level of productivity (Daya *et al.* 2010). Indian Agricultural Research Institute, New Delhi developed wheat varieties, viz. HD 2967 and HD 3086 suitable for cultivation under normal sown irrigated conditions of North Western Plain Zone (NWPZ). The average yield of HD 2967 is 5.1 tonnes/ha while HD 3086 has average yield of 5.46 tonnes/ha. The grains of HD 2967 are amber, medium bold, hard and lustrous with high zinc (46.8 ppm), copper (6.01 ppm), manganese (44.2 ppm), and protein (12.7%) content. The variety HD 2967 is moderately resistant to yellow rust and resistant to brown rust and less susceptible to Karnal bunt and loose smut diseases and takes about 157 days to mature. HD 3086 is resistant to yellow rust and brown rust (Singh *et al.* 2014). In terms of grain quality traits, a number of studies have tested the relationship of variety choice to crop diversity using microeconomic models of farmer decision making and adoption of technology (Marites and Mahabub 2015). The adoption rate and spread of varieties increased, due to their superior agronomic traits like higher yields, higher disease and pest resistance, shorter maturity periods, and better grain quality compared with traditional varieties (Hossain *et al.* 1994). Hence an experiment was conducted to assess the suitability and acceptance among farming community.

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MATERIALS AND METHODS

This research paper is outcome of the institute research project 'Out-scaling of Agricultural Innovations for Enhancing Farm Income' which was carried out from

2014–15 to 2019–20 in two states of North Western Plain Zone (NWPZ), Haryana and Uttar Pradesh. One district from each State, i.e. Palwal in Haryana and Aligarh in Uttar Pradesh was selected. From each district, one village was selected purposively on account of prevailing rice-wheat cropping system. Thus village Khajurka, in district Palwal in Haryana and village Rajpur, in district Aligarh in Uttar Pradesh were selected. At initial stage, participatory exploratory analysis of prevailing agro-eco system was done to understand village profile, existing cropping system and the related parameters. Based on this analysis suitable wheat varieties developed by Indian Agricultural Research Institute, New Delhi were assessed with the objective to analyze the yield advantage, profitability and extent of diffusion of the varieties. The convenience sampling technique was employed to select 572 farmers to conduct assessment trials in their fields. During period of five years, 572 assessment trials on wheat varieties (T2) HD 2967 (302) and HD 3086 (270) were conducted keeping farmers' varieties (T1) as the control. Participating farmers were given the know-how and do-how of all the related technologies and packages to realize the yield potential of these improved wheat varieties in field conditions. The analysis of data was done using quantitative and qualitative methods. The spread of quality seed of each variety was calculated on the basis of respondents feed-back with assumption that 18% and 10% of produce of HD 2967 variety and 15% and 8% of HD 3086 was utilized as quality seed in succeeding two seasons respectively. The year wise total area spread in hectares and total spread of quality seed (q) in and the surrounding villages was calculated. The Area Diffusion Effect (ADE) was calculated using following formula:

$$\text{ADE} = \frac{\text{Total area diffused by quality produce after 5 years}}{\text{Total area covered by actual seed supplied to farmers}}$$

Quality seed diffusion (QSD) was calculated as:

$$\text{QSD} = \frac{\text{Total diffusion of quality produce after 5 years}}{\text{Total quantity of seed supplied and area covered}}$$

Eight focused group discussions (4 in each selected village) were arranged to collect qualitative data to assess farmers' feedback about economic and social acceptance of the improved wheat varieties.

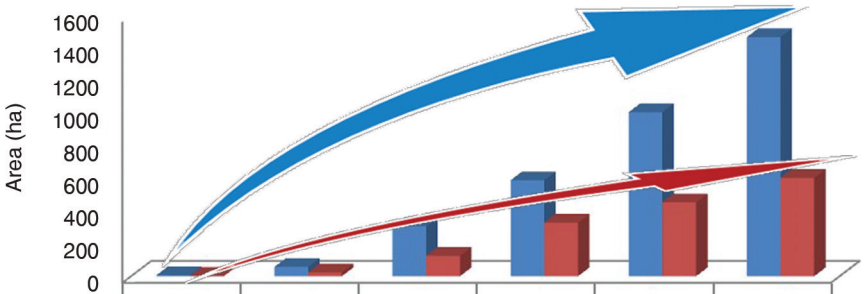
RESULTS AND DISCUSSION

Both the selected villages are located in the North Western Plain Zone (NWPZ) in National Capital Region. Rice-wheat is major cropping system therein and agriculture is the main occupation in both the villages as maximum numbers of households are engaged in farming. The main source of irrigation in these villages are canal water in low lying (*jheel)* areas and tube wells in up lands (*bangar)*areas. Village Khajurka is at the bank of Yamuna Canal and village Rajpur is on bank of Ganga Canal.

Rajpur is small village located in Khair tehsil of Aligarh district, Uttar Pradesh with total of 382 resident families. Rajpur has population of 3070 with male-female sex ratio of 847. In village Rajpur, most of the farmers belong to marginal category (44.50%) followed by small farmer (16.75%) although a sizeable proportion of the villagers are landless and work as labourers. Medium and big farmers constitute 11.78% and 3.93% of the population respectively who either own large agricultural land or have taken large lands on lease for the purpose of farming. Khajurka is village located in Palwal district, Haryana with total 264 resident families. The Khajurka village has population of 1989 of which 1113 are males while 876 are females. Average sex ratio of Khajurka village is 787 which is lower than Haryana state average of 879 and all India average of 943. The total cultivated area of the village is 450 acres. A total of 42.8% of the households are landless, 46.96% are of marginal category. The medium and large holdings are owned by one family for each category.

Before initiation of project interventions, the prevalent wheat varieties in Rajpur were WH 711, PBW 343, PBW 550, PBW 502 and DBW 17. In Khajurka, prevalent varieties were WH 711, PBW 343, HD 2851, HD 2967, PBW 502 and WR 544. In both the villages, WH 711 occupied about 60% of total cropped area. In Khajurka, HD 2967 was adopted by few farmers and covered 2% of total wheat area.

During 2014–15 to 2019–20, a total of 266 and 306 assessment trials were conducted 66.8 ha and 82.4 ha on farmers' fields in village Khajurka and Rajpur respectively. The yield, income and economic performance of the improved varieties were compared with prevailing local varieties. These assessments demonstrated that improved varieties performed better (yield advantages: 14–22%) consistently in comparison to local check. This was evident from relatively CV for both the varieties namely HD 2967 (CV: 7-12) and HD 3086 (CV: 5-8.) were comparable to the local check (CV: 6-10). Both the wheat varieties demonstrated had less lodging during untimely rains which happened at the time of maturity. The average yield of HD



	14–15	15–16	16–17	17–18	18–19	19–20
HD 2967	6	57.6	307.6	589.6	1007.6	468.6
HD 3086	2	23.2	125.7	329.3	453.9	604

Fig 1 Cumulative area wise growth of wheat varieties in village Khajurka, Palwal.

Table 1 Assessment trials from 2014–15 to 2019–20

Variety	Area (ha.)	No. of farmers	Avg. yield of the crop in q/ha		Increase in yield (%)	Avg. net return demo. (₹/ha)	B:C ratio
			demo.	local			
Khajurka, Haryana							
HD 2967	41.6	143	56.6 (56.6+1.62)* [7.02]	46.9 (HD 2851, WH 711, PBW 343) (46.9+1.14)* [5.98]	21.7	73859	2.72
HD 3086	25.2	123	55.79 (55.79+1.07)* [4.73]		19.9	72071	2.7
Rajpur, Uttar Pradesh							
HD 2967	44.8	159	55.08 (55.08+2.64)* [11.77]	45.0 (PBW 343, HD 2967) (45.0+1.82)* [9.93]	17.5	76971	2.86
HD 3086	37.6	147	53.62 (53.62+1.64)* [7.52]		14.3	74712	2.85
	Location	*2014–15*	*2015–16*	*2016–17*	*2017–18*	*2018–19*	*2019–20*
Estimated area spread (ha)							
HD 2967	Khajurka	6	51.6	250	282	418	468.2
	Rajpur	6.4	55.52	251.33	300.79	317.03	383.2
HD 3086	Khajurka	2 .0	21.2	102.5	203.6	124.6	158
	Rajpur	2.0	20.72	97.23	220.67	143.38	166.01
Estimated spread of quality seed (q)							
HD 2967	Khajurka	312	2731	13017	15519	17415	25414
	Rajpur	333	2754	13823	17404	19580	23099
HD 3086	Khajurka	110	1158	5567	11229	6524	8278
	Rajpur	96	1039	5110	11358	8097	9393

Note: (Avg.+SE)* and [CV] are based on the year-wise performance data of both the varieties at respective sites.

2967 in village Khajurka and Rajpur was 56.6 q/ha and 55.10 q/ha which was 21.7% and 17.5% higher than the respective local checks (T1). Yield wise, wheat variety HD 3086 performed better in village Khajurka as there was 19.9% advantage of yield as compared to village Rajpur (14.3%) with respect to their respective local check. The best traits as reported by farmers were good tillering, bold grain, high yield, less lodging and less damage on grain quality in high rainfall during grain maturation period observed in variety HD 3086 and profuse tillering, high yield and more straw in variety HD 2967.

Horizontal spread of varieties: The wheat variety HD 2967, which was initiated in year 2014–15 with the trials in 6 ha and 6.4 ha in Khajurka and Rajpur spread over to 468.2 ha and 383.2 ha respectively in the year 2019–20 (Table 1) (Fig 1). Spread of wheat variety HD 3086 was from 2 ha in both the villages in 2014–15 to 158 ha and 166 ha in Khajurka and Rajpur respectively during 2019–20 (Fig 2). A high rate of technological change is a major feature of modern agriculture. New technologies are introduced gradually; through diffusion process which spread technologies throughout the farm sector over time. While adoption is the decision by an individual producer to

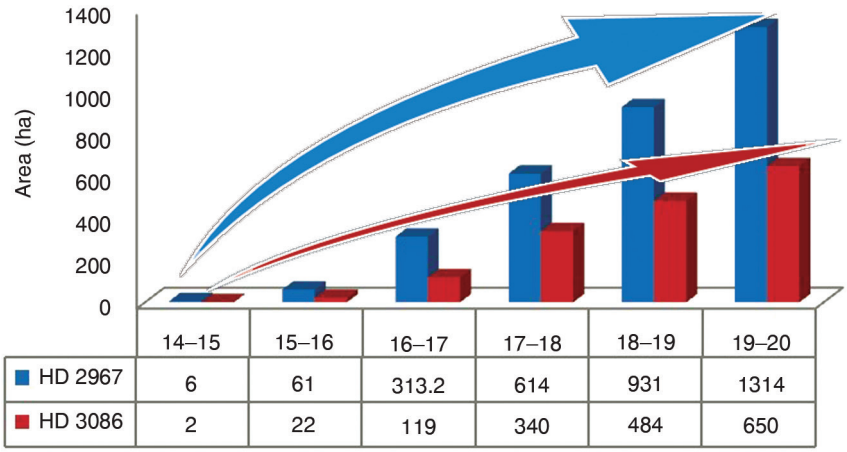


Fig 2 Cumulative area wise growth of wheat varieties in village Rajpur in Aligarh.

Table 2 Diffusion effect and rate of diffusion of high yield wheat on farmers' fields

	Location	HD 2967	HD 3086
Total quantity of seed supplied and area covered	Khajurka	41.6 q 41.6 ha	25.2 q 25.2 ha
	Rajpur	44.8 q 44.8 ha	37.6 q 37.6 ha
Total diffusion of quality produce after 5 years	Khajurka	1469 q - potential to cover 1469 ha area	604 q – potential to cover 604 ha area
	Rajpur	1314 q - potential to cover 1314 ha area	650 q – potential to cover 650 ha area
Area diffusion effect	Khajurka	1469/41.6 = 35.3 times	604/25.2 = 23.9 times
	Rajpur	1314.27/44.8 = 29.3 times	650.01/37.6 = 17.3 times
Quality seed diffusion	Khajurka	1469/ 41.6 = 35.3 times	604/25.2 = 23.9 times
	Rajpur	1314.27/44.8 = 29.3 times	650.01/37.6 = 17.3 times
Rate of diffusion (area) ha/year	Khajurka	76.83	24.66
	Rajpur	63.86	27.66
Rate of diffusion (seed) t/year	Khajurka	423.3	137.9
	Rajpur	384.98	156.54

use a new technology at a given moment, diffusion is the aggregate measure of adoption decisions (Zilberman 2008).

Diffusion of quality seed: As seed is an important input, an assessment of availability of quality seed in village was done (Table 1). The wheat variety HD 2967 which was initiated in year 2014–15, the availability of quality seed supplied was 312 q and 333 q in Khajurka and Rajpur respectively which multiplied to 25414 q and 23099 q respectively in the year 2019–20 (after 5 years). While the availability of quality seed of wheat variety HD 3086 during same period increased from 110 q and 96 q in Khajurka and Rajpur to 8278 q and 9393 q respectively in the year 2019–20; the wheat variety HD 2967 which was initiated in year 2014–15, the availability of quality seed was estimated as 312 q and 333 q in Khajurka and Rajpur to 25414 q and 23099 q respectively in the year 2019–20.

Diffusion effect and rate of diffusion of high yield wheat on farmers' fields: Based on the foundation seed supplied and production of farmers' own seed in subsequent year, the diffusion of high yield wheat on farmers' fields were calculated both in terms of area and seed (Table 2). The area diffusion effect of variety HD 2967 was more than HD 3086. In Khajurka, the area diffusion effect and quality seed diffusion of HD 2967 was 35.3 times while for HD 3086, it was 23.9 times. In Rajpur, the area diffusion effect and quality seed diffusion of HD 2967 was 29.3 times while for HD 3086, it was 17.3 times. The rate of diffusion of HD 2967 in terms of area was 76.83 ha/year and 63.86 ha/year in Khajurka and Rajpur respectively. The calculated seed diffused per year was 423 t/ha and 384 t/ha in Khajurka and Rajpur respectively. The rate of diffusion of HD 3086 in terms of area was 24.66 ha/year and 27.66 ha/year in Khajurka and Rajpur respectively. The calculated seed diffused per year was 137.9 t/ha and 156.54 t/ha in Khajurka and Rajpur respectively.

Table 3 presents the determinants of adopters of wheat varieties with area diffusion effect and correlation and regression of selected characteristics of subjects, viz. age, education, family size, type of family, occupation, operational land holding, farming experience, contact with extension agencies/line departments, training received and communication behavior. The relationship between adopters of improved wheat varieties and other independent analyzed was found that the area diffusion of wheat variety adopters is positively correlated with age, education,

Table 3 Correlation and regression coefficients of characteristics of adopters of wheat varieties with Area Diffusion Effect

Variable	Correlation coefficient (r)	Estimate (B)	Standard Error	Significance (P)
Constant	-	0.076	1.370	0.0371
Age	0.31786	1.361	0.043	0.0046*
Education	0.22117	1.226	1.311	0.0085**
Family size	-0.003258	0.779	0.993	0.7452^{NS}
Type of family	0.032166	1.756	0.710	0.1446^{NS}
Major occupation (agriculture)	0.004529	0.451	0.922	0.2996^{NS}
Operational land holding	0.10023	0.327	0.443	0.0353*
Farming experience	0.19327	0.561	0.227	0.0011*
Contact with extension agencies/ Line departments	0.11287	0.174	1.061	0.0047**
Training received	0.13674	0.781	0.672	0.0258**
Communication behavior	0.22563	1.012	0.323	0.0098**

**Significant at 0.01% level of significance, *significant at 0.05% level of significance. R= 0.771, R^2=0.742, Adjusted R^2=0.739, Standard Error of Estimate=0.0251, Durbin-Watson=1.529.

operational land holdings, farming experience, contact with extension agencies/ line departments, training received and communication behavior (R=0.771, R^2=0.742, Adjusted R^2=0.739, Standard Error of Estimate=0.0251, Durbin-Watson=1.529).

Farmer level seed multiplication for generating the quality produce for use in subsequent seasons has been proved to be a convincing approach for ensuring seed sufficiency at the village level. The diffusion of two improved varieties of wheat in terms of area coverage and quality produce across the farmers of the identified villages under the study re-affirms the philosophy of Farmer-to-Farmers spread of modern technologies including the HYV seeds.

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