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Farmers' Maize Variety Ranking as a Food-Feed Crop and the Influence of the Feed Attribute on Variety Preference in Selected Mixed Crop-Livestock Production Areas of Ethiopia

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የሕዝብ ቁጥር መጨመር በግጦሽ መሬት ይዞታ ላይ በሚያሳድረው አሉታዊ ተፅዕኖ ምክንያት እንስሳት ለመኖ ምንጭነት በሰብል ተረፈ ምርቶች ላይ የበለጠ ጥገኛ እንዲሆኑ ያደርጋቸዋል:: በቅይጥ ሰብል ምርትና እንስሳት ርባታ ስራ ላይ የተሰማሩ አርሶ አደሮች የበቆሎ ዝርያን የመኖነት ጠቀሜታ ከዝርያ ምርጫ መመዘኛዎች አንዱ አድርገው እንደሚወስዱ የሚሰጥ መላምት አለ። የአሁኑ ጥናት ዓላማ የአርሶ አደሩን የበቆሎ ዝርያ ምርጫ ከሰብል ምርት በተጨማሪ የመኖነት ጠቀሜታን (ፖቴንሻል ዩቲሊቲ ኢንዴክስን) እንደመመዘኛ ይወስዳሉ የሚለውን መላምት ለመመርመር ነው። የዝርያ ምርጫ መረጃዎች በሞዴል (መልቲኖሚያል ሎጂት) በመታገዝ የተተነተኑ ሲሆን በውጤቱም BH 660 የተባለው የበቆሎ ዝርያ በሰብል ምርታማነቱ፣ በገለባ ምርቱና በገለባ የመኖነት ጠቀሜታው በአርሶ አደሮች የላቀ ደረጃ ተሰጥቶታል። በተያያዘ የአባወራው/የእማወራዋ የትምህርት ደረጃ፣ የግብርና ስራ ልምድ፣ የቤተሰብ ብዛት፣ የእርሻ መሬት ይዞታ፣ የእንስሳት ባለቤትነት፣ የብድር አቅርቦት፣ የግብርና ስርዐት አገልግሎት እና ፖቴንሻል ዩቲሊቲ ኢንዴክስ በአርሶ አደሮች የበቆሎ ዝርያ ምርጫ ላይ ተፅዕኖ እንዳላቸው ታውቋል። የዚህ ጥናት ውጤት በጥቅሉ በቅይጥ ሰብል ምርትና እንስሳት ርባታ የግብርና ስርዓት ውስጥ የሚገኙ አርሶ አደሮች የተሻሻሉ የበቆሎ ዝርያዎችን ሲመርጡ የመኖነት ጠቀሜታቸውንም ከግምት ውስጥ ያስገባሉ የሚለውን መላምት የሚደግፍ ሆኖ ተገኝቷል። በተጨማሪም ውጤቱ እንስሳት የሚያረቡ በቆሎ አምራች አርሶ አደሮች የተሻሉ የመኖነት ባህሪያትን ከሰብል ምርታማነት ጋር አዳቅለው የያዙ የበቆሎ ዝርያዎችን እንደሚመርጡ በተጨባጭ አሳይቷል።

Abstract

The ever increasing population pressure with subsequent dwindling grazing land area pushes greater dependence of livestock on crop byproducts as feed source. There is a hypothesis that maize producers in the mixed farming system value the feed attribute of maize varieties for adoption. This study was conducted to investigate farmers' rankings of maize varieties as a food-feed crop and analyze the influence of the feed attribute as described by the potential utility index in addition to grain production. The preference data generated from the study were fitted to a multinomial logit model. Results of the ranking exercise showed that BH660 was the highest in grain, stover and digestible stover yields whereas it was least in terms of palatability followed by BH540. Socio-economic variables which included education level of the household head, farming experience, family size, farm size, livestock ownership,

access to credit and access to extension service, and the variety attribute - potential utility index (PUI) - influenced farmers' maize variety preference. The results generally support the hypotheses set regarding factors that influence farmers' preference to improved maize varieties. Moreover, strong indications that livestock owning farmers do show preference to maize varieties that are with desirable stover characteristics for feeding livestock in addition to grain yield were evident.

Keywords: Digestible stover yield, maize, multinomial logit, potential utility index, variety preference

Introduction

The crop-livestock system is the most dominant land use system in Ethiopia where there is a great deal of interdependence between livestock and crops in food production and natural resource conservation. In this system, land holding per household has been seriously declining due to the steadily increasing population pressure. The largest share of the arable land goes to crop cultivation with a shrinking size of grazing land. Forage technologies have failed to be widely adopted by farmers in the country as is common to tropical developing countries (Mannetje, 1997 as cited by Reddy *et al*., 2003), due to inadequate technical support and lack of appropriate and sufficient input supply particularly forage seed. These make livestock depend more on crop byproducts for their feed source. The increasing dependence of ruminant livestock on crop residues calls for greater innovation through integration of crop and livestock production since livestock also greatly influence the ability of farmers to produce food and cash crops through draft power, cash availability and manure.

Maize contributes a significant amount of fodder in the form of green or dry stover for livestock feeding more importantly in the major maize growing areas. The yield and quality of the residue are determined by the genetic makeup of the crop, growing and harvesting conditions, threshing and storage methods. Increasing demand for fodder, shortage of arable land and water together are likely to put further pressure on feed resources. Failure of producers to feed animals adequately throughout the year continued to challenge livestock production and productivity in the country. Shortage of feed causes forced sale of livestock (Berhanu Gebremedhin *et al*., 2007a) which consequently affects overall agricultural production and productivity of a household by limiting the inputs/benefits that come from livestock. Improving the feed supply, both in quality and quantity, is an effective means to build assets and increase livestock productivity.

The need for food-feed maize cultivars that provide good stover yield and quality besides grain yield has been strongly advocated by researchers (Adugna Tolera, 2002; Devendra and Pezo, 2004; Singh *et al*., 2004). If varieties of maize that are

with desirable fodder characteristics are generated, it is believed to be of great contribution to the integration of maize and livestock as a result of increased feed supply to farmers to feed their livestock. However, farmers' choices depend on many factors. It is believed that decisions to innovate are often conditioned by the behaviour of individuals and the social and economic contexts within which decisions are made (Spielman, 2005).

This paper reports famers' perceptions about the feed values of released maize varieties as reflected by their ratings, and the influence of the feed attribute on varietal preference.

Materials and Methods

The study involved three important processes, namely, analysis of grain yield, and stover yield and quality of maize varieties, farmers' ratings of the varieties employing the rural appraisal technique and analysis of the factors that influence variety preference considering the feed attribute as one of the more conventional variables considered in adoption studies.

Description of the study sites

Three study areas from the mixed crop-livestock production system where maize is the dominant cereal crop grown were purposively identified. The study areas were identified by combining and overlaying maps and information related to maize cropping areas and mega environments, human population densities, livestock systems and livestock numbers which were synthesized using GIS. The identified sites were Awassa, Bako and Ambo areas from which Awassa, Bako Tibe and Ambo districts were randomly selected for the household level study.

Sample size and method of sampling

Sample size for the household based survey was determined according to Arsham (2007), $N = 0.25/SE^2$ where N = number of sample; SE = standard error, with the assumption of 4% SE. The calculated value came to be 156. However, the total sample size was set to be 350 with the intent of increasing precision. The number of sample households per district was determined based on the principle of 'probability proportional to size'. Accordingly, 90, 120 and 140 sample households were randomly selected and contacted from Awassa, Bako Tibe and Ambo districts, respectively.

Stover sampling and analysis

Stover sampling was done at the mature (dry) stage after grain harvest from on-station maize fields grown under recommended management conditions by cutting

on average 10 randomly selected maize plants from a plot and the conversion of yield per ha was according to the planting density. The fresh stover samples were oven dried at 60^0C for 48 hours and ground to pass through 2 mm size. The chemical composition and *in vitro* dry matter digestibility (IVDMD) values of the stover samples were estimated using the near infrared reflectance spectroscopy (NIRS) technique (Windham *et al.*, 1989). Moreover, digestible stover dry matter yields (DSY) were determined as a product of stover dry matter yield and the respective IVDMD coefficient. Analysis of variance (one way ANOVA using SPSS version 15.0 software) was carried out to see variety effects on the measured variables and mean separation was done according to the Duncan's multiple range test procedure (p=0.05). The variety preference data were analyzed using the STATA software.

Explanatory variables and hypotheses

There have been numerous reports on factors that influence agricultural technology adoption. Therefore, the factors hypothesized to influence farmers' maize variety preference (the dependent variable) were selected based on available literature. The factors (explanatory variables) considered were farmer characteristics, institutional factors and the variety attribute. The farmer characteristics included total farm size owned, livestock ownership, family size, education level of the household head and farming experience of the household head. The institutional factors, on the other hand, included access to credit, market and extension services. The variety attribute considered was 'potential utility index' which takes into account both grain and feed (stover quality and quantity) related attributes.

During the selection of the explanatory variables, this research has heavily drawn information from the work of Tesfaye Zegeye *et al*. (2001) on determinants of adoption of improved maize varieties in major maize growing regions of Ethiopia. These authors reported positive and significant influence of family size and livestock ownership and negative influence of distance to the nearest market center on improved maize variety adoption. However, Berhanu Gebremedhin *et al*. (2007b) reported a negative influence of distance to the nearest market center on maize variety adoption which is in a complete agreement with the logic that farmers located far from market centers will be less likely to be adopters of a technology.

The variables hypothesized to influence maize variety preference in this study are described as follows:

Location (LOC): This variable indicates where a farmer resides. Location variation is highly related with variations in the physical environment (agro-

ecology) and access to information and resource which in turn affects the type of maize variety to be grown and farmers' preference of maize varieties.

Family size (FAMSZ): This variable refers to the total number of people who are members of the household in question. This is expected to influence variety preferences by affecting labor available for farm activities. Different maize varieties require different management practices, the successful practice of which depends on the household's labor endowment.

Total farm size (FARMSZ)**:** This represents the total cultivable land owned (ha) by a household. This variable is expected to negatively influence the household's decision to use improved maize varieties with better fodder value since households with relatively large cultivable land will have the inclination to leave a portion of their land for grazing and therefore, have less need of stover for fodder.

Education level of the household head (EDU): This variable refers to the grade or years of formal schooling that the household head attended. Higher educational level is believed to be associated with the ability of obtaining, processing and utilizing new information, suggesting households with higher level of education would be more likely to adopt new technology.

Farming experience (FRMEXP): This is the number of years that a farmer experienced farming on his own. Short planning horizons in this study are equated with older but more experienced farmers who may be reluctant to switch from traditional methods to new practices because of their accumulated experiences whereas younger farmers with longer planning horizons may be more likely to take up new opportunities (Chilot Yirga and Hassan, 2008).

Livestock ownership (LVSTK): This variable refers to the total number of tropical livestock units (TLU) that a household owns. As the level of livestock ownership increases, the strength of the household to adopt new technologies becomes stronger. Moreover, livestock ownership is expected to positively influence the preference to maize varieties that can supply good fodder quality and quantity. In this study, livestock ownership is confined to cattle, small ruminants and equines as these are the species to which maize stover is and could be fed (the conversion of animal numbers into TLU was done according to Gryseels (1988)).

Access to credit (CRDIT): It is a dummy variable taking a value 1 if the household head reported that he/she has an access to credit and 0 otherwise. Access to credit for agricultural purposes can relax farmers' financial constraints and is expected to increase the probability of being involved in technology adoption. This is expected

to influence varietal preference in connection to the level of input requirement associated with a particular choice.

Access to extension services (DISEXT): Refers to the walking distance to the nearest development center measured in minutes. This variable accounts for the time a farmer may need to walk to contact his/her extension agent. The farther an extension office is located from farmers' homes, the less likely it is that farmers will have access to information and then make informed choices. Several studies show that farmers' contact with extension increased the probability of adoption and area allocation to improved maize varieties (Getahun Degu *et al.*, 2000; Abdissa Gemeda *et al.*, 2001). Based on these grounds, farmers' contact with extension workers is hypothesized to increase their likelihood of adopting improved maize varieties.

Access to market (DISMRKT): This variable refers to the walking time required to reach the nearest market center, which was expressed in minutes. The longer the walking time to markets, the lesser will be the likelihood of the household head to adopt new technology. Access to market is an important factor that affects farmers' inclination towards commercialized (market-oriented) production in terms of ease of procuring inputs and selling output. This in turn, influences farmers' choice of a variety and scale of production. If a farmer is far away from the market, it may be difficult for him/her to get improved farm input technologies or sell increased output from growing improved varieties. The study by Shiferaw Feleke and Tesfaye Zegeye (2006) indicated that access to market (distance to market) is negatively related to the probability of growing improved maize varieties.

Potential utility index (PUI): Farmers have subjective preferences for technology characteristics and these could play major roles in technology adoption. Adoption or rejection of technologies by farmers may reflect decision making based upon farmers' perceptions of the appropriateness (inappropriateness) of the characteristics of the technologies under investigation (Adesina and Zinnah, 1993). Guided by the maize breeding programs which basically aimed at improving grain yield without concern for yield and quality of the stover, variety attribute issues so far have been literally confined to grain yield whenever considered. However, realizing the contribution of maize stover for livestock feeding in the mixed crop – livestock production system of the major maize growing areas of the country, it was hypothesized that both grain yield and feed related attributes of maize varieties influence farmers' decisions or preferences for adoption. Therefore, potential utility index (PUI) was considered as one of the explanatory variables as a variety attribute expected to influence variety preference. Potential utility indices of the varieties were computed according to Adugna Tolera *et al*. (1999) employing the formula:

$$\text{Potential Utility Index (PUI)} = \frac{Grain\ \ yield\ + Digestible\ \ \ stover\ \ dry\ \ matter\ \ yield}{Total\ \ above\ \ ground\ \ biomass\ \ yield} \times 100$$

Because of the difference in the set of maize varieties available for choice in Ambo, Bako and Awassa areas, the analysis excluded the Ambo data. Some farmers failed to state their preference by name of the variety and these were also excluded. Therefore, the total sample size for this analysis was 181. Moreover, during the initial steps of the analysis, walking distance to the nearest market center and distance to development center were found highly correlated and thus distance to the nearest market was omitted. The model was also corrected for the presence of heteroscedasticity using White's heteroscedasticity correction standard error (Robust standard error). The dependent variable takes on three discrete values (1= BH660, 2= BH540 and 3= Pioneer), and BH540 was used as a reference category in the variety choice model (multinomial logit) and Bako was considered as the reference category for analyzing location effect. The maize varieties considered in this study are those recommended and commonly grown in the study locations.

Results and Discussion

Farmers' rankings of maize varieties as a food-feed crop in the study areas

The yield parameters of interest as computed from agronomic data and chemical composition analysis of the stovers obtained from the maize varieties are presented in Table 1. There were no significant differences ($p>0.05$) between the varieties in all the measured variables. However, numerically, BH660 was superior in terms of grain, stover and digestible stover yields followed by Pioneer.

Table 1. Grain, stover, digestible stover yield (DSY), cob and total biomass yields of the maize varieties (n=2)

	Yield (t DM/ha)				
Variety	Grain	Stover	DSY	Cob	Total biomass
BH540	7.58	7.16	3.87	1.47	16.21
BH660	9.20	10.01	5.85	1.34	20.55
Pioneer	8.63	9.48	5.05	1.72	18.99
Overall mean	8.47	8.88	4.92	1.36	17.84
SE	1.50	1.20	0.81	0.27	2.57

t = tones; DM = dry matter; ha = hectare

Table 2 presents a summary on farmers' rankings of maize varieties in the study areas. The farmers' evaluation of the maize varieties in terms of total stover yield agrees with the data collected from on-station trial fields (Table 1) where the improved variety with the name BH660 was the highest yielder. However, it was

rated least in terms of palatability in which case the locals (landraces) were ranked best. The local varieties were rated best for palatability mainly because of their softer stems but were characterized for being susceptible to lodging. The improved ones are with stronger stems which negatively affects the palatability of their stovers. This suggests that a breeding and selection strategy for maize genotypes with better feed value needs to focus, in addition to improving stover yield, on manipulating traits responsible for structural tissue development without compromising the merit for resistance to lodging. A high degree of structural tissue deposition limits the intake and digestibility of a feedstuff of plant origin since it is accompanied by a high rate of lignification of carbohydrates in structural tissues.

Table 2. Farmers' rankings (pair-wise) of maize varieties for feed value (stover yield and palatability) in the study areas listed in a descending order row wise

District	Total stover yield	Palatability
Bako	BH660, BH540, Local (*Burre*)	Local (*Burre*), BH540, BH660
Awassa	BH540, Pioneer, Local (*Sidancho*)	Local (*Sidancho*). Pioneer, BH540

* Words in parenthesis and italics are names of local varieties (landraces)
Source: Results of focus group discussions

Factors that affect farmers' preference for improved maize variety

The list of preferred maize varieties included BH660, BH540 and Pioneer. A descriptive summary for the demographic, socio economic and institutional characteristics of the sample farmers considered in the analysis are shown in Table 3.

Table 3. Demographic, socio-economic and institutional characteristics of farmers (n=181)

Variable	Minimum	Maximum	Mean	SD
Age of the household (HH) head (years)	20	81	41.18	12.84
Education level of the HH head (years of schooling)	0	12	3.29	3.23
Farming experience (years)	1	55	21.21	11.63
Family size (number)	2	24	7.38	3.12
Farm size (ha)	0	10	1.94	1.77
Livestock ownership (TLU)	0	53.08	4.46	5.73
Distance to market center (minutes)	0	180	37.74	32.25
Distance to development office (minutes)	0	180	34.20	30.35
Potential Utility Index (PUI)	70.5	73.2	72.16	1.27
Access to credit (1=Yes; 0=No)	0	1	(0.53)*	

*mean proportion; HH = household; TLU = tropical livestock unit; SD=Standard Deviation

Table 4 presents parameter estimates of the multinomial logit model. Differences in location and education level had no significant ($p>0.1$) effect on the preference of BH660 in relation to BH540. However, the effects of these variables were negative and highly significant ($p<0.01$) on the choice of Pioneer in relation to BH540. These imply that Pioneer is more likely to be adopted in Awassa than in Bako, and those farmers (in both locations) with higher education level are less

likely to grow Pioneer. Though this was the situation, this observation may differ from an outcome that could be obtained if education level were treated as a categorical variable.

Table 4. Parameter estimates of the multinomial logistic regression

Variable	BH660 (n1=71)		Pioneer (n2=49)	
	Coefficient	Standard Error	Coefficient	Standard Error
LOC	2.918	2.643	-160.743***	8.173
EDU	-0.052	0.115	-0.404***	0.070
FRMEXP	0.258**	0.127	0.176**	0.088
FAMSZ	-0.882*	0.456	-1.495***	0.339
FARMSZ	-0.628	0.716	-27.738***	0.711
LVSTK	0.533*	0.307	0.383	0.346
CRDIT	1.122	1.238	6.821***	1.309
DISEXT	-0.026	0.052	-0.151**	0.059
PUI	32.299***	0.093	66.525***	0.058
Constant	-2320.401		-4686.366	
No. of Observations		181		
Log Likelihood		-2.998e-15		
Pseudo R^2		0.957		

Note: BH540 is a reference category for variety preference, and Bako was the reference location. ***, ** and * are meant to indicate the significance of the corresponding coefficient estimates at 1%, 5%, and 10%, respectively.

The regression results revealed that socio-economic variables which included education level of the household head, farming experience, family size, farm size, livestock ownership, access to credit and access to extension service, and the variety attribute - potential utility index (PUI) - influenced farmers' maize variety preference. The results reported in the current study are in line with earlier reports on farmers' preferences and adoption of improved maize varieties elsewhere.

Moti Jaleta *et al*. (2013) showed that the probability of adopting improved maize increases with the level of household head's education, available family labor for farming, number of improved maize varieties known to a household, livestock owned, better soil fertility and soil depth of maize plots, increased number of reliable nonrelatives a household has within the village, better confidence in the skills of extension agents, availability of credit for seed purchased when needed. Danso-Abbeam *et al*. (2017) reported that variables such as the age of the household head, household size, level of experience, farm workshop attendance, the number of years in formal education, access to agricultural credit, membership of a farmer-based organization, availability of labor and extension contacts influence the adoption of improved maize varieties in Ethiopia. Similarly, Wang *et al*. (2017) reported several demographic and socioeconomic variables such as access to modern farm equipment, distance to market, age, gender, education level and occupation of the household head to have positive effects on hybrid maize adoption in Kenya. In a related work, Shiferaw Feleke and Tesfaye Zegeye (2006) reported positive influences of extension service, credit service, education level

and availability of labor force on improved maize variety adoption in Sothern Ethiopia.

Farm size did not have a significant effect on the preference of BH660. However, farmers with larger farm size are less likely to choose Pioneer.The other variable which had a significantly ($p<0.01$) positive effect on the preference of both BH660 and Pioneer in relation to the reference variety BH540 was potential utility index. This implies that farmers prefer BH660 and Pioneer for their better yield of grain and digestible stover. Farmers with better farming experience are able to weigh the overall utility of the varieties of maize they grow. However, education had no significant effect on the preference of BH660, while this variable exhibited highly significant ($p<0.01$) and negative influence on the preference of Pioneer, and this could be explained by the reason that most educated farmers are considered as model farmers and go for and/or prefer varieties that are supplied through the government facilitated (extension) channel.

Family size had significant negative influence on the preference of both BH660 and Pioneer. This came against the hypothesis that households with larger family size are more likely to grow maize varieties with better grain yield since the two give higher grain yields than BH540. Moreover, the positive and significant ($p<0.1$) effect of livestock ownership on the preference of BH660 over BH540 suggests that farmers owning livestock are more likely to grow maize varieties that are with better total and digestible stover yields.

Access to credit and walking distance to the nearest extension office had no effect on the preference of BH660. However, walking distance to the nearest extension office negatively and significantly affected the adoption of Pioneer. Farmers who have access to credit are more likely to prefer Pioneer, and this may be due to the fact that Pioneer seeds are more expensive than other improved seeds. The model results also showed that potential utility index had highly significant positive influence on the adoption of BH660 and Pioneer implying that the potential utility index, of a variety which includes the feed related parameters, is an essential variable that needs to be included in the process of maize variety generation and release.

Conclusion

The results generally support the hypotheses set regarding factors that influence farmers' preference to improved maize varieties implying that livestock owning farmers do show preference to maize varieties with desirable stover characteristics for feeding livestock in addition to grain yield. The variety BH660 was preferred most.The author recommends that maize breeders should consider the feed

attribute of the varieties they intend to develop when maize farmers in the mixed crop-livestock system are target beneficiaries.

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