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FACTORS INFLUENCING WHEAT VARIETAL TURNOVER IN NAROK AND NAKURU COUNTIES OF KENYA

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Abstract
Varietal turnover is very low in the study Counties of Narok and Nakuru. To increase wheat varietal turnover rate, factors that influence wheat farmers' decision process must be understood. This study determined factors that influenced improved wheat varietal turnover in Narok and Nakuru Counties of Kenya. The study was conducted based on a sample size of 344 wheat farmers from the two Counties. Multi-stage sampling technique was employed to select the sample farmers and the data was collected using a structured questionnaire. Descriptive statistics was used for analyzing quantitative data, while binary logit model was used to determine factors that influence wheat varietal turnover. The model results indicated that seed price, field day visits, access to new variety, farm size and disease resistance were significant determinants of wheat varietal turnover. Therefore, any effort geared towards increasing wheat varietal turnover rate should consider at most the varietal attributes/traits and institutional characteristics.

Keywords: Binary Logit model, varietal turnover, wheat

1. INTRODUCTION

The adoption of new improved superior varieties of crops is imperative to ensure the food security of the growing population and to reduce the vulnerability of the marginal farmers to various kinds of biotic as well as abiotic stresses. Availability and use of good quality seed is also an important factor which determines the yield and quality of the output, as the response of the crop to other inputs depends on the quality of the seed. Estimates show that quality seed alone contributes 15-20% to the total production directly, which can be further increased to 45% with the efficient management of other inputs (Ali, 2016). Hence it is important to develop a seed production and delivery system that continuously develops new varieties suited to the changing environment and disseminate it faster replacing obsolete varieties. Frequent seed and varietal turnover not only helps in achieving yield potential but also prevents varietal deterioration and depreciation, reduces the potential damage due to newly evolved pest and diseases (Krishna *et al*, 2014) and climate change.

Farmers can benefit from improved yield potential and/or better disease resistance in the newer varieties because of recent advances in plant breeding methodologies, but these gains can only be realized by delivering improved varieties to farmers rapidly (Lantican *et al*. 2016; Witcombe *et al*. 2016). A continuous flow of improved and competitive crop varieties produced by breeding programs is a prerequisite for the replacement of old and obsolete varieties to ultimately improve crop productivity and address the overall challenge of food security. However, delivering new varieties to farmers does not guarantee that they will necessarily be adopted. Studies have shown that smallholder farmers regard high yield of new varieties as the most important trait (Walker *et al*. 2015. According to Walker *et al*. (2015), increased productivity gains, reduction in poverty and contribution to food security lead to the adoption of improved varieties. Similarly, it has been shown that particular varietal attributes can lead to strong farmer preferences for adopting specific cultivars. For example, resistance to biotic and abiotic stresses, high yield and superior quality are the major attributes that determine the level of adoption of new wheat varieties (Lantican *et al*. 2016). In the case of rice, however, improved grain quality, shorter maturity, improved lodging resistance, high milling recovery, improved resistance/tolerance to insect pests, and diseases were found to be important secondary traits (Hossain 2012).

Crespo-Herrera *et al*. (2017), reported that genetic gains per annum in CIMMYT wheat germplasm over widely grown Attila variety of wheat ranged from 0.31 to 2.7%, whereas the genetic gains over local checks were between 0.41 and 1%. Historically, it has generally been thought that every new batch of recommended crop varieties would be more competitive, appropriate, and profitable for farmers than the old improved most widely grown varieties. Any failure to adopt was assumed to be attributable to factors unrelated to varietal traits or shortcomings hence low varietal turnover. Several studies have indicated that, for one reason or another, not all the crop varieties released get into seed production segment of the wheat value chain. (Walker *et al*. 2015, and Javed *et al.* (2015), while assessing the impact of new wheat varieties reported that only eight out of 28 varieties released between 1981 and 2011 covered nearly 84% of total wheat area in Punjab (Pakistan). However, when it comes to uptake and adoption of new crop varieties, noticeable yield advantage plays a decisive role. For example, Bangladeshi farmers selected only those wheat varieties that had at least 10% yield advantage over the checks (Pandit *et al*. 2010). Walker *et al*. (2015) stressed that the absence of detectable yield differences between new improved and old improved/traditional crop varieties was thought to be the main determinant of the low varietal turnover. Average age of wheat cultivars in Pakistan during 2014 was 8–10 years. A study conducted in Sub Saharan Africa under Diffusion and Impacts of Improved Varieties in Africa (DIIVA) project measured varietal turnover using area weighted grand mean of 21 crops across 117 countries and found that the average age is 14 years (Walker and Alwang, 2015). Varieties should turn over at an optimal rate, at which it becomes profitable for the farmers to change varieties and optimum replacement rate of crop varieties depends on the cost and benefits of releasing new varieties (Byerlee and Heisey, 1990). In the case of India the weighted average age in years of various crop cultivars were estimated, as rice-11.5, pearl millet-5.8, maize-16.6, sorghum-15.9, ground nut-15.3, chick pea-19.7 and wheat-9.3 (Witcombe et al, 1998).

2.0 RESEARCH METHODOLOGY

2.1 Description of the Study Areas

The areas selected for this study are in Nakuru and Narok Counties of Kenya, and among the major wheat growing counties in the country. Nakuru County covers an area of 7,495.1 Km^2 and has a bimodal rainfall pattern with a high of 1800mm and a low of 500mm. The county covers an area of 7,495.1 Km^2 and is located between Longitude 35 º 28` and 35º 36` East and Latitude 0 º 13 and 1º 10` south. The climate of the County is strongly influenced by the altitude and physical features. There are three broad climatic zones (II, III and IV). Zone II covers areas with an altitude between 1980 and 2700 m above the sea level and receives minimum rainfall of 1000mm per annum. Zone III receives rainfall of between 950 and 1500 mm per annum and covers areas with an altitude of between 900-1800m above sea level. This zone covers most parts of the county and is the most significant for agricultural cultivation. Zone IV occupies more or less the same elevation (900-1800m) as Zone III. However, it has lower rainfall of about 500-1000mm per annum, NCIDP (2013-2017). Nakuru County is Kenya's traditional wheat production region as well as the Centre of wheat research in the country where the KALRO National Plant Breeding center is situated. The County of Narok lies between latitudes 0° 50´ and 1° 50´ South and longitude 35^o 28´ and 36^o 25´ East. It borders of Tanzania to the South, Kisii, Migori, Nyamira and Bomet counties to the West, Nakuru County to the North and Kajiado County to the East. The County covers an approximate area of 17,933 square kilometers with a population of 850,920 people, KNBS, (2013). The climate is strongly influenced by the altitude and physical features and has five agro-climatic zones namely; humid, sub-humid, semi-humid to arid and semi-arid Narok DEAP 2009- 2013. Temperatures range from 20^0C (January- March) to 10^0C (June- September) with an average of 18^0C. Rainfalls amounts are influenced by the passage of inter tropical convergence zones giving rise to bi-modal rainfall pattern. Long rains fall between the months of February and June while the short rains are experienced between August and December.

2.2 Sampling Technique and Data Collection

A multi-stage sampling procedure was applied to identify farmers to be included in the survey.
At the First Stage, the Narok and Nakuru Counties were selected purposively for their potential of wheat production. Second stage, farmers in these Counties were stratified according to scale of production. Large-scale farmers were farmers who own 500 acres and above of land, medium scale- 50-499 acres, and small-scale farmers were farmers who own 49 acres and below. According to the Cereal growers association, (CGA, 2017), the number of registered wheat farmers in Nakuru county was 185, while there were 428 wheat farmers registered in Narok County.

The number of respondents from the three farmer categories was derived based on probability proportional to the size method. The sample size was determined based on Krejcie and Morgan, (1970) sample size determination formula. $s = X^2NP(1-P) \div d^2(N-1) + X^2P(1-P)$.

Where: s = required sample size, X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (1.962 or 3.841 for 95% confidence), N = Number of wheat farmers, P = the population proportion (assumed to be 0.50 since this would provide the maximum sample size) and d = the degree of accuracy expressed as a proportion/ is the desired level of precision. Primary and secondary quantitative and qualitative data were used in the study. The primary data were collected from respondent household heads using pre-tested structured questionnaire. The interviews were conducted by trained enumerators. The survey was carried out from May to August, 2018.

2.3 Analytical Method

The quantitative data were analyzed using descriptive statistics. To estimate the probability of wheat varietal turnover binary logistic regression (logit) model was used. The justification to use logit model was its simplicity of calculation and that its probability lies between 0 and 1 (Gujarati, 1995). The data processing was carried out using SPSS-20 software package.

2.3.1 Empirical model

1. This study's empirical model draws on household data to estimate the determinants of adoption of recently released varieties at the farm household level along the lines of Heisey and Brennan (1991). This estimation is done by calculating the varietal turnover as described earlier, whereby the average age in the seed system for a varietal adopted by a given farmer is weighted by the area planted in each variety, that is,

$$A_i = \sum_{j=1}^{j} A_{ij} \frac{L_{ij}}{\sum L_{ij}} \qquad (1)$$

where A_i is the average age of varietals cultivated by the i^{th} household, A_{ij} is the number of years since the jth variety was officially released, and L_{ij} is the area under the j^{th} variety on the ith household's farm. Each of the sample wheat farmers is associated with an average variety age that is calculated by his or her varietal portfolio during the year of the survey. This measure is simple to calculate and avoids the use of arbitrary definitions of recent or older varieties in the seed distribution system, Maertens (2013). Further, multiple regression models are estimated with on-farm average varietal age as a function of a number of farm, household, and village characteristics. Although this measure is at the farm level, it captures two features of the (macro-level) wheat seed distribution system: the relative speed (diffusion) at which a new variety is adopted by farm households while a lower age represents a highly responding wheat varietal system with efficient dissemination) and the varietal turnover rate of the system. Most of the sampled farmers purchase seeds every year instead of relying on their own saved seeds, and they select a portfolio that includes varieties that are released at different points in time.

It is expected that certain village-level attributes and socio networks can explain patterns of varietal turnover. Logistic regression (logit) model is used in estimating the probability of wheat varietal turnover. To estimate the probability of wheat varietal turnover binary logistic regression (logit) model was used. The justification to use logit model was its simplicity of calculation and that its probability lies between 0 and 1 Gujarati, (1995).
Empirical model According to Gujarati (1995) the logistic distribution function is:

$$l_n = l_n\left(\frac{p_t}{1-p_i}\right) = z_j = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon$$

Where, Ln is log, i is the ith observation in the sample, P_i is the probability of wheat varietal replacement for the ith farmer given the explanatory variables $X_1, X_2 \ldots X_n$. $1-P_i$ indicates the probability of absence of varietal replacement. β_0 is the coefficient of intercept, $\beta_1, \beta_2 .... \beta_n$ are parameters to be estimated and ε is error term.

Model specification

Wheat varietal replacement as a function of a set of explanatory variables, the actual model specification would be:

Varietal turnover=$\beta_0+\beta_1$(AGE)+β_2(FEXP)+β_3(EDUC)+β_4(FRMSZE)+β_5(ASPRICE)+ β_6(RCREDIT) + β_7(EXTCONT) + β_8(ANWVAR) +β_9(FIDAY) + β_{10}(YIELDH) + β11(DISREST) + ε

Where:

AGE = Age of the respondent in years.
FEXP = Wheat farming experience of the respondent in years.
EDUC = 1 if the respondent attended formal education, 0 otherwise.
FRMSZE = Farm size of the respondent in hectares.
ASPRICE = 1 if the wheat seed price was affordable to the farmer, 0 otherwise.
RCREDIT = 1 if the respondent received credit, 0 otherwise.
EXTCONT = 1 if the respondent had contact with extension agent, 0 otherwise.
ANWVAR = 1 if the farmer had access to new varieties, 0 otherwise.
FDAY = 1 if the respondent visited field day site, 0 otherwise.
YIELDH = It is amount of product measured in Kgs per hectare.
DISREST = 1 if the respondent perceives new varieties have resistance to disease, 0 otherwise.

For the study, a variety replacer was defined as a farmer who grew improved new improved wheat varieties during the 2015-16 cropping season. A new improved wheat variety is a variety that has been used for less than 10 years from the year of release and hence we consider varieties released from the year 2011.

3.0 RESULTS AND DISCUSSIONS

3.1 Wheat Varieties Grown in The Study Area

In the study Counties, farmers are growing different wheat varieties. The wheat varieties that encountered during the survey are described in (Table 1). In the 2014 production season, the wheat varieties found grown in the study area were Kwale, , K.Pasa, Duma, Mwamba, Njoro BW2, K.Heroe, K.Chui, Eagle10, Robin, K.Korongo, K. Kingbird, and K.Hawk (Table 1).

According to results (Table 1), farmers tend to grow more than one wheat variety on their farms. As was noted, in the survey result, old varieties were found grown along with new released varieties. The results revealed that 56.3% of the sample farmers planted both new and old wheat varieties together. The most important reasons for growing more than one wheat varieties could be to spread risk and to identify the best performing wheat variety under their own conditions. This would enable farmers to choose varieties in terms of yield, disease resistance, marketability and early maturity among other aspects. The use of old wheat varieties like Kwale and NjoroBW2 was very high despite their age. It was reported grown by 56.8% and 57.9% of the sample farmers respectively (Table 1). Nevertheless, Robin, an old wheat variety, was still grown variety by the sample farmers (23.7%) despite its susceptibility to stem rust. This could be an indication of low awareness among farmers or a specific variety attribute preference by farmers in the study area.

Table 1: Wheat varieties grown by sample farmers in 2015-2016 production season (n=344)

Variety name	Frequency	Percentage	Year of release
Kwale	196	56.8	1987‡
Duma	83	24.2	1998‡
NjoroBW2	200	57.9	2001‡
Eagle10	148	43.1	2011
Robin	82	23.7	2011
K. Korongo	228	66.3	2012
K.Kingbird	131	38.2	2012
K.Hawk	203	59.2	2012

Note: ‡ = Old wheat varieties (> 10years)
Source: Field survey data and KALRO (2015)

3.2 Determinants of wheat varietal replacement: logit model results

Results from the logit model used to examine the factors affecting wheat varietal turnover are presented in (Table 2). Thirteen variables were hypothesized to influence wheat varietal turnover. The results revealed that farm size, price of wheat seed, access to new improved wheat variety, field day visit, maturity duration and disease resistance were found to contribute to wheat varietal turnover rate at significant level.

All the variables that showed significant effect on varietal turnover were found to be in conformity with the prior expectations of the study. Variables that influenced varietal turnover significantly are discussed below:

Farm size of the respondents had the expected positive sign and was significant at 5%. The logit model result indicated that, the odds in favor of wheat varietal turnover increased by a factor of 1.933 as the farm size increased by one unit (Table 2). The result implies that wheat farmers with larger farm size are 93% more likely to use new improved wheat varieties than farmers with small land holdings. The possible explanation is that, farmers with large farm size might grow new improved varieties along with old improved either to evaluate varietal traits or to spread risk due to the rust disease. The result was in line with the finding of Bedru and Dagne, (2014) Kafle, 2010).

According to the logit model analysis result seed price had significant influence on wheat varietal turnover at 1% significant level. The odds in favor of wheat varietal turnover increased by a factor of 7.712 when the price of wheat seed was affordable (Table 2). This implies that new wheat variety usage by farmers increased when the price of seed was affordable. The result was consistent with the findings reported by Khanal and Maharjan (2013) which found that price of seed was a significant determinant in the adoption of improved rice varieties. Access to new variety had positive and significant influence varietal turnover in the study area. The likelihood of varietal turnover increased by a factor of 24.592 for farmers that had access to new varieties. This finding agrees with findings by Awotide *et al.* (2012) who found that access to improved seed had a positive and significant relationship with adoption of improved rice varieties in Nigeria. Participation in wheat varietal field days had a positive significant effect on farmers' varietal turnover rates. Participation on wheat variety field day increased the likelihood of wheat variety turnover by a factor of 7.884 (Table 2). This indicates that farmers who had an opportunity to attend wheat varietal field day were much more likely to change varieties. Thus, field day is an efficient means of promoting new improved wheat varieties. The result was consistent with findings by Yemane (2014) who found that field day participation had significant effect on the adoption of improved upland rice variety.

As anticipated, maturity duration positively and significantly influenced varietal turnover at 5% level. Varietal turnover increases by a factor of 8.496 if a wheat variety is early maturing. The result reveled that wheat variety with early maturity trait increased the likelihood of its selection by wheat farmers. Shortage of rainfall especially on some parts of lower zones of Narok and Nakuru Counties could be the possible reason the preference of early maturing varieties. This is consistence with findings by Salasya et al. (2007) who reported that maturity period had a significant influence on the adoption of stress-tolerant maize hybrid in Kenya. From the results, disease resistance had a positive and significant influence on the probability of varietal turnover rate at 5% significant level. This indicates that varietal turnover rate would be increased by a factor of 6.716, if a wheat variety was resistance to wheat rust disease. The results reveal that new wheat varieties with disease resistance attribute were more likely to be adopted by the farmers.

Table 2. Logit model result for factors influencing varietal replacement

Predictors Sig.	B	Wald	Sig	Exp(B)
Age	0.019	0.398	1.017	0.530
Formal education	0.077	0.013	0.912	1.081
Farm size	0.661	5.063	0.023**	1.933
Seed price	2.044	11.151	0.001***	7.712
Access to credit	0.283	0.241	0.623	1.329
Distance to seed source	0.062	2.087	0.151	1.064
Extension contact	-1.166	1.886	0.172	0.313
Access to new improved variety	3.203	17.404	0.000***	24.592
Field day visit	2.066	11.573	0.001***	7.884
Yield	-0.069	2.317	0.129	0.933
Maturity Duration	2.140	5.524	0.018**	8.496
Disease resistance	1.903	5.453	0.020**	6.716
Constant	-7.512	10.068	0.002	0.001

	$\chi 2$	P
Goodness of fit test Hosmer & Lemeshow	9.214	0.326
Omnibus Model chi-square test	133.983	0.000***

Overall Prediction percentage = 86.3%

4.0 CONCLUSION AND RECOMMENDATIONS

This study has shown that wheat varietal turnover rate was significantly influenced by farm size, price of seed wheat, access to new improved wheat varieties, field day visits, maturity duration, and wheat rust disease resistance. Since access to new improved varieties and price of wheat seed were influencing varietal turnover rates, efforts should be geared towards decentralizing the wheat seed system and sell at an affordable price or subsidized price to be able to realize returns to wheat breeding. Furthermore, farmers should be trained on how to multiply their own seed by accessing breeders' seed from the KALRO Centre for multiplication. This will not only reduce on seed cost but also it will be a form of decentralization of the seed system. The study has also revealed that field day visit influences varietal turnover. This implies that for every newly released variety a promotion campaign through field days should be carried out for awareness creation about new the wheat varieties, their inherent characteristics and performance. Because farmers have their attribute valuation criteria, breeders should work closely with the wheat farmers to be able to understand the farmer preferred attributes and hence incorporate them in their breeding process. This can be achieved through participatory plant breeding. In this regards greater consideration of participatory approaches to wheat variety improvement should be considered. Therefore, expanding participatory variety selection and participatory plant breeding approaches is important to meet farmers' interest regarding trait preference. Breeding organizations, regulatory bodies responsible for varietal release, national seed systems, and seed companies need to take responsibility for increasing the rate of varietal turnover in farmers' fields.

The policy implication is the goal of national seed systems in Kenya should be to ensure that the average age of varieties in farmers' fields is under 10 years, both to ensure that genetic gains are delivered steadily to farmers.

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