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Crop residue usage and its determinants in Kano State, Nigeria

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This study examined crop residue usage and determined factors influencing the decision to allocate as well as the intensity of crop residue in Kano state, Nigeria. A multi-stage sampling technique was employed to select 160 farming households in three local government areas of the state. Data collected were analyzed with descriptive statistics and double hurdle Tobit model. The results of the study showed that on a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using crop residue for feeding than mulching. The allocation of the legume residues for feed purposes was about 64 percent; the share for cereal residues of animal feed was 26 percent. Other important competing uses of crop residue of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel. About 17 percent of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume crop residue (CR) was used within the farm/community (88.9 percent) while only 11 percent was exported. The decision to adopt cereal crop residue as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. On the other hand, decision to use legume crop residue was positively and statistically influenced by farm size and access to extension facilities. However, the intensity of use of both categories of residues was mostly determined by age, education and access to credit. Furthermore, results indicated that where both residues were available, farmers complemented the use of one with another. Concerted efforts should therefore be made at increasing awareness and education on the use of crop residues in the crop-livestock system. Similarly, facilitation of extension services in crop residue training and increased access to credit will reduce the degree of residue export from the system.

Key words: Double hurdle Tobit model, multi-stage sampling technique, legumes, cereal, crop residue.

INTRODUCTION

Background Information

Crop and livestock agriculture is important to the lives of most Nigerians. Fifty to eighty percent of Nigerians are involved in crop, livestock, or crop-livestock agriculture. Nigerian agriculture is dynamic. Farmers who were hitherto involved only in crop production have adopted crop-livestock production. Similarly, formally transhumant pastoralists are increasingly turning into agro-pastoralists (Agyemang et al., 1993). This change is largely spontaneous and is based on perceived reciprocal benefits that such a system offers. To meet the rapidly increasing demand for food by an ever-expanding human population (estimated at 2.5% annually) (Manyong et al., 2005), production from crop agriculture must expand by 4% annually while the production of food from animal agriculture must expand by more than 3% annually, between now and the year 2025. This will increase the pressure on land, leading to further intensification of land use. Under these conditions, full integration of crop and livestock production offers the greatest potential for increasing agricultural productivity, especially in the sub humid and wetter parts of the semiarid zones (Powell and Williams, 1995).

Crop residues from crop produced are of two general types: Those of the cereals (millet, sorghum, and maize) and those of the legumes (cowpea, groundnut, and soybean). The major crop residues which are grazed or stockpiled for ruminant feeding are millet and sorghum stalks, cowpea vines, cowpea husks, maize stover, maize husk, and groundnut haulms. The potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritional value are employed. According to Lal (2008), the amount of crop residues produced was estimated at ~ 0.5 billion Mg in USA and ~ 4 billion Mg in the world. These residues contained ~ 11 × 106 Mg of NPK in USA and 81 × 106 Mg in the world. Legume crop residues, such as groundnut haulms, cowpea vines, and cowpea husks have higher crude protein content and are generally used as supplements in addition to the grazing of ranges and cereal crop residues (Singh et al., 2003).

The crop residues of cereals may be left in the field as grazing material for livestock. They may be used as mulch, transported to the homestead for stall feeding, used as fencing, building, or roofing materials, or as fuel. The legumes on the other hand could be harvested and conserved either for dry-season feeding for the farmers' animals or for sale to other farmers during the critical period of feed scarcity in the mid-to-late dry season (Singh and Tarawali, 1997).

Many authors including (McIntire and Gryseels, 1987; Latham, 1997; Erenstein and Thorpe, 2010; Moritz, 2010) had identified two major uses of crop residues - use as livestock and use as mulch and opined that residue use as livestock feed exerts a competitive pressure on residue use as soil mulch. However, literature is scanty on the drivers of crop residue usage particularly in northern Nigeria. Therefore, analyzing the potential tradeoffs in the allocation of these residues and the socioeconomic setups influencing the decision and extent of use in a mixed crop-livestock systems becomes imperative in the study area. Enhancing the level of awareness on possible tradeoffs between crop residue use for livestock feeds and other competing uses need to be fully understood by farmers and other stakeholders in crop-livestock system for better management and improved livelihood.

Pertinent questions that may arise include the following: What factors influence their allocation decision? What factors determine the extent of use of the main uses crop residues are allocated? This study attempts to examine crop residue usage and determine factors influencing the decision to allocate as well as the intensity of use to main uses in Kano State, Nigeria.

Theoretical framework

This work is conceived as an adoption study. Adoption has been defined as decision to use a new technology or practice by economic units on a regular basis. Akinola et al. (2011) defines adoption as 'the use or non use of a technology by a farmer at a given period of time. Bekele and Drake (2003) opined that adoption decision involves the choice of how much resource (that is, land to be allocated to the new and old technologies, if the technology is not divisible (e.g. mechanization, irrigation). However, if the technology is divisible (e.g. improved seeds, fertilizer and herbicides), the decision process involves area allocation as well as the level of use or rate of application). Therefore, the process of adoption involves the concurrent decision of whether to use a technology or not and the intensity of its use. Besides, before adoption choices are made, a farmer makes a set several interdependent decisions (Hassan, 1996). Based on these definitions, use or non-use of a technology with subsequent intensity of usage is purely an adoption decision and process. The usage of crop residues could be seen as adoption of crop residue either as an intensification technology that boost the availability of biomass and consequent release of nutrients to the soil or a technology used as means of producing/raising livestock (feeds) . This is in view of substantial efforts put in place through the System-wide Livestock Program (SLP) in encouraging a systematic approach to the use of crop residues as animal feeds or nutrient enhancing technologies.

Moreover, according to Adesina and Zinnah (1993) and Negatu and Parikh (1999), three main models are used in explaining adoption. The models are the innovation-diffusion, economic constraints, and technology characteristics-user's context models. The innovation–

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diffusion model is mainly based on the ideas of Rogers (1962). The model regards information dissemination as a key factor of adoption decisions. It assumes that the technology is appropriate for farmer's problem but access to information on the technology to the potential adopters is the main constraint to adoption. It therefore emphasizes that medium such as extension system, on-farm trials, experimental station visits and mass media are necessary for new technologies to be adopted (Negatu and Parikh, 1999; Langyintuo et al., 2005). On the use of crop residues, extension services and media had been engaged for the adoption of crop residue as mulching or animal feeds.

The economic constraint model assumes that resources such as capital, credit and land are important for adoption decisions. The pattern of distribution of these resource endowments among potential users determines the pattern of adoption of a technology (Adesina and Zinnah, 1993). The specific influence of these resources as they pertain to use and non-use and the intensity of use of crop residue are duly explained under the empirical model.

The technology characteristics-user's context model assumes that characteristics of a technology in an agro-ecological, socioeconomic and institutional context of the potential user are necessary factors of adoption. This model further explains the importance of the perception of the potential adopter regarding the characteristics of a technology as a component factor affecting adoption decisions. It emphasizes the importance of the involvement of farmers through a participatory approach in the technology development process with the aim of generating technologies with appropriate and acceptable characteristics (Negatu and Parikh, 1999; Udoh and Kormawa, 2009).

The nature and the associated characteristics of crop residue to a large extent will determine the decision to use crop residues for any purpose at any point in time. Therefore, these three theoretical bases support the conception of crop residue as an adoptable technology.

METHODOLOGY

Study area

The study area was Kano State. Kano State is a state located in North-Western Nigeria. Kano state borders Katsina State to the North-west, Jigawa State to the North-east, Bauchi State to the South-east and Kaduna State to the South-west. Kano State has been a commercial and agricultural state, which is known for the production of groundnuts as well as for its solid mineral deposits. The state has more than 18,684 km^2 of cultivable land and is the most extensively irrigated state in the country. The primary occupation of most of the inhabitants is agriculture in the form crop farming and animal husbandry. The cultivation of food and cash crops remain common engagements of the people (Olofin, 1987). The mean annual rainfall is about 850 mm. The rainfall is highest in August (single maximal) with a sharp decline in September and an abrupt end in October (Olofin, 1980).

Sampling technique and data analysis

A multi-stage sampling technique was used for this study. The first stage involved a purposive selection of Kano South senatorial zone comprising of 16 LGAs. The second stage was also a purposive selection of three LGAs namely, Albasu, Wudil and Garko based on the intensity of crop-livestock production management system, marketing and utilization prevailing in the area. The third stage involved proportionate sampling of eight (8) villages based on their population. The villages chosen were Fadisonka, Indabo, Lajawa, Lamire, Utai and Kausani in Wudil LGA. Kafin Malama was chosen in Garko LGA while Saya Saya was selected Albasu LGAs. At the household level, farmers were stratified into very poor, poor middle and wealthy based on the degree of ownership of livestock and landed properties. In each category, 5 households were selected to make 20 households per village. On the overall 160 households were interviewed using a structured questionnaire. The sample size could have presented a limitation on the ability of the study to capture effects adequately at household level. But in view of the concentration of households that use crop residue in the study area and fewness of villages in the Sahel region that practiced crop-livestock integration, the sample can to a large extent describe the scenario of crop residues usage. Data collected were analyzed using descriptive statistics and double hurdle model.

Econometric specification

Double hurdle model

This study used the double hurdle model which was originally proposed by Cragg (1971). This has been recently used in the study of agricultural technology adoption (Gebremedhin and Swinton, 2003; Simtowe and Zeller, 2006; Langyintuo and Mungoma, 2008; Asfaw et al., 2010). This model assumes that households must cross two hurdles or make two decisions in order to adopt a given technology, e.g., crop residue (CR). The first decision is to decide whether to adopt or not (probability of adoption). The second decision is about the share of land that the household will allocate for its cultivation (intensity of adoption) which is conditional on the first decision. The model allows for the possibility that the probability and intensity of adoption have different explanatory variables and even variables appearing in both may have different effects (Asfaw et al., 2010; Teklewold et al., 2006; Simtowe and Zeller, 2006; Langyintuo and Mungoma, 2008. The first hurdle, decision to adopt CR (d) is expressed as:

$$d^{*}=z_{i}\alpha+\varepsilon_{i.}$$
$$di=1 \text{ if } d_i^{*}>0 \text{ and } 0 \text{ if } d_i^{*}\leq 0 \qquad (1)$$

The second hurdle, intensity of adoption (y) is expressed as

$$y^{*}=xi\,\beta+\mu i.$$
$$yi=yi^{*} \text{ if } yi^{*}>0 \text{ and } di^{*}>0$$
$$yi=0 \text{ otherwise} \qquad (2)$$

Where d_i^* is a latent variable that describes household decision to adopt CR, y_i^* is a latent variable describing the intensity of adoption and y_i is the observed response on intensity of CR. z and x are vectors of variables explaining the decision to adopt and intensity of use of CR respectively. α and β are vectors of the parameters. ε_i is an error term with mean 0 and variance 1. μ_i is also an error term with mean 0 and variance σ^2. The two error terms are assumed to be independent. They are based on the assumption that the double hurdle model is equivalent to a combination of a probit model and a truncated regression. The two hurdles are normally estimated with the maximum likelihood method of probit regression for probability

Table 1. Description of key variables for regression.

Variable	Variable descriptions	Unit
HHHHAGE	Age of the household head in years	Years
HHEDU	Number of years of formal education completed by the household head	Years
HHSIZE	Number of people living together under the same roof and eating from the same pot	
EXTENSION	An ordinal measure of training on crop residue use. It is proxied by household possession of radio or mobile phone which are the reliable channels of communication in the study area; 1 if possessed, 0 if not	
CREDITAC	Access to credit measured by the farmer's access to a source of credit such as co-operative society at a reasonable cost. 1 if there was access, 0 otherwise.	
ELECTRICITY	Access to electricity. An ordinal measure 1, if there was access, 0 otherwise	
PLOTSIZE	Size of household farm land used for farming	ha
RENT	Value of land leased for agricultural purposes	Naira
TLU	Livestock holdings of the household as probable source of wealth	Tropical Livestock Units
QTLEGUMECR	Quantity of available legume crop residue	kg
QTCEREALCR	Quantity of available cereal crop residue	kg

of adoption using all observations. They also employ truncated regression using the non-zero observations (Gebremedhin and Swinton, 2003; Teklewold et al., 2006).

Empirical model

The empirical model employed for each of the two stages of the double hurdle model is as stated below:

$$Y_i = \beta_0 + \beta_1 HHHHAGE + \beta_2 HHEDU + \beta_3 EXTENSION + \beta_4 HHSIZE + \beta_5 TLU + \beta_6 CREDITAC + \beta_7 ELECTRICITY + \beta_8 PLOTSIZE + \beta_9 RENT + \beta_{10} QTLEGUMECR + \beta_{11} QTCEREALCR + \mu \quad (3)$$

The dependent variable is the proportion of cereal or legume crop residue used for feed The explanatory / independent variables included farmer, farm and institutional factors postulated to influence adoption of technologies. These variables include age of the household head in years (*HHHHAGE*), education of the household head *(HHEDU*) measured in years, number of people in the household (*HHSIZE*), livestock ownership *(TLU)* measured in Tropical Livestock Units, access to credit (*CREDITAC*), farm size of the respondents (*PLOTSIZE*) and extension services (*EXTENSION)* proxied with possession of radio or mobile phones via with the information relating to crop residue uses are disseminated Also included were the value for which land is leased for agricultural purposes *(RENT*) in Naira, quantity of legume crop residue (QTLEGUMECR) or/and cereal crop residue (QTCEREALCR) available (Table 1).

The rationale for inclusion of these factors was based on previous agricultural technology adoption literature and the analysis of these systems. The effect of age (*AGE*) on the use of crop residue could be negative or positive irrespective of intensification gradients and .manners of redistribution. Previous studies show that the age of individuals affect their mental attitude to new ideas and influences adoption in several ways (Feder et al., 1985; Nkonya et al., 1997; Oluoch-Kosura et al., 2001; Bekele and Drake, 2003). Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risk and adopt innovation because of their longer planning horizons. The older the farmers, the less likely they are to adopt new practices as he gains confidence in his old ways and methods. On the other hand, older farmers may have more experience, resources, or authority that may give them more possibilities for trying a new technology. Thus for these study, there is no agreement on the sign of this variable as the direction of the effect is location- or technology-specific (Feder et al. 1985; Nkonya et al. 1997; Oluoch-Kosura et al. 2001; Bekele and Drake 2003).

Education (*HHEDU*) was hypothesized to positively influence the decision and proportion of residue that would be redistributed in the farm and in the system and negatively related to the export of nutrients from the systems. Education increases the ability of farmers to use their resources efficiently and the allocative effect of education enhances the farmer's ability to obtain, analyze and interpret information (Feder et al., 1985; Alene et al., 2000; Nkonya et al., 1997; Oluoch-Kosura et al., 2001).

Household size (*HHSIZE*) has been identified to have either positive or negative influence on adoption (Manyong and Houndekon, 1997, Zeller et al., 1998; Oluoch-Kosura et al., 2001; Bamire et al., 2002; Bekele and Drake, 2003). However, larger family size could be associated with a greater labor force being available to the household for the timely operation of farm activities including crop residue use. More labor hours will be spent on transporting crop residue away from the farm. The study hypothesize that increased household size could favour export of crop residue away from the farm.

Institutional factors of training on crop residue use (*EXTENSION)* as well as access to credit (*CREDITAC*) are hypothesized to positively influence the redistribution of nutrients in the farm and in the systems. The training variable incorporates the information that the farmers obtain on their production activities on the importance and application of innovations through counselling and demonstrations by extension agents on regular bases. The effect of this information on adoption varies depending on channel, source, content, motivation, and frequency. The present study hypothesized that the respondents who frequently receive training have higher probability of adoption than those that do not (Adesina and Zinnah, 1993; Shiferaw and Holden, 1998; Oluoch-Kosura, 2001; Bamire et al., 2002; Mazvimavi and Tmomlow, 2009). Access to electricity (*ELECTRICITY*) is generally perceived to reduce the use of biomass such as CR for household energy (like fueling, burning). It is employed through the use of electric boiler and cooker especially for domestic purposes. However, such role depends on its affordability by rural households. It is hypothesized that access to electricity will reduce export of crop residue from the farm and thereby aiding redistribution of nutrients in the system.

The variable, credit access *(CREDITAC),* takes cognizance of farmers' access to sources of credit to finance the agricultural activities and thereby boosts farmers' readiness to adopt technological innovations. It is hypothesized that the variable has a positive influence on the probability of the adoption and use of improved technologies (Zeller et al., 1998; Oluoch-Kosura et al., 2001; Bekele and Drake, 2003). It is measured as a dichotomous variable with access being one, and zero for no access. It is expected to boost redistribution of nutrients within the farm or systems.

The variables *QTCEREALCR* and *QTLEGUMECR* are hypothesized to positively influence redistribution of nutrients within the farm and outside the systems as they indicate the level crop residue production. But availability of one in a given system may reduce the quantity of another needed at any point in time. Measure of livestock holdings possessed by the households *(TLU)* could be positively or negatively related to redistribution of nutrients in the farm because it can serve as a source of manure for increased crop residue production. The livestock can also feed on crop residue thereby exporting it away from the system. Ownership of larger number of livestock is expected to increase the demand for crop residue as feed. Moreover, the demand for crop residue as feed potentially on livestock type households keep (Erenstein and Thorpe, 2010).

The value for which land is leased or rented (*RENT*) is expected to be negatively related to the quantity of crop residue produced. And the lower the production of crop residue, tieless will be the quantity available for redistribution in or out of the farming system.

RESULTS AND DISCUSSION

Socioeconomics characteristics and asset ownership of farming households

According to Hassan and Babu (1991), the level of asset ownership in a household is an indication of its endowment. It provides a good measure of the state of households in times of food crisis, resulting from famine, crop failures, or natural disasters. In general, household capital assets or livelihood resources could be classified into five: Human assets (e.g. household labour capacity, family and non-family labour), natural assets (e.g. total and cultivated farm land), physical assets (e.g. ownership of cattle, bicycle, radio, television, etc,), financial assets (e.g. access to cash credit and remittances) and institutional/social capital assets (e.g. access to social networks and membership of associations) (Elis, 2000). Tables 2 and 3 show socioeconomics characteristics and asset ownership of farming households.

Age has been found to determine how active and productive the head of the household would be. Age has also been found to accelerate the rate of household adoption of innovation that in turn affects household productivity and livelihood improvement strategies (Derion and Kushmen, 1996). Average household head age was 45 years, which is still within economic active working life. The farming household size was relatively large with an average household size of 11. Large household size could provide family labour for the household especially where hire labour is scarce. It could also place higher burden on the household in term of feeding and sustenance demands of its members. In traditional agriculture, household labour endowment which can be a proxy to family size is an important factor when new technologies are introduced into an area. Availability of labour will go a long way to determine the adoption of such technologies. In the absence of sufficient family labour, the cost of hiring labour or opportunity cost of labour can hinder the adoption or promotion of new agricultural technologies. However, a person equivalent labour force was 4.5, indicating that children and old aged people characterized the family size. This might imply that thus hiring of labour for farm work will be a major alternative to meet labour demand of the farming households.

Education of the household heads is another socioeconomic feature which also fall under human capital: it is expected that the higher the level/years of education, the higher the probability of taking the right decision, read simple instruction relating to farming and take necessary precautions where necessary.

The level of education determines the level of opportunities available to improve livelihood strategies. The average year of education was 9 years, meaning that at least average household head could read and write. Extension services would also play a major role in building the knowledge stock of farming communities. They help farmers to translate research results into improvement in crop and livestock production and thus livelihoods. Visits by extension agents to farmers and participation in field day/training are cost effective ways of reaching out with the new technologies to a larger number of farmers. More than 70% of households had contact with farmers on various issues relating to crop livestock production and its technologies.

With respect to natural assets, 96% of the respondent own personal land while the average farm size cultivated was 4.5 ha. Average TLU per household which was based on ownership of ruminants was 5. This may suggest availability animal dung for farm manuring and other purposes that will help ensure soil fertility maintenance and management. It is also availability of CR from household farms to serve as feeds to livestock

Physical asset comprises the basic infrastructure required to support livelihoods in a given environment (rural or urban). These basic infrastructures include adequate water supply, sources of energy, secure shelter, and access to transportation and communication facilities. Table 3 indicates that majority of the household heads have basic assets and. On the average, 97% of the household heads owned houses. Seventy two percent have access to electricity power supply, 52% own mobile phone and 97% possessed radio. Majority of the respondents (97%) possessed radio. This implies that radio is the highest means of information/communication

Table 2. Socioeconomics characteristics and asset ownership of farming households.

Variable group	Variable's name	Variable's estimate (N =159)
Demographic feature		
	Gender percent	
	Male (%)	*99.4*
	Female (%)	*0.06*
	House head age- average	45±11.3
Livelihood capital		
Natural	Own land (percent hh)	96
	Farm size (ha hh-1)	4.5±3
	Livestock size (TLU hh-1)	5±4.5
	Good productivity plot (percent as perceived by farmers)	84.5
Human capital	Family size (head hh-1)	11.1±8.3
	Person equivalent labor force	4.5±2.9
	Average year of education	9.1±4
	Information from extension-percent	89.1
Physical (percent households)	Access to electricity	72.3
	Has radio	96.9
	Has mobile phone	51.6
	Own house	97.5
	Transport	
	motor mbike	50.4
	Car	1.3
	Power fodder chopper	12.0
	Manual fodder chopper	9.0
	Water sources	
	Well	94.0
	tube well	27.0
	River	27.0
	Pond	33.3
	Pipe borne	47.8
	Others*	14.5

Source: Field Survey (2011). Figures added represent standard deviations

available to farmers.

Information on farming activities including crop residues (CR) management could be accessed through radio. Communication on marketing of CR can be done using mobile phones. Although, very few farming household own car/vehicle, but majority 50% of them have motor bike, which can facilitate transportation for effective CR management. Only 12% had access to power chopper in their CR management. Table 1a reveals that 'well' and 'pipe born water' were the highest sources of water in the study areas. All the households have access to drinking water. However, water access for irrigational practices is absent across the project villages but 91 percent have access to water for livestock production. Grass is predominantly used for roofing (75%). Iron and asbestos roofing is employed by 11% while only 6percent used crop residue for roofing. On the other hand, majority (76%) used mud for their wall material; 14% claimed that their wall material is dried brick; 8% used bamboo/wood and only 1% used concrete.

With respect to social capital, quite numbers of the household heads are member of different agricultural associations. About 43% are member of crop association. This could be an avenue for accessing credit facilities among the members. It could be a forum for productive ideas in the farming activities especially on CR management. In the study area, for financial capital, crop, livestock, labor and business were the major sources of income. Business/self employment had the major share A significant proportion of households in the study areas

Table 3. Socioeconomics characteristics and asset ownership of farming households (hh).

Variable group	Variable's name	Value (N=159)
Social (Percent households)	Member of crop producer association	42.8
	Member of livestock producer association	16.4
	Member of dairy cooperative	3.8
Financial-income (Percent total household income)	Total farm income	37.5
	Crops, main products	15.5
	Crops ,residues	5.9
	Other feed or forage	4.7
	Livestock sales	10.1
	Dairy product sales	1.3
	Total non –farm income	62.5
	Agricultural labour	8.9
	Other non agric labour	7.9
	Regular employment	11.4
	Business/ self employed	24.6
	Remittances	8.8
	Other non farm income	0.9
Financial-access to credit (percent households)	Credits	28.3
	Savings	95.0
Financial-expenditure (Percent total)	Farm Expenditure	12
	Crop inputs	3.8
	other farm input	0.5
	harvesting/transp.	2.1
	Livestock inputs	2.6
	hired labour	3
	Non-farm expenditure	87.9
	Food	35.8
	Education	5.9
	Health	5.6
	Social events/leisure	9.2
	Transport	6
	Housing	15.9
	Others	9.5

Source: Field Survey, 2011.

reported an access to credit (28%) with the majority from informal sector (54%). About 97.4% of the respondent in Kano has cultivated a good habit of saving through acquisition of livestock (72.3%). Saving in banks is low (9.2%).

Information on crop residue and its technologies

The result shows that 89% of the household sold crop residue for monetary gains. Different storage type existed for crop residue; namely - field heap, home heap, room and hanger type. About 18% of the households heaped crop residue on the field. 49% of households heaped crop residue at home at the backyard, 34% of household kept crop residue in a room and about 9% of the household used hanger in storing crop residue. However, home heap constitutes the highest storage type used (49%). About 97% of household stored all part of cereal plant as crop residue. Only 3% of the households stored leaves as crop residue. About 85% of the households stored all part of legume plant but only 10% stored leaves as crop residue.

Crop residues uses and its determinants

Crop residue uses

Table 4 summarizes crop residues uses by type and

Table 4. Percent of crop residues uses by purpose and type.

Crop residue (CR) uses (%)	Cereals (N =159)	Legumes (N =159)
Within the farm (on farm)		
Stall feeding	26.15	63.52
Mulching	0.20	0.01
Grazed by own animals	0.96	2.29
Subtotal on farm	*27.31*	*65.82*
Within the system (on site)		
Grazed by others animals	0.17	0.02
Sold to others on field	7.09	13.58
Sold later	5.39	14.59
Subtotal on site	*12.65*	*28.19*
Outside the system (exported)		
Burnt	2.88	1.50
Used as fuel	41.52	1.86
Used for construction	10.80	1.02
Used for other purposes	4.84	1.61
Subtotal exported	*60.04*	*5.99*

Source: Field Survey, 2011

purposes. Ten purposes of legume and cereals residues uses, with three major grouping, were distinguished: (i) those that redistribute nutrient within the farm (e.g. mulching, and stall feeding and grazing by own animal); (ii) those that redistribute nutrients within the system (e.g. grazed by other animals; sold to others on filed; sold later), and (iii) those that export nutrient out of the system (e.g. burning, household fuel, construction and used for other purposes).

On a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using CR for feeding than mulching. The allocation of the legume residues for feed purposes was 63.52% while for cereal residues the share of animal feed was 26.15%.
Other important competing uses of CR of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel.

About 17% of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume CR was used within the farm/community (88.9%) while only 11% was exported.

Regression analysis

Adoption and intensity of use of cereal CR as livestock feeds

Factors determining farmers' decision of crop residues use are numerous and complex (Harries, 1999). This is particularly true in the early stage of crop livestock intensification systems where locally available organic resources are under competitive uses. Factors influencing adoption and intensity of adoption of cereal CR as livestock feeds are shown in Table 5. The decision to adopt cereal CR as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. An increase in age by one year led to 5% increase in the probability of using cereal CR as feeds for livestock. However, a one year increase in education of average household increased the probability of using cereal CR as feeds for livestock by about 15%. On the other hand, a one percent increase in access to credit resulted in about 150% increase in probability of adopting cereal CR as feed. This might not be unconnected with increased production as a result of better funding ability of farming households.

As regard intensity of use of cereal CR for livestock feed, increase in farming experience used as proxied for age indicated that 1 year increased the quantity of cereal CR used for livestock feed by about 3%. Experienced household heads preferred using their CR for feeds than selling it. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Access to information made available by increased education has positive and statistical significant influence on the quantity of CR used for the feeding.

A one year increase in education increased the quantity of CR used for feeding livestock by about 8percent. Similarly, a one unit increase in access to credit increased the quantity of CR residue used for livestock feeds by about 30%. Access to credit will provide alternative means of

Table 5. Factors affecting adoption and intensity of use of cereal CR as livestock feeds.

Coefficient	First hurdle		Second hurdle	
Variable	**Coefficient**	**T-Value**	**Coefficient**	**T-Value**
CONSTANT	0.0034	0.59	-0. 0076	-0.02
AGE	0.0503***	1.70	0.0257*	5.59
EDUCATION	0.1506***	1.64	0.0782*	5.85
FAMILY SIZE	0.0326	0.61	-0.0005	-0.08
ELECTRICITY	0.3793	0.53	0.1605	1.38
CREDIT	1.5099***	1.93	0.3079*	2.8
PLOT SIZE	0.0114	0.23	0.0268*	2.69
QTCEREALCR	0.0202**	2.38	0.0061*	4.37
QTLEGUMECR	0.0165	0.76	-0.0095***	-1.75
TLU	-0.0429	-0.46	-0.0081	-0.56
EXTENSION	-	-	1.5271*	6.52
Number of observation	132		107	
Waldchi^2(14)	37.58		2329.280	
Log likelihood	-37.0157		-590.923	
Prob> chi^2	0.0006		0.0001	

*, **, ***, the estimate is significant at 1, 5 and 10%, respectively.
Source: Field Survey (2011).

Table 6. Factors affecting adoption of usage of legumes CR as livestock feeds.

Coefficient	First hurdle		Second hurdle	
Variables	**Coefficient**	**T-value**	**Coefficient**	**T-value**
CONSTANT	0.0006	0.93	0.0004	0.11
AGE	0.0005	0.03	0.0500*	7.50
EDUCATION	-0.0113	-0.15	0.1070*	3.72
FAMILY SIZE	-0.0106	-0.26	-0.0160	-1.15
EXTENSION	1.2420**	2.13	0.7030*	4.16
CREDIT	-1.0145***	-1.71	0.538*	2.70
QTLEGUMECR	-0.1162	-1.2	0.1030*	3.20
QTCEREALCR	0.0071	0.74	-0.004	-0.52
PLOT SIZE	0.1356*	2.63	-0.012	-0.74
RENT	0.2095	1.16	0.0000	0.11
TLU	0.0557	0.74	-0.0044	-0.52
Number of observation	127		127	
Wald chi^2 (11)	31.8		2329.280	
Log likelihood	-42.4734		590.923	
Prob > chi^2	0.0008		0.000	

*, **, ***, the estimate is significant at 1, 5 and 10%, respectively.
Source: Field Survey (2011).

of getting fund for energy, construction materials and other uses to which cereal CR were being used for. However, availability of alternate source of feed like legume CR has a negative influence on the quantity of cereal CR used for feeding. The use of legume CR as feeds complemented the probability of using cereal CR as feeds.

This may indicate that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 1% reduction in the quantity of cereal CR used for livestock feeds. The effect of TLU was negative and not significant.

Adoption and intensity of use of legume CR as livestock feeds

Factors influencing the adoption and intensity of adoption of legume CR were investigated. Table 6 shows factors influencing the adoption and intensity of adoption of legume CR. Extension facilities made available through the use of mobile phones and radio was a significant variable positively influencing decision to use legume CR as livestock feed and not for sales. One percent increase in access to extension facilities increased the probability farmers deciding to use legume CR as livestock feed by about 124%. This is because mobile phones provide a medium for farmer-to-farmer interaction through which information is spread on technological adoption. The size of land used by the household also has positive and significant influence on the decision to use legume CR as feeds for livestock. An increase in farm size by 1 ha increased probability of using legume CR as livestock feeds by about 14%. On the other hand, access to credit discouraged the used of legume CR for livestock feed. This might be because access to credit might provide money for another means of feeding livestock one unit increase in access to credit decreased the probability of using legume CR as livestock feed by about 100%.

Intensity of use of legume CR as livestock was influenced by age, education, extension and the quantity of crop residue produced on the farm. Increase age by 1 year increased the quantity of legume CR used for livestock feed by about 5%. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Education has positive and statistical significant influence on the quantity of legume CR used for the feeding. The better educated a farmer is the less he will want to sell his legume CR. A one year increase in education increased the quantity of CR used for feeding livestock by about 11%. Extension facilities also played significant role in influencing the quantity of legume CR used for livestock feed. Increase in access to extension facilities by 1 units increased the quantity of legume CR used by about 70%. Similarly, a one unit increase in access to credit increased the quantity of legume CR used by about 54%. This implied that access to credit will provided alternative means of getting fund for energy and construction materials. The use of cereal CR as livestock feeds also complemented the use of legume CR. This implies that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 0.4% reduction in the quantity of legume CR used for livestock feeds. Although, TLU was negative in the second hurdle, but it was not significant.

Conclusion

The potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritional value are employed. Legume crop residues, such as groundnut haulms, cowpea vines, and cowpea husks, are high in protein and are generally used as supplements in addition to the grazing of ranges and cereal crop residues. This study examined crop residue usage and determined factors influencing the decision to allocate as well as the intensity of use to main uses in Kano State, Nigeria.

About 18% of the households heaped crop residue on the field. About 49% of households heaped crop residue at home at the backyard. About 34% of household kept crop residue in rooms while 9% of the household used hanger. However, home heap constitutes the highest storage type used (49%). About 97% of household stored all part of cereal plant as crop residue. Only 3%of the households stored leaves as crop residue. About 85%of the households stored all part of legume plant but only 10% stored leaves as crop residue. On a general note, crop residues allocated for own animal feeding had the major share. Farmers preferred using crop residue for feeding than mulching. The allocation of the legume residues for feed purposes was about 64% while for cereal residues the share of animal feed was 26%. Other important competing uses of crop residue of legumes and cereals were also different. These included stall feeding, burning, house construction and fuel. About 17% of legumes residues are sold either on field or offsite. Legume residues were major sources for redistributing nutrient within the farm and between farm units (within the systems). More of legume CR was used within the farm/community (88.9%) while only 11% was exported.

The decision to adopt cereal CR as livestock feeds was positively and significantly influenced by age, education, access to credit facilities and quantity of cereal crop residue available to the farmers. Increase in farming experience 1 year increased the quantity of cereal CR used for livestock feed by about 3%. Experienced household heads preferred using their CR for feeds than selling it. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Access to information made available by increased education has positive and statistical significant influence on the quantity of CR used for the feeding. A one year increase in education increased the quantity of CR used for feeding livestock by about 8%. Similarly, a one unit increase in access to credit increased the quantity of CR residue used for livestock feeds by about 30%. Access to credit will provide alternative means of getting fund for energy, construction materials and other uses to which cereal CR were being used for. However, availability of alternate source of feed like legume CR has a negative influence on the quantity of cereal CR used for feeding. The use of legume CR as feeds complemented the probability of using cereal CR as feeds. This may indicate that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 1% reduction in the quantity of cereal CR used for livestock feeds.

The decision to adopt legume crop residue as livestock feeds is influenced by extension and farm size. Intensity of use of legume CR as livestock was influenced by age, education, extension and the quantity of crop residue produced on the farm. Increase age by 1 year increased the quantity of legume CR used for livestock feed by about 5%. Literate farmers know the importance of using CR for feeds than immediate gain of trading that may not be profitable in the long run. Education has positive and statistical significant influence on the quantity of legume CR used for the feeding. The better educated a farmer is the less he will want to sell his legume CR. A one year increase in education increased the quantity of CR used for feeding livestock by about 11%. Extension facilities also played significant role in influencing the quantity of legume CR used for livestock feed. Increase in access to extension facilities by 1 units increased the quantity of legume CR used by about 70%. Similarly, a one unit increase in access to credit increased the quantity of legume CR used by about 54%. This implied that access to credit will provided alternative means of getting fund for energy and construction materials. The use of cereal CR as livestock feeds also complemented the use of legume CR. This implies that farmers know the importance of combining cereal and legume CRs to maximize livestock production. A one percent increase in the quantity of legume CR available led to about 0.4% reduction in the quantity of legume CR used for livestock feeds.

Concerted efforts should therefore be made at increasing awareness and education on the use of crop residues in the crop-livestock system. Similarly, facilitation of extension services in crop residue training and increased access to credit will reduce the degree of residue export from the system.

Conflict of Interest

The authors have not declared any conflict of interests.

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