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DETERMINANTS OF POST-HARVEST MAIZE LOSSES BY PESTS IN MID HILLS OF NEPAL

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ABSTRACT

A survey was conducted in the mid and far western mid-hills of Nepal randomly sampling 120 household heads to determine the factors influencing post-harvest maize losses due to pests. Ordinary least squares regression was used to analyze the parameters associated with losses. Results showed that post-harvest maize loss was significantly influenced by time of harvest, altitude, occupation of household head, structures for storing cobs (husked and de-husked) and shelled grains. Farmers who harvested maize cobs before the first week of September and stored shelled grains in jute bags (katto), suffered grains loss by 14% and 5%, respectively. The findings clearly indicated 8%, 6%, 4% and 2% reduction of postharvest losses by growing and storing maize below 800 masl, households with farming occupation, storing de-husked cobs in bamboo basket (dokko) and storing husked cobs in vertical/horizontal wooden or bamboo frames (thakro), respectively. Hence, it is necessary to aware farmers about appropriate harvesting time, storage structures and post harvest handling practices to reduce pest loss in maize storage.

Keywords: Household, survey, maize, post-harvest loss, determinants

INTRODUCTION

Maize is the second most important cereal crop in terms of area cultivated (891583 ha) and productivity (2.5 t/ha) after rice (1362908 ha and 3.2 t/ha) in Nepal. Maize occupies 27% area and contributes 26% of the total cereal production (MOAD, 2015/016). The crop suffers with severe post-harvest losses due to different factors. In Nepal, 10-20% of cereal grains are lost during post-harvest (Bhandari et al, 2015). Ransom (2000) reported several factors; physical (temperature, moisture, and elevation), biological (insects, diseases and, rodents), mechanical (harvesting, processing and transportation and storage structures) and socio-economic (education, occupation of household head, storage period, purpose and, affordable level of protection) factors affecting post-harvest losses in maize. Among them, insect pests and diseases are considered major ones, causing not only direct loss but also paving the way for fungal and bacterial infection, and affecting food value, quality and acceptability. The loss and damage caused by storage pests has been variably estimated by a number of researchers in the range of 10 - 100% depending upon maize storage structures and physical environment (Boxall and Gillet, 1980; Khanal et al., 1990; Paneru et al., 1996; Golob, 1994; Shivakoti and Manandhar, 2000).

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Farmers follow diverse maize storage structures and practices especially in mid hills of Nepal. These affect the occurrence and incidence of pests in maize storage. Research works are limited on such crucial factors associated with maize storage losses by pests in mid and western mid-hills of Nepal. Therefore, an attempt was made to assess factors associated to pest losses in post-harvest maize storage.

MATERIALS AND METHODS

Study areas and sampling methods

Two sites in each of the district namely; Surkhet and Dadeldhura as a representative of mid-western and far-western mid hills, respectively, were selected in consultation with personnel of CSISA-NP (Cereal Systems Initiative for South Asia), KISAN-Project (Knowledge-based Integrated Sustainable Agriculture and Nutrition) and DADO (District Agriculture Development Office) as shown in Table 1. These districts were selected because maize is the major crop for food and feed in these districts. Furthermore, the study sites were stratified with the help of concerned local leaders and staff of agriculture service center. Accordingly, the number of eligible households was determined on the basis of altitude and quantity of the maize seeds sown by farmers. The household, who used more than three kg of seeds and then stored considerable quantity of maize in a particular storage structure for a considerable time period was considered as eligible household. A total of 120 household representatives comprising of 30 households from each of the four sites were included in this study. For this, the survey questionnaire was prepared, pre-tested and finalized through a face-to-face interview with the farmers and required information was collected. The survey was conducted during May to December, 2015.

Table 1. Survey sites selection in Surkhet and Dadeldhura districts of mid and far-western region of Nepal, 2015

Region*	District	Altitude	Study site	Villages
MWR	Surkhet	Low (<800msl)	Kunathari VDC	Anpkholi, Sunadwari, Badigaun, Sajpani, Salghari, Simalpani, Giddamare, Belchaur, Halduamala Khali Village
		Mid (800-1500msl)	Gadi VDC	Gothikanda, Baelkanda, Ramrikanda, Tijugaira, Mahelpani, Ghodilas, Thanitol
FWR	Dadeldhura	Low (<800msl)	Alital VDC	Bahirisen, Tallobhavar, Mallkheda, Banstol
		Mid (800-1500msl)	Amaragadi MP & Koteli VDC	Bhatsiraula, Sallagaun, Rautgaun, Ayartol and Asurba

* MWR=Mid Western Region, and FWR=Far Western Region of Nepal

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Regression analysis

We used an ordinary least squares regression (OLS), to identify the parameters associated with post-harvest maize losses due to pests. Both numerical and categorical variables were used for the analysis. If Y is the percentage losses caused by the pest during storage then the numbers of factors are likely to determine the losses. A review of related literature shows that post-harvest maize losses was expected to influence by number of variables like; early harvest, altitude, illiteracy, primary education, occupation, household number, land holdings, maize variety, storage period and storage structures. So, the factors influencing the post-harvest maize losses (Y) can be derived by using regression function as;

$$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \beta_{14}X_{14} + \mu_i$$

Where,

Y= Post harvest maize loss percent

α = Intercept term

X_1= Farm size (ha)

X_2= Early harvest (=1 if crop is harvested before first week of September, otherwise 0)

X_3= Altitude (=1 if <800 masl and 800-1500 masl = 0)

X_4= Primary education (=1 if household head is primary educated, otherwise 0)

X_5= Secondary education (Dummy variable, 1= if got the secondary education, otherwise 0)

X_6= Occupation (Dummy variable, (=1 if household head's primary occupation is farming, otherwise 0)

X_7= Total number household members

X_8= Maize variety (Dummy variable, 1= if maize variety is *SETO* local, otherwise 0)

X_9= Storage period for husked cob maize (month)

X_{10}= Storage period for shell grain maize (month)

X_{11}= Storage period for de-husked cobs (*thiti*) (months)

X_{12}= Storage structure for husked cobs (1= *thakro*, otherwise 0)

X_{13}= Storage structure for de-husked cobs (*thiti*) (1= *doko*, otherwise 0)

X_{14}= Storage structures for shelled grains ((1=*katto* otherwise 0)

β_i = Partial slope of the independent variables (i= 1, 2……14)

μ_i= Disturbance term

RESULTS AND DISCUSSION

The survey indicated post-harvest maize losses up to 19.5% ±12.5 due to pests (insect and rats) and the diseased (rotten) cobs up to 3.2% in mid- and far-western mid hills of Nepal, where, the mean loss percent due to pest was higher (26.2%±13.5) in the mid altitude as compared to low altitude (12.9% ±6.5) (Table 2). While, the mean cobs diseased percent (rotten) was higher (4.0%±1.8) in the low altitude as compared to mid altitude (2.4±2.4%).

Table 2. Farmers' response on proportion of grain loss (due to pest) and rotten cobs in maize storage in MWR & FWR of Nepal, 2015

Parameters	Mean grain loss (%) ±SD at indicated altitudes						
	MWR (Surkhet)		FWR (Dadeldhura)		Region		
	Low (N=30)	Mid (N=30)	Low (N=30)	Mid (N=30)	Low (N=60)	Mid (N=60)	Total (N=120)
Grain loss by pest (insects, rats)	12.8 ±7.9	19.1±11.0	13.0 ±5.0	33.3 ±12.2	12.9 ±6.5	26.2±13.6	19.5 ±12.5
Rotten cobs	3.6 ± 2.1	1.7±1.8	4.3 ±1.5	3.1 ±2.8	4.0 ±1.8	2.4 ±2.4	3.2 ±2.3

SD= Standard deviation, MWR=Mid-western region, FWR=Far-western region, Low altitude=<800 masl & Mid altitude = 800-1500 masl.

The results showed that, the major causes of cob rotten were due to aflatoxin, high grain moisture content (GMC), insect and disease attack, damage by rats, birds and other animals, harvest from lodged and de-tasseled plant, and immature cob harvest (Table 3).

Table 3. Farmers' response on major causes of cob rotten in mid- and far-western region of Nepal, 2015

Causes	Frequency (%)						
	MWR (Surkhet)		FWR (Dadeldhura)		Region		
	Low (N=30)	Mid (N=30)	Low (N=30)	Mid (N=30)	Low (N=60)	Mid (N=60)	Total (N=120)
i	15(51.7)	11(36.7)	0	13(43.3)	15(25.4)	24(40.0)	39(32.8)
ii	0	0	4 (13.3)	0	4 (6.8)	0	4 (3.4)
iii	0	3(10.0)	0	1(3.3)	0	4 (6.7)	4 (3.4)
iv	0	5(16.7)	0	10(33.3)	0	15 (25.0)	15(12.6)
v	6(20.7)	3(10.0)	0	1(3.3)	6(10.2)	4(6.7)	10(8.4)
vi	5(17.2)	3(10.0)	0	0	5 (8.5)	3(5.0)	8(6.7)
vii	0	0	1(3.3)	1(3.3)	1(1.7)	1(1.7)	2(1.7)
viii	0	0	23(76.7)	0	23 (39.0)	0	23(19.3)
ix	0	3 (10.0)	0	0	0	3(5.0)	3(2.5)
x	2(6.9)	2(6.7)	0	0	2 (3.4)	2 (3.3)	4(3.4)
Other combinations : xi – xvii							1(0.8)

MWR=Mid-western region; FWR=Far-western region, altitude=Mid, Low; Low =<800 masl;

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Mid =800-1500 masl; I = high GMC; ii = diseases; iii = high GMC + insects; iv = high GMC + diseases; v = high GMC + harvest from lodged plant; vi = high GMC + immature cobs harvest; vii = insects+ diseases; viii = Aflatoxin + high GMC + insects + diseases; ix = high GMC + insects + diseases; x = high GMC + diseases + harvest from lodged plant; xi = Aflatoxin+high GMC; xii=Aflatoxin+high GMC+ rats, birds & other animals; xiii=Aflatoxin+high GMC+insects+diseases+rats, birds & other animals; xiv=high GMC+disease+ rats, birds & other animals; xv=high GMC+disease+immature cob harvest; xvi=high GMC+ immature cob harvest+harvest from detassel plant; xvii=Aflatoxin+high GMC+ diseases+rats, birds & other animals.

The Table 4 shows the summary statistics of the variables used for ordinary least square (OLS) regression to determine the factors responsible to post harvest maize losses.

Table 4. Summary statistics of the variables used in the regression analysis, 2015

SN	Variables	Mean	St.dev.	Min.	Max.
	Percentage grain damage during post-harvest	19.54	12.52	2	52
1.	Farm size (ha)	0.73	0.43	0.1	2
2.	Early harvest (=1 if crop is harvested before 1st week of September, otherwise 0)	0.06	0.24	0	1
3.	Altitude (=1 if <800 masl and 800-1500 masl = 0)	0.50	0.50	0	1
4.	Primary education (=1 if household head is primary educated, otherwise 0))	0.35	0.48	0	1
5.	Secondary education (=1 if household head is secondary level educated, otherwise 0)	0.25	0.43	0	1
6.	Occupation (=1 if HH head's primary occupation is farming, otherwise 0)	0.68	0.47	0	1
7.	Total number of household members	7.58	2.97	3	20
8.	Maize variety (=1 if variety grown is ***SETO*** local, otherwise 0)	0.38	0.49	0	1
9.	Storage period for husked cob (month)	6.41	2.12	2	12
10.	Storage period for shelled grains (month)	3.37	2.75	0.5	9
11.	Storage period for de-husked cobs(*Thiti*) (month)	2.63	1.64	0.25	8
12.	Storage structure for husked cobs (1= *thakro*, otherwise 0)	0.67	0.47	0	1
13.	Storage structure for de-husked cob (*Thiti)* (1= *doko*, otherwise 0)	0.25	0.43	0	1
14.	Storage structure for shelled grain (1=*katto* otherwise 0)	0.83	0.37	0	1

Mean values of 120 respondents; St.dev. = Standard deviation; Min. = Minimum and Max. = Maximum.

Table 5 presents the results of OLS regression model for determining the factors of post-harvest maize losses. The coefficient of early harvesting is statistically significant at 1% level indicating that farmers who harvest maize early before first week of September suffer post-harvest loss by 14%. Similarly, the coefficient of storage structure for shelled grain in jute bag (*katto*) was statistically significant at 5% level. It indicates that the farmers who store shelled grains in jute bag (*katto*) suffer grain loss by 5%. In contrast, the value for altitude was statistically significant at 1% level and negatively associated with grain losses. This indicates that storing maize in lower region (<800 masl) reduces post harvest losses by 8%. The farmers in lower region store shelled grains for shorter duration as compared to mid altitude and sell their produce before weevil damage occurs. Similarly, the coefficient of household with farming occupation is statistically significant at 1% level and negatively associated with maize loss. This implies that the relevancy of farmers experience on farming occupation minimize post-harvest loss by 6%. The coefficient of storage structure for husked cobs in vertical/horizontal frame (*thakro)* was also statistically significant at 5% level and negatively associated with grain damage and thus reducing post-harvest maize losses by 2%. Similarly, the coefficient of storage structure for de-husked cobs in bamboo basket (*dokko*) was statistically significant though at 15% level and negatively associated to grain loss. It contributed to minimize the post-harvest maize losses by 4%. The R square is mainly due to effect of harvesting time, altitude, occupation, and storage structures. These factors contribute 58% (R value) of losses.

Table 5. Determinants of post-harvest maize losses by pests in mid- and far-western region of Nepal, 2015

SN	Variables	Coefficient	Standard error	t-value	P>t
	Model intercept	29.67	7.18	4.13	0.000
1.	Farm size (ha)	-2.66	2.08	-1.27	0.205
2.	Early harvest (=1 if crop is harvested before 1st week of Sept. , otherwise 0)	13.7***	3.16	4.35	0.000
3.	Altitude (=1 if <800 masl)	-8.43***	2.90	-2.9	0.004
4.	Education of household head (1= illiterate, 0 otherwise)	2.52	4.72	0.54	0.594
5.	Education of household head (1= primary level, 0 otherwise)	5.24	4.80	1.09	0.278
6.	Education of household head (1= secondary level, 0 otherwise)	0.89	4.68	0.19	0.849
7.	Occupation of household head (1= farming, 0 otherwise)	-6.30***	2.22	-2.84	0.005
8.	Household size (no of household members)	0.31	0.33	0.96	0.337

9.	Maize variety (=1 if variety grown is ***SETO*** local)	-0.22	1.81	-0.12	0.902
10.	Storage period for shelled grains (month)	-1.44	2.58	-0.56	0.579
11.	Storage period for de-husked cobs (*Thiti*) (month)	0.59*	0.38	1.54	0.127
12.	Storage structure for husked cobs (1= *Thakro*, otherwise 0)	-1.72**	0.77	-2.24	0.027
13.	Storage structure for de-husked cobs (*Thiti*) (1= *doko*, otherwise 0)	-4.31*	2.57	-1.68	0.096
14.	Storage structure for shelled grain (1=*katto* otherwise 0)	4.96**	2.44	2.03	0.044
	F (15, 104)	71.57			
	R-squared	0.585			
	No of observations	120			

*, **, ***, indicate that corresponding coefficients are statistically significant at 15%, 5% and 1% level, respectively.

DISCUSSION

It is evident that post-harvest maize loss was significantly influenced by harvesting time, altitude, occupation of household head, storage structures (for husked and de-husked cobs, and shelled grains). Ransom (2001) reported that there is direct relationship between relative humidity, room temperature and grain moisture content (GMC) to activate biological process in the grain storage. High humidity coupled with high temperature and GMC (>12%) can allow insects and diseases to establish and cause grain loss. Early harvesting of maize (before physiological maturity) encourages insect pest activity due to high GMC and easy access to grains (Paneru and Sah, 2001). The present survey showed that farmers start harvesting of *SETO* local maize as early as on the last week of August and as late as third week of October. The GMC of maize is high in early harvested maize, which is coincided with the rainy season (high temperature and air moisture). Usually monsoon rain in Nepal ends September onward. Therefore, early harvest of maize before first week of September could have significant impact on the post harvest loss. Rembold et al. (2011) reported that the post-harvest loss in maize depends upon the weather conditions at harvesting, storage length and presence of pests, which are highly variable (5 – 30%) in developing countries.

Mwangi et al. (2017) reported that in Kenya post-harvest losses in maize was mainly caused by biological factors, such as insects, moulds, moisture, rodents, spillage and birds. Farmers commonly stored the shelled grain in polypropylene bags. Many smallholder farmers sold their grain immediately after harvest to avoid damage by storage pests (Boxall, 1998; Proctor, 1994). Bhandari et al. (2015) reported that farmers follow diverse maize storage practices varying from location to location. They reported over two-third of the maize growers (73%) in Baglung storing maize in jute bags in the form of shelled grains. Similarly more than three-fourth of the maize growers (77%) in Palpa, Gulmi and Syangja districts stored in form of husked maize cobs. Metal silos are found very effective in reducing stored grain losses by insect pests, that has impact on the welfare and food security of farm households (Gitonga et al. 2013). The insects can easily access to shelled grains stored in jute bags as compared to husked cobs in vertical/horizontal frame outside the house (*thakro)* and de-husked cobs in bamboo basket (*doko)*. The GMC of husked cobs stored in *thakro* and de-husked cobs in *dokko* remains low as compared to grains stored in jute bags. This survey revealed that the farmers in lower altitude stored shelled maize grains for shorter duration as compared to mid altitude and sold their produce before weevil damage occurs. Thus, relevancy of farmers experience on farming occupation minimizes post-harvest loss. These findings provide important clues to ascertain the post-harvest maize loss causing factors, which influence pest damage in maize storage. Thus, it is necessary to aware maize growers about these factors to protect post-harvest losses.

CONCLUSIONS

Results showed that post-harvest maize loss was significantly influenced by time of harvest, altitude, occupation of household head, structures for storing cobs (husked and de-husked), storage period for de-husked cobs and shelled grains. Farmers, who harvested maize cobs before the first week of September and practiced jute bag (*katto)* storage, suffered grains loss by 14% and 5%, respectively. The findings clearly indicated 8%, 6%, 4% and 2%, reduction of post-harvest losses by growing and storing maize below 800 masl, household with farming occupation, storing de-husked cob in bamboo basket (*dokko)*, and storing husked cobs in vertical/horizontal wooden or bamboo frames (*thakro*), respectively. Therefore, farmers must be aware of these loss determinants to protect post-harvest maize losses.

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