Adoption and Impact of Wheat variety HD 3086: An analysis using structural equation modeling

Article *in* The Indian Journal of Agricultural Sciences · March 2022

DOI: 10.56093/ijas.v92i3.122699

3 authors, including:

Amarjeet Singh
Indian Agricultural Research Institute
23 PUBLICATIONS **69** CITATIONS
SEE PROFILE

Akriti Sharma
Indian Agricultural Research Institute
17 PUBLICATIONS **130** CITATIONS
SEE PROFILE

Indian Journal of Agricultural Sciences **92** (3): 377–81, March 2022/Article

Adoption and Impact of Wheat variety HD 3086: An analysis using structural equation modeling

NEERU BHOOSHAN[1], AMARJEET SINGH[1]* and AKRITI SHARMA[1]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012, India

Received: 08 November 2020; Accepted: 03 September 2021

ABSTRACT

Varietal development plays a crucial role in improving the overall yield of a crop and the impact assessment of a particular variety is essential to support this statement. Present study was carried out in North-Western Indo-Gangetic Plains (Punjab, Haryana and Western Uttar Pradesh) in India during 2017–18 to observe the response on the yield with the adoption of newly developed yellow rust resistant wheat variety HD 3086. The Structural Equation Model (SEM) was used to establish a relationship between the rate of adoption and factors affecting the same. Households (1000) were surveyed through random sampling for the study. Punjab was found to have the highest adoption rate amongst the 3 states followed by Haryana. This study has observed an increasing trend in coverage of farm area under HD 3086 in Punjab and Haryana. However, in Uttar Pradesh creating awareness among the seed companies and Krishi Vigyan Kendra (KVK) centres was found imperative for the multiplication of HD 3086.

Keywords: Adoption, Research Centre, SEM model, Wheat variety HD 3086, Yield

Seed technology played a dominant role in the green revolution (1965–66) along with other input practices in India. The use of technological improvements would have played a key role (Maertens and Barrett 2013). Now, there is a challenge to increase wheat production for the growing population with stagnant or declining arable land. Therefore, it is essential to develop quality high yielding seeds to meet the future generation's demand. The application of new agricultural technologies can raise farms' productivity and increase agricultural growth (Dadi *et al.* 2004) and seem to be an important way to alleviate poverty (Simtowe *et al.* 2011). Variety changes and genetic diversity are essential means for combating crop losses from pests and diseases in modern agricultural systems (Smale *et al.* 2008, Mazid *et al.* 2009). The wheat yield suffered after 2008–09 due to the onset of yellow rust disease in northern India. Yellow rust reduced yields by more than 50% {Agriculture and Horticulture Development Board (AHDB), 2016}. It also adversely affected the previously developed wheat varieties like PBW343, PBW117, PBW 50, PBW 621, PBW 502, WH 711, HD 2329, WH 147, and local varieties. In the meantime, the Indian Council of Agricultural Research-Indian Agricultural Research Institute (ICAR-IARI) developed HD 3086 wheat varieties in 2014 respectively as a solution for yellow rust.

This study aims to identify adoption rate of HD 3086 and its impact on the yield, besides examining the factors for the rapid adoption of wheat variety and the preferred traits for adopting new wheat variety. Also, the study analysed the benefits for farmers and its impact on adoption rate and yield in association with agricultural universities and state universities.

MATERIALS AND METHODS

The present study is based on primary data of three states, Punjab (PB), Haryana (HR), and western Uttar Pradesh (UP) obtained during 2017–18. As the wheat variety HD 3086 is recommended for India's three states, the available statistical abstract data (2015–16) is used for selecting the number of households in the three states. In 2015–16, the total area under wheat was 35.0 lakhs ha, 33 lakhs ha, and 25.8 lakhs ha in PB, UP, and HR, respectively. As per area covered under wheat, we have conducted proportion sampling to choose the number of households from each state. Therefore, 400 households were selected from PB, 326 households from UP, and 274 from Haryana. Further, six districts were selected randomly from each state using the same technique. Mathura, Etah, Muzaffarnagar, Moradabad, Aligarh, and Mainpuri districts from UP; Amritsar, Ludhiana, Moga, Sangrur, Faridkot, and Mohali from Punjab; while Jhajjar, Hisar, Rohtak, Mehendragarh, Kurukshetra and Karnal districts from Haryana were selected by applying the proportion sampling. A similar way selected the villages. For the selection of households, stratified random sampling was done. Four villages were selected from each district that led to the selection of twenty-four

[1]ICAR-Indian Agricultural Research Institute, New Delhi.
*Corresponding author email: admztmiari@gmail.com

villages from each state and seventy-two villages from all the three sample states. The sample was collected from 1000 households through pre-tested (pilot survey) schedule. The survey was done in February-March 2017. The months of October, November, and December were the sowing season for wheat in three sampled states, and April was harvesting season. Therefore, the yield data for the year 2016–17 was collected telephonically from all sample households from April to June 2017. For examining the adoption rate of wheat HD 3086, the months of October, November and December 2016 were considered. The variety was released in June, 2014 and its commercialization was started in August 2014. After collecting the data, it was cleaned and standardized to apply the Structural Equation Model (SEM).

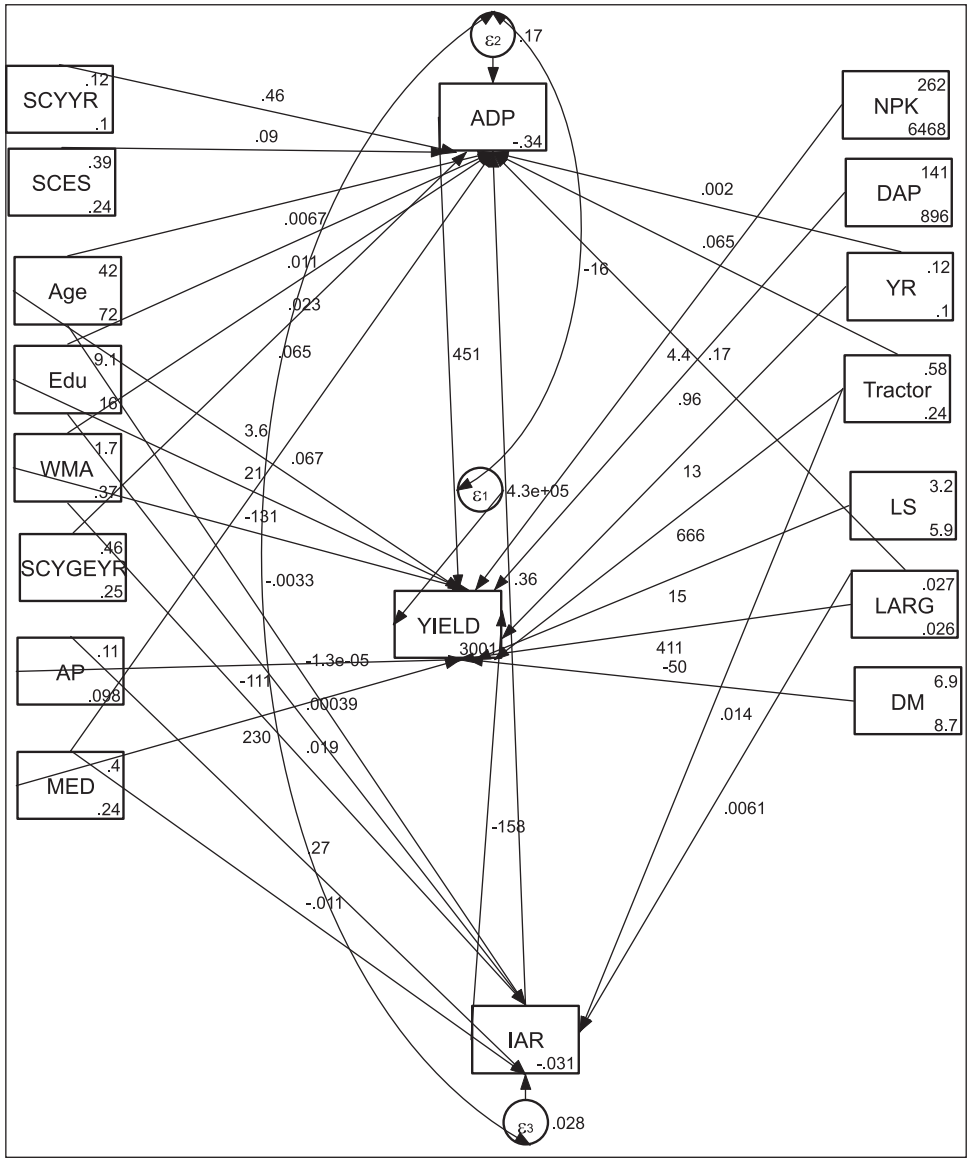

Fig 1 Factors affecting yield with the adoption of wheat HD 3086 and impact on adoption of farmers' information with the linkages of agricultural universities and Research Cenre through structural equation modeling (SEM).

Structural Equation Model (SEM): The structural equations represent causal relationships among the variables. In general, there is one structural equation for each endogenous variable. The remaining variables on the model's right-hand side are exogenous variables, whose values are treated as conditionally fixed (Fig 1). The exogenous variables are assumed to be independent of the errors. It is essential to mention that Y_2 and Y_3 are independent in first equation and dependent in second and third equations, respectively. Further, Y_2 (adoption of HD3086) is influenced by Y_3 (Information dissemination from Agricultural Universities) in equation (3). Yield data of 2017 was considered as a result of adoption data of 2016 (October, November, and December) of 2016.

$$Y_1(YIELD) = \alpha_0 + \alpha_1 ADP + \alpha_2 IAR + \alpha_3 Age + \alpha_4 Edu + \alpha_5 WMA + \alpha_6 NPK + \alpha_7 DAP + \alpha_8 YR + \alpha_9 Tractor + \alpha_{10} LS + \alpha_{11} MED + \alpha_{12} LARG + \alpha_{13} AP + \alpha_{14} DM + \varepsilon_1 \quad (1)$$

$$Y_2(ADP) = \beta_0 + \beta_1 IAR + \beta_2 Age + \beta_3 Edu + \beta_4 WMA + \beta_5 YR + \beta_6 Tractor + \beta_7 MED + \beta_8 LARG + \beta_9 SCES + \beta_{10} SCYYR + \beta_{11} SCYGEYR + \varepsilon_2 \quad (2)$$

$$Y_3(IAR) = \lambda_0 + \lambda_1 Age + \lambda_2 Edu + \lambda_3 WMA + \lambda_4 MED + \lambda_5 LARG + \lambda_6 AP + \beta_6 Tractor + \varepsilon_3 \quad (3)$$

ε Stochastic disturbance term.

Endogenous variables: Observed:

1. YIELD: Yield of wheat (kg/ha),
2. ADP: Adoption of Wheat HD 3086. if yes -1, otherwise – 0,
3. IAR: Farmers information with the linkages of agricultural universities and research centre (SAU and R&D) (yes-1, otherwise-0).

Exogenous Variables: Observed:

1. Age: years;
2. WMA: Working members in agriculture (number);
3. LARG: A large farmer: if yes -1, otherwise – 0;

4. MED: Medium farmers.: if yes -1, otherwise – 0;
5. NPK: Use of urea in kg/ha, (nitrogen, phosphorus, and potassium);
6. DAP: Use of DAP in kg/ha, (Diammonium Phosphate);
7. LS: Livestock in number;
8. Tractor: Owned tractor if yes -1, otherwise – 0;
9. Edu: Education (year of schooling);
10. SCES: Preference combination of yield and straw: if yes-1, otherwise – 0;
11. SCYYR: Preference combination of yield and yellow rust;
12. SCYGEYR: Preferences combination of yield, good for eating and yellow rust: if yes-1, otherwise -0;
13. YR: Yellow rust,
14. DM: Distance from nearest market/*mandi,*
15. AP: Agricultural practices following (as guided by seed producer, seed dealers, or universities & research centre, among other): yes-1, otherwise-0.

It is not out of context to observe here that in the estimation of Structural Equation Model (SEM), Chi-square (χ^2) - test statistic is a measure of poorness of fit rather than goodness of fit. Generally, for over-identified models, a high value of χ^2 is observed, and for precisely identified models, its value converges to zero.

Therefore, the use of χ^2 as a measure of goodness of fit was challenged in the literature on Structural Equation Model (SEM). Therefore, the limit of χ^2 must not be larger than three times of its degree of freedom. Thus, χ^2– statistic divided by its degree of freedom must be less than three. The estimated χ^2 statistic is 40.328 with 18 degrees of freedom. Thus, the said statistic does not exceed the limit 3×18 (d.f.) = 54 to the reliability test. The modification indices were run in STATA to check the co-variances of structure and measurement error, and no modification indices were reported. All MI values were found to be less than 3.8414. There was no endogeneity problem in the model. Therefore, the estimated χ^2 statistic is 40.328, with 18 degrees of freedom.

RESULTS AND DISCUSSION

Source of seeds and selection criteria of wheat variety in sampled states: The bulk of the national seed requirement is met through the informal system of local seed maintenance and exchange. The study shows that Farmers approached the local seed dealers and local shopkeepers (87.3%) for new seed varieties. Merely 2.8% were directly associated with seed producers. Around 4.8% farmers were linked with agricultural universities and research institutes and 4.1% farmers were getting new seed from neighbor's fields

Moreover, yield, palatability, more straw, and disease resistance were identified as preference traits for seeds. The combination of yield and straw was the preferable factor for farmers to select a wheat variety for sowing. The second most crucial combination was yield and palatability. The third combination was yield, palatability, and more straw and the fourth combination was yield and disease-resistance. Breeding programs need to focus on potential target user groups' requirements and conditions to improve yield performance, income, and nutritional benefits (Efisue *et al.* 2008).

Table 1 State-wise comparative yield of surveyed farmers

Comparative yield (kg/ha) of different wheat varieties across three sampled states and year			
	2014–15	2015–16	2016–17
Punjab			
HD 2967	5192	5441	5450
HD 3086	5273	5508	5297
HD 1105	4885	4885	4699
Other	4873	4952	4812
Haryana			
HD 2967	4678	4883	5059
WH 711	4379	4305	4524
HD 3086	NA	4571	4630
1105	5031	5189	5040
Other	4685	5095	4946
Uttar Pradesh			
HD 2967	4329	4230	4495
WH 711	3059	3126	3158
PBW550	2790	3010	3002
PBW 502	2624	2876	29
PWB 343	2602	2810	2863
Other	3007	2992	3000

2-NA: not available. Source: Field Survey 2016–17.

The yield of HD 3086 was maximum in Punjab while less in Haryana in the first year (2015–16) of adoption of HD 3086. It is pertinent to note that wheat variety HD 3086 was not sowed by farmers in UP in 2015–16 as there was no technology transfer being done to UP's seed producer companies (information from Zonal Technology Management and Business Planning and Development unit, ICAR-IARI, New Delhi). This was observed as the strong factor for no adoption of the wheat variety in UP**.** Wheat HD 2967 was the dominant variety in 2014–15 in Punjab and Haryana. In 2016–17, wheat HD 2967 was replaced by wheat HD 3086. Over time, as farmers gain-experience, they progressively switched from traditional agricultural technologies to improved technologies based on observed performance and learning by doing. The adopters of wheat technological package gained higher yield of about 970 kg/fed in compared to non-adopters (Hanan and Abdalla 2014), and R&D played an important role in productivity (Thapa 2003).

The adoption of HD 3086 rapidly increased in Punjab and Haryana, whereas a declining adoption rate was observed for other competitive varieties (Fig 2). HD 3086 created a dominant place in northern states (Table 1). It was observed that farmers adopted previously developed low yielding varieties in UP.

Impact on yield with the adoption of new variety HD

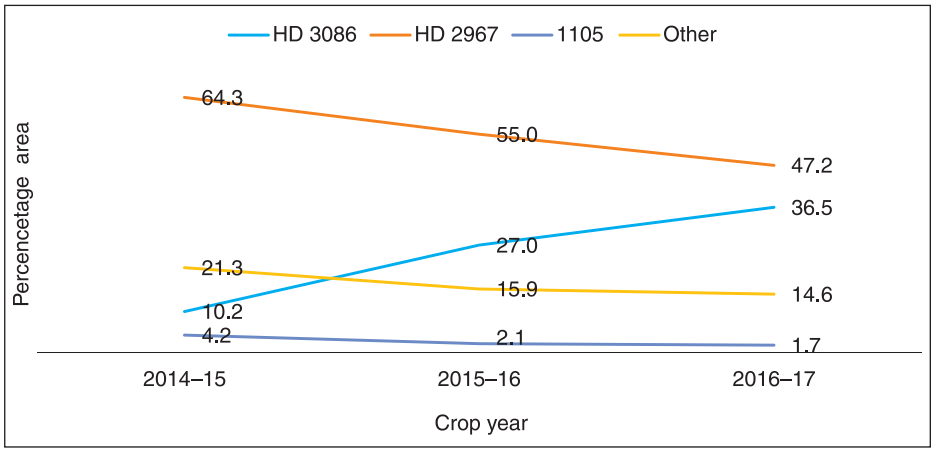

Fig 2 Wheat varieties adoption from 2014–15 to 2016–17 in northern states.

3086 and impact on adoption of farmer's information with the linkages of agricultural universities and research centre with other variables through Structural Equation Modeling (SEM): We have used Structural Equation Model to identify the association in the observable variables, namely-yield of wheat (quintal/hectare (q/ha)), adoption of HD 3086 (yes-1, otherwise-0), and farmers' information with the linkages of agricultural universities and research centre (yes-1, otherwise-0). This study hypothesizes that the high yield of wheat is due to the adoption of new wheat variety HD 3086 (Table 2). Also, adoption is impacted by farmers' information with the linkages of State Agricultural Universities (SAU) and Research & Development (R&D) Institutions. Thus, yield is a dependent variable, and adoption is independent with other control variables. Furthermore adoption of wheat HD 3086 appears to be the dependent variable and farmers' information with the linkages of agricultural universities and research centre to be an independent variable in equations to explain the direct and indirect impact on adoption and yield, respectively.

The evolution of new seed variety raises the expectations of the farmers about increasing the yield. Through Structural Equation Modeling (SEM), we tried to find the direct and indirect association of the various parameters with yield. The adoption of new HD 3086 helped in increasing the yield with the coefficient value of 450.8311 at 1% significant level. It is important to note that farmers' information from the linkages with agricultural universities and research centre was not directly associated with yield, nevertheless, this variable significantly affect adoption rate at 5 per cent level with coefficient value 0.361803. Therefore, the source of information was considered to help in the early adoption of a variety. State agricultural universities & research centers were the sources of information that had a highly significant impact on adoption at 1 per cent level. Education was found to be directly associated with adoption and yield and significantly impacting at 1 per cent level on yield. The number of working members from single-family negatively influenced the yield at 1 per cent level. Fertilizer is an important input for augmenting the yield of wheat. Consumption of more fertilizer NPK (Urea) significantly impacted the yield at 1 per cent. High quantity of DAP is not significantly related to yield. The relation between yield and yellow rust was not found to be significant. It may be due to the adoption of pre-developed wheat variety HD 2967 which covered maximum area in northern India with the resistance of yellow rust. Tractor helped farmers in timely sowing and harvesting of agriculture activities and significantly impacted at 10 per cent along with Livestock number. As the farmers were using dung as manure (input) in the field to increase the yield, therefore, we have used the number of livestock as a proxy of manure in the model. The results of the model showed the coefficient value of 15.47 with Z value 1.350 is not significant. As per Indian land classification in model, small landholdings (>2 ha) were taken as base, medium (>10 ha) and large (<10 ha) landholdings were taken as independent variables. The results show that medium and large farmers were positively associated with adoption at 10 per cent level of significance with coefficient value 0.066713 and 0.166903 respectively. It means large farmers were getting high yield. Farmers generally see the characteristics of the variety before sowing in the field. Therefore, their variety preference combination was set in the model based on adopted variety. The combination of yield and yellow rust resistance were significant (1%) preferred traits. The combination of yield and straw had a significant impact on adoption at 10 per cent level. Other seed preference combinations were also positively not significantly associated. Some farmers have adopted the suggested farming practices by seed producers and dealers, apparently resulted in higher yields. Therefore, agricultural practices were put as exogenous variable (yes-1, otherwise-0). This variable also had a significant impact on linking the farmers with state agricultural universities (SAU) and research centers. It implies that these farmers were more inquisitive to get the early information of the new seed technology from SAU & research centre.

The study reveals that Punjab adopted wheat HD 3086 in 2014–15 and Haryana adopted in 2015–16, while in Uttar Pradesh, no adoption took place. Hence, it is imperatively needed to push this technology through established links with R&D/technology transfer units in lagging states to increase the yield of wheat. Moreover, the Structural equation model was fit to know the response on yield after the adoption rate of wheat HD 3086 with other correlated variables, i.e. age, landholding size, tractors, NPK, DAP. The livestock was positively associated and did not have any significant impact on yield. The relation between yield and yellow rust was found negative, but does not give

Table 2 Results of Structural Equation Model for adoption of wheat HD 3086

	Coef.	Std. Err.	z	P>|z|
Structural ADP Wheat HD 3086				
IAR	0.361803**	0.17572	2.060	0.039
Age	0.006678*	0.002308	2.890	0.004
Edu	0.010635**	0.004969	2.140	0.032
WMA	0.023447	0.023396	1.000	0.316
YR	0.001986	0.04411	0.050	0.964
Tractor	0.065431***	0.038459	1.700	0.089
MED	0.066713***	0.036395	1.830	0.067
LARG	0.166903***	0.089439	1.870	0.062
SCES	0.089617	0.076838	1.170	0.243
SCYYR	0.458329	0.08293	5.530	0.000
SCYGEYR	0.064763	0.076651	0.840	0.398
_cons |	-0.34147	0.155517	-2.200	0.028
Yield (kg/ha)				
ADP	450.8311	196.4353	2.300	0.022
IAR	-157.955	131.1863	-1.200	0.229
Age	3.599091	3.974565	0.910	0.365
Edu	20.67618	8.139013	2.540	0.011
WMA	-131.437	39.43111	-3.330	0.001
NPK	4.392363	0.313697	14.000	0.000
DAP	0.961327	0.888879	1.080	0.279
YR	13.25795	70.83487	0.190	0.852
Tractor	666.4845	66.47148	10.030	0.000
LS	15.47822	11.23641	1.380	0.168
DM	-49.9629	8.835375	-5.650	0.000
AP	-110.965	93.14608	-1.190	0.234
MED	229.6331	61.80021	3.720	0.000
LARG	410.9944	154.5754	2.660	0.008
_cons	3000.958	260.2495	11.530	0.000
IAR- farmers information with the linkages of agricultural universities and Research Centre (yes-1, otherwise-0)				
Age	-1.3E-05	0.000945	-0.010	0.989
Edu	0.000394	0.002023	0.190	0.846
WMA	0.018783	0.009345	2.010	0.044
Tractor	0.014156	0.01463	0.970	0.333
AP	0.268765	0.018691	14.380	0.000
MED	-0.01086	0.014205	-0.760	0.444
LARG	0.00612	0.035688	0.170	0.864
_cons	-0.03137	0.055262	-0.570	0.570
var (e.ADP)|	0.167109	0.007562		
var (e.YIELD)|	426421	20140.55		
var(e.IAR)|	0.028044	0.001254		
cov(e.ADP,e. YIELD)|	-16.4458	33.99156	-0.480	0.629
cov (e.ADP,e. IAR)|	-0.00328	0.005372	-0.610	0.541

Note: * significant at 1 per cent level, ** significant at 5 per cent level, *** significant at 10 per cent level.

significant results. It may be due to the adoption of pre-developed yellow rust resistant variety wheat HD 2967, which covered maximum area in northern India. Moreover, the adoption rate was impacted by farmers' linkages with agricultural universities and research centers, age, education, large land holding, preference trait of yield and yellow rust resistance variety, working members in farming, tractor, and others. The farmers were getting information due to linkages with agricultural universities and research centre due to the involvement of working members in farming, and farmers following the agricultural practices as guided by seed producer, dealers, and local shop keepers. A need to concentrate on research of high yielding varieties was observed. The establishment of technology transfer units in each state agricultural university and in research institutions for developing the partnerships with seed companies for rapid multiplication of the seeds is needed. Moreover, there is a requirement of active participation of KVK centers for rapid introduction of technologies to farmers.

REFERENCES

Agricultural Statistics at Glance. 2016. Govt. of India, Ministry of Agricultural & Farmer Welfare, Department of Agricultural, cooperation and Farmers Welfare, Directorate of Economics and Statistics.

AHDB. 2016. Cereal and oilseeds. Wheat disease management guide. February, P.14.

Dadi L, Burton M and Ozanne A. 2004. Duration Analysis of Technological Adoption in Ethiopian Agriculture. *Journal of Agricultural Economics* **55**(3): 613–31.

Efisue A, Tongoona P, Derera J, Langyintuo A, Laing M and Ubi B. Ubi. 2008. Farmers' perceptions on rice varieties in Sikasso region of Mali and their implications for rice breeding. *Journal of Agronomy and Crop Science* **194**(5): 393–400.

Franklin Simtowe, Menale Kassie and Aliou Diagne.2011. Determinants of Agricultural Technology Adoption: The Case of Improved Pigeonpea Varieties in Tanzania. Quarterly. *Journal of International Agriculture* **4**: 325–45.

Hanan Suliman Mohamed and Samar Abdalla. 2014. Impact Assessment of Improved Wheat Production Package in Sudan, Agricultural Research Corporation, Agricultural Economics and Policy Research Centre (AEPRC) Shambat. Sudan.

Maertens A and Barrett C B. 2013. Measuring Social Networks' Effect on Agricultural Technology Adoption. *American Journal of Agricultural Economics* **95**(2): 353–59.

Mazid A, Amegbeto K N, Keser M, Morgounov A, Peker K, Bagc A, Akin M, Kucukcongar M, Kan M, Karabak S, Semerci A, Altikat A and Yaktubay S. 2009. Adoption and impacts of improved winter and spring wheat varieties in Turkey. Aleppo, Syria, International Center for Agricultural Research in the Dry Areas (ICARDA).

Smale M, Singh J, Di Falco S and Zambrano P. 2008. Wheat breeding, productivity and slow variety change: evidence from the Punjab of India after the Green Revolution. *Australian Journal of Agricultural and Resource Economics* **52**(4): 419–32.

Thapa G, Otsuka K and Barker R. 1992. Effect of modern rice varieties and irrigation on household income distribution in Nepalese villages. *Agricultural Economics* **7**(3–4). 245–65.