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Research Article

Assessment of Maize Production and Adoption of Improved Maize Seeds in Tanahun District of Nepal

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Abstract

The major objective of this study is to assess the status of maize production and adoption of improved maize seeds in Tanahun district. The study also aims to determine the factors affecting the adoption of the improved seeds. 100 maize farmers from four different local bodies of Tanahun were selected by the purposive sampling method for the household survey. Descriptive statistics, chi-square test, independent samples *t*-test, one-way ANOVA, logit model and index score ranking method were used for the data analysis. The productivity of maize and annual income from maize were 767.62 kg/ha and Rs 9500 higher for the farmers using improved seeds as compared to those using the local seeds. The mean annual household income of farmers replacing the seeds yearly was Rs 18983 higher than the farmers replacing the seeds rarely. The frequency of the agriculture technician support and the frequency of seed replacement with the improved seed were found to significantly determine the adoption of the improved maize seeds. Farmers receiving the regular technician support were 15.726 times more likely to adopt the improved seeds as compared to those receiving the technician support rarely or never. The adopters had 458.10 kg/ha higher productivity than the non-adopters. Lack of irrigation facility was found to be the major problem in maize cultivation whereas the lack of timely availability of improved seed was found to be the most important constraint for the adoption of improved seeds.

Keywords: Maize; seeds; improved; production; adoption

Introduction

After rice, maize (*Zea mays* L.) is the second most important crop of Nepal in terms of both area and production. In Nepal, maize is cultivated in 900288 ha with the production of 1300121 mt (MOALD, 2017). It is cultivated for food, feed and fodder. More than 80% of the maize produced in Terai is used for poultry and animal feed whereas more than 86% of the maize produced in hills is used for human consumption (Gurung *et al*., 2011). The feed demand in Nepal is increasing at the rate of 11% per annum (CDD, 2011). KC *et al*. (2015) reported that the demand of maize is shifting from food to livestock and poultry feed. The productivity and attainable yield of maize in Nepal is 2.55 mt/ha and 5.70 mt/ha respectively (MOALD 2017; KC *et al*., 2015). The factors causing lower yield of maize in

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Nepal are the use of low-quality seeds, poor crop management practices and low soil fertility (Karki *et al*., 2015).

Seed is the most important input that determines the agricultural production. The productivity of other inputs and the upper limit of yield is determined by the seed (Bernard *et al*., 2010). Thus, it is important to assure the farmer's access to improved and high yielding seeds to sustain and increase the overall production. But the limited amount of improved seed is available in Nepal and it is not sufficient to meet the increasing demand of the improved maize seeds (Sapkota *et al*., 2018). Most of the farmers use the farm retained seeds. The number of farmers using the farm-saved seeds is more than 88% in Nepal (Gurung, 2011). The improved seeds developed by various national and international research centers are often not adopted by the smallholder farmers (Morris *et al*., 1999). Poor availability of improved seed often limits the maize production of smallholder farmers (Bett *et al*., 2006). The major constraints for increasing the production are lack of quality seeds of preferred varieties at the right time, in required quantities and at the reasonable price (Adhikari *et al*., 2003). Thus, technology transfer through the adoption of improved seeds is crucial to increase productivity and farm income (Feder and Onchan, 1987).

There can be numerous causes for the lower adoption of the improved maize seeds. It can include; negative attitude of the farmer towards the improved seeds, lack of knowledge, poor availability, higher price, farmer's age and lack of labour. Kaliba *et al*. (2000) studied the factors determining the adoption of improved maize seeds among the maize farmers in Tanzania. They reported the availability of extension services, varietal characters, on-farm trials and irrigation as the most important factors. Oyekale and Idjesa (2009) also reported the higher probability of adopting the improved maize seeds by the farmers with greater access to the extension services. Mureithi *et al*. (2002) used a logit model to analyze factors affecting the adoption of maize production technologies in Kenya. They reported gender, access to the extension services, credit facilities and labour availability to be the determining factors. Miller and Tolley (1989) recommended that market intervention by price support and government subsidies can help to enhance the adoption of improved maize seeds. In addition, Sapkota *et al*.(2018) recommended that better cultivation practices and use of the quality seeds for seed production can raise the yield of maize seeds. They also suggested the use of the larger area for maize seed production so that the cost of the inputs can be minimized and higher profitability can be achieved.

The major objective of this study is to assess the status of maize production and the adoption of improved maize seeds in Tanahun district. The area, production and productivity of maize in Tanahun are 22002 ha, 65684 mt and 2985 kg/ha respectively (MOALD, 2017). Although the yield of this district is greater than the national average, there is a possibility to increase it further towards the attainable yield. This study aims to determine the factors affecting the adoption of improved seeds among the farmers and generate the results that can be used for designing the policy strategies and interventions to increase the adoption and utilization of improved seeds.

Materials and Methods

Survey Design and Study Area

In order to study the status of maize production and adoption of improved maize seeds in Tanahun, four local bodies of the district; Vyas Municipality, Myagde Rural Municipality, Bandipur Rural Municipality and Shukhlagandaki Municipality were selected. A total of 100 respondents, 25 from each local body of maize growing households were surveyed and the sample was selected on the basis of purposive-random sampling. A semi-structured questionnaire was used to collect data on the status of production of maize and the adoption of maize seeds among the respondents. Four focus group discussion (FGDs) and key informants' interview were conducted to double check the survey data.

Statistical Analysis

Data were analyzed by using IBM SPSS (Version-25.0), STATA (Version-13.0) and MS-Excel 2016. Descriptive statistics tool was used to calculate the frequencies, mean and percentages. Chi-square test was performed to test the relationship of frequency of agriculture technician support with farmer's source of seed and frequency of seed replacement with the improved seed. One-way ANOVA was used to test the effect of frequency of seed replacement with improved seed on the annual household income. An independent samples *t*-test was performed to test the statistical significance of the association between adopters and the non-adopters for the maize productivity.

The adoption index for improved maize seed was calculated by using the following formula;

$$\text{Adoption Index} = \frac{\text{Total Score Obtained by an Individual}}{\text{Maximum Possible Score}} \times 100$$

Eqn. 1: Adoption Index

Here, the total score obtained by an individual is represented by the area of maize under improved seeds and the maximum possible score is represented by the total area under maize cultivation.

A binary logit regression model was used to determine the determinants of adoption of improved maize seeds. The model assumed the adoption of improved seeds as the binary dependent variable with '1' for the higher level of adoption i.e. adopters (adoption level > 75 percentage) and

'0' for a lower level of adoption i.e. non-adopters (adoption level < 75 percentage). In this model, dependent variable was the adoption of improved maize seeds whereas the explanatory variables used were the frequency of agriculture technician support, annual household income, the frequency of seed replacement with improved seeds, education of the household head and the total cultivated land.

The problems faced by the farmers were identified through FGDs and were ranked by using the index score method by using the formula,

$$I = \frac{\sum Sifi}{N}$$

Eqn. 2: Index Score Ranking Formula

Where,

I = Index Score (0<I<1)

Si= score obtained

fi= frequency

N= total number of the respondents

Results and Discussion

Status of Maize Production in Nepal

Maize is the second most important crop of Nepal after rice in terms of both the area and production. It is cultivated for food, feed and fodder. The area and production of maize in Nepal is 900288 ha and 1300121 mt respectively (MOALD, 2017). As shown in Fig. 1, the area, production and productivity of maize in Nepal has a variable trend. The area of maize increased from 870166 ha in 2007/08 to 906253 ha in 2010/11, decreased to 849635 ha in 2012/13 and gradually increased to 900288 ha in 2016/17. The area under maize cultivation is at increasing trend after 2014/15. Similarly, the production of maize is also at increasing trend from 2014/15 (2145291 mt) to 2016/17 (2300121 mt). Farmers use the improved seeds and/or local seeds for maize cultivation. As shown in Fig. 2, the productivity of improved seed is rising in hills of Nepal. In the fiscal year 2016/17, the productivity was 2607 kg/ha as compared to 2510kg/ha in 2015/16. However, there is a decline in productivity of local seeds in hills of Nepal from 1694kg/ha in 2015/16 to 1263kg/ha in 2016/17 (Fig. 3).

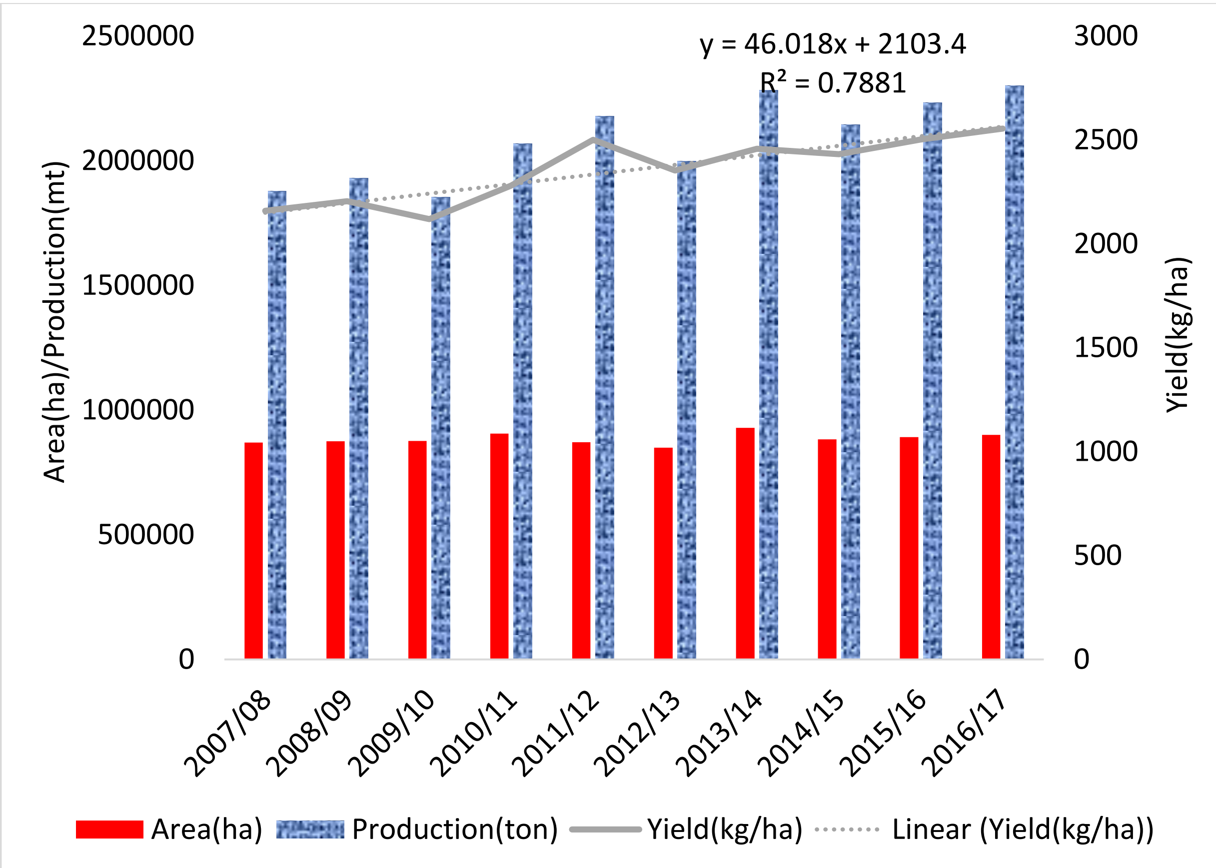

Fig. 1: Area, production and productivity of maize in Nepal (Source: MOALD, 2017)

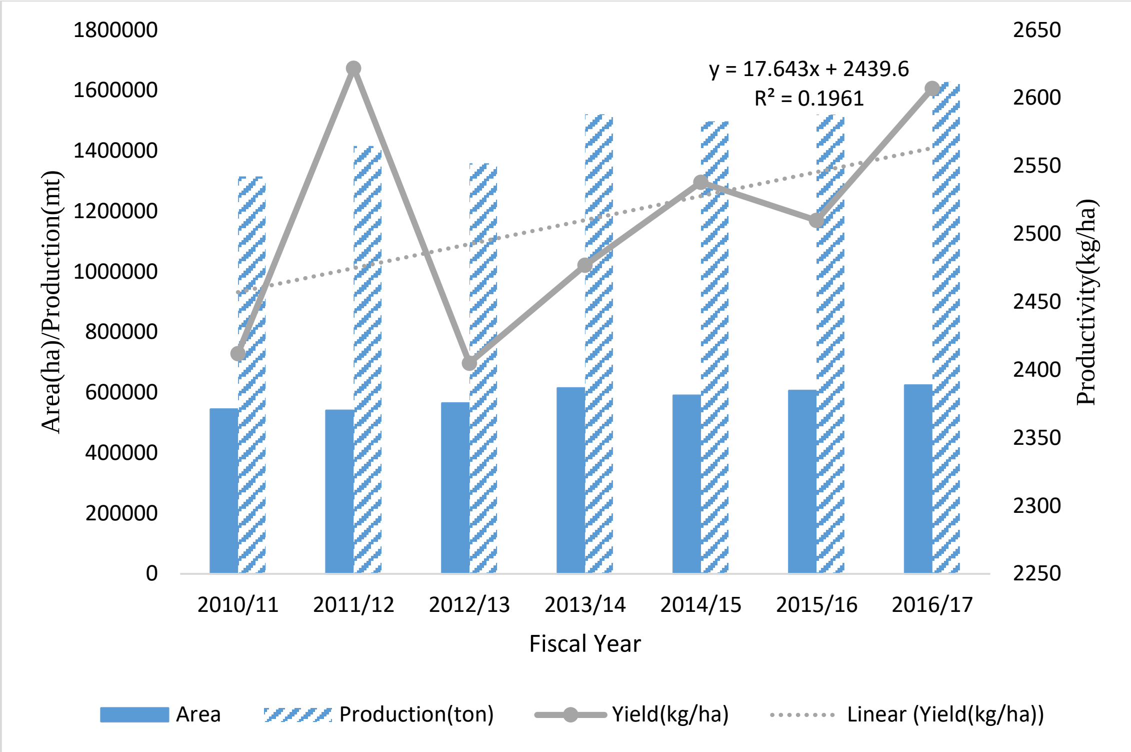

Fig. 2: Area, production and productivity of improved seeds in hills of Nepal (Source: MOALD, 2017)

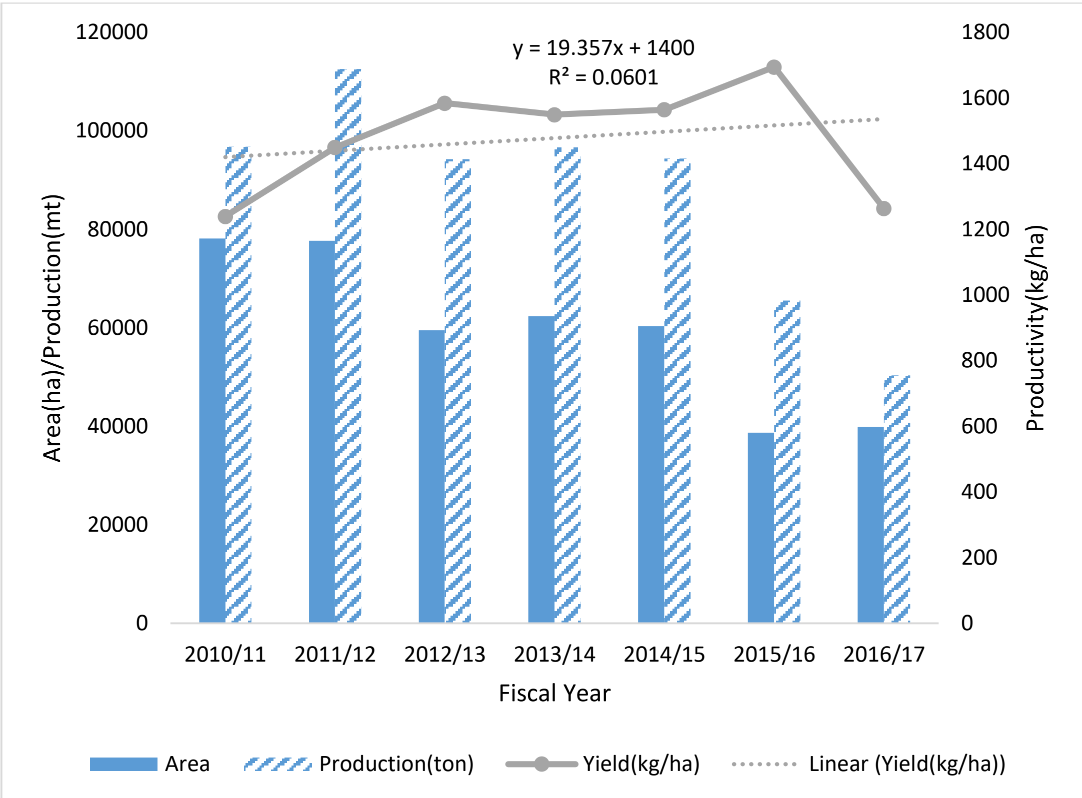

Fig. 3: Area, production and productivity of local seeds in hills of Nepal (Source: MOALD, 2017)

Status of Maize Production in the Study Area

The mean area under maize cultivation was 0.31 ha whereas the mean area under improved and local seeds were 0.167 ha and 0.15 ha respectively. The mean productivity of the improved seeds and local seeds were 1582 kg/ha and 1121.35 kg/ha respectively. The maximum productivity of the improved seed was found to be 2751.98 kg/ha greater than the maximum productivity of the local seeds in the study area.

In the study area, farmers were found to use improved seeds only, local seeds only or the combination of both improved and local seeds. 40% of the respondents were found to use improved seeds only, 40% were found to use local seeds only while 20% were found to use both. The use of improved seeds only had the highest mean area of 0.34 ha while the use of the local seeds only had the lowest mean area of 0.283 ha. Percentage of household consumption of maize among the farmers using the local seeds only was 94%, it was 87.50% for those using both improved and local seeds whereas the household consumption was 85% of the farmers using improved seeds only (Fig. 4). The lower household consumption of the improved seeds may be due to the taste preference and better storability of the local seeds. As shown in Fig. 5, the productivity of maize was highest in improved seed only (2540.57 kg/ha) followed by those using both improved and local seeds (2378.61 kg/ha) and those using the local seeds only (1772.38 kg/ha). The annual income from maize was also found to be highest in the improved seeds only (NRs 17075) as compared to both improved and local seeds (NRs 10150) and the local seeds only (NRs 7575). The productivity and annual income from maize of farmers growing only improved seeds were respectively 767.62kg/ha and Rs 9500 higher than farmers growing only the local seeds.

Table 1: Area, Production and Productivity of Maize in the Study Area

	Improved Seeds		Local Seeds		Total	
	Mean	Maximum	Mean	Maximum	Mean	Min-Max
Area (ha)	0.167	1.73	0.15	0.76	0.31	0.03-1.73
Production (kg)	397.95	3850	257.65	2100	655.6	70-3850
Productivity (kg/ha)	1582	6879.95	1121.35	4127.97	2200.9	655.23-6879.95

Table 2: Area and Production of maize under different seed usage system

Seed Usage		**Percentage (%)**	**Mean Area (ha)**	**Mean Production (kg)**
Improved Only		40.00	0.34	792.25
Local Only		40.00	0.28	458.13
Both Improved and Local	**Improved**	20.00	0.15	405.25
	Local		0.17	372.00

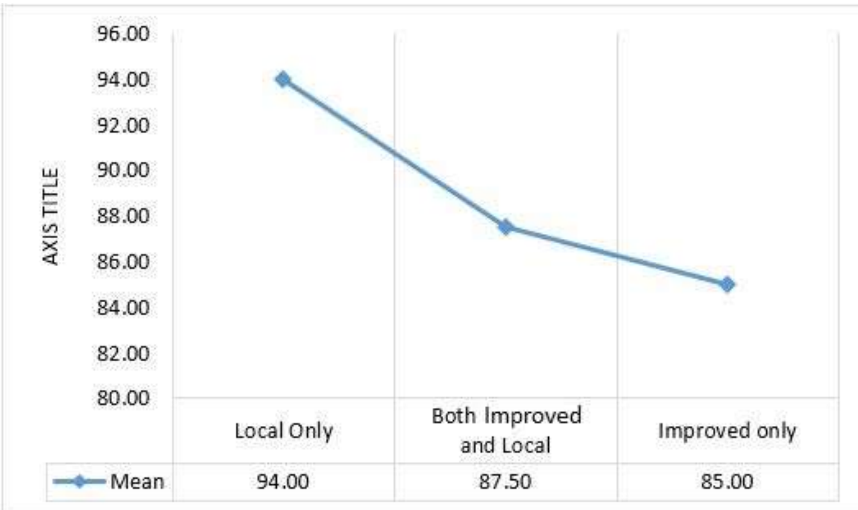

Fig. 4: Percentage of household consumption across different seed usage system

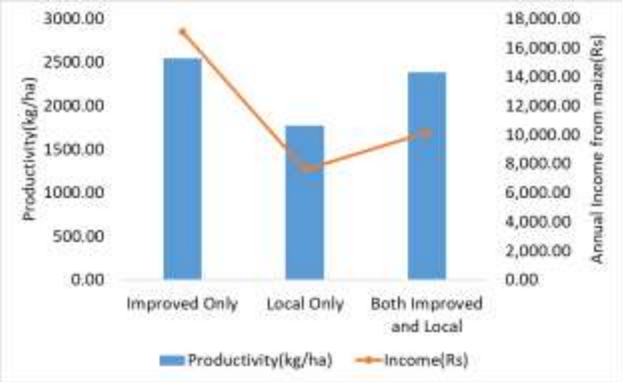

Fig. 5: Productivity and income in different seed usage systems

Seed Replacement Status

As shown in Table 3, 39 respondents replaced the seeds with improved seeds every year, 19 respondents replaced the seeds every 2 years, 6 respondents replaced the seeds every 3-5 years while 36 number of farmers rarely replaced with the improved seeds. The productivity of maize was found to be highest in those replacing the seeds yearly (2526.142 kg/ha) followed by replacing the seeds every 2 years (2019.584 kg/ha), rarely (1992.713 kg/ha) and every 3-5 years (1910.122 kg/ha).

Chi-square test was performed to test the association between frequency of agriculture technician support and the frequency of seed replacement with improved seeds. The association between these variables was found to be highly significant, X^2 (6, N=100) =43.780, $p < 0.01$. Bonferroni correction was used for the post hoc analysis. The Bonferroni adjusted *p*-value required for significance was 0.004167. The regular technician support was found to be significant with the yearly and rare seed replacement and the rare technician support was found to be significant with the rare replacement of seed. There was a significant difference in all categories of seed replacement for those who never received the technician support.

23.08% of farmers who replaced the seeds yearly never received the technician support while 63.16% of farmers who replaced the seeds every 2 years never received the technician support. None of the farmers replacing the seeds every 3-5 years received the regular technician support while 91.67% of farmers who rarely replace their seeds never received the technician support.

One-way ANOVA was used to test the effect of frequency of seed replacement with improved seeds on the annual household income. The dependent variable was transformed using natural logarithms (*Ln)* to meet the assumptions of one-way ANOVA. There was a statistically significant difference between the groups, F (3,96) = 4.062, *p*=0.009. A Tukey post hoc test revealed that the annual household income of farmers replacing the seeds yearly was significantly different (*p*=0.004) from those who replaced the seeds rarely. The *Ln* transformed dependent variable was back-transformed to report the mean difference. The mean annual household income of farmers replacing the seeds yearly was Rs 18983 higher than the farmers replacing with improved seeds rarely (Table 4).

Table 3: Productivity for different frequencies of seed replacement with the improved seeds

Frequency of Seed Replacement	Productivity			
	Mean	N	Minimum	Maximum
Yearly	2526.142	39	786.28	6879.95
Every 2 years	2019.584	19	786.28	4586.633
Every 3-5 years	1910.122	6	786.28	4212.214
Rarely	1992.713	36	655.2333	4586.633
Total	2200.9	100	655.2333	6879.95

Table 4: Frequency of seed replacement across various frequencies of technician support

Frequency of Technician Support		Yearly	Every 2 years	Every 3-5 years	Rarely	Total
Regularly	N	15	3	0	0	18
	%	38.46%	15.79%	0.00%	0.00%	18.00%
	Adjusted P Value	0.0000206	0.7804998	0.2365325	0.0004416	
Rarely	N	15	4	4	3	26
	%	38.46%	21.05%	66.67%	8.33%	26.00%
	Adjusted P Value	0.0231092	0.5848815	0.0191639	0.0025216	
Never	N	9	12	2	33	56
	%	23.08%	63.16%	33.33%	91.67%	56.00%
	Adjusted P Value	0.0000001	0.4849321	0.2486383	0.0000001	
Total	N	39	19	6	36	100

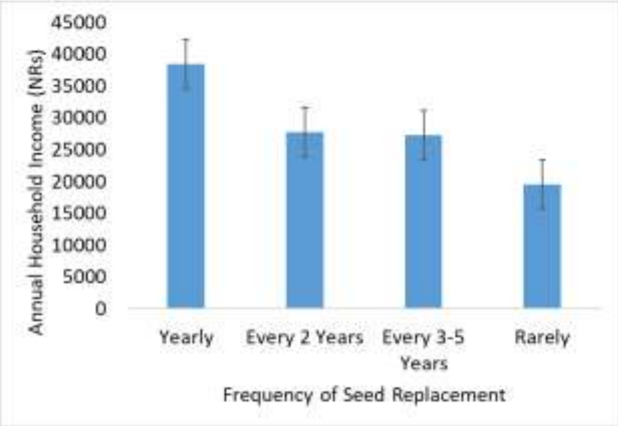

Fig. 6: Annual household income of the respondents across different frequencies of seed replacement

Seed Source and Storage

It was found that 13% of the respondents used metal bin for the storage of the seeds while remaining 87% used the locally available materials for the purpose. 51% of the respondents self-retained the seed, 14% bought the seeds from agro-vets, 16% obtained the seeds from Agriculture Knowledge Center (AKC) and 19% obtained the seed from Community Based Seed Production (CBSP).

Chi-square test was performed to test the existence of relationship between frequency of agriculture technician support to the farmer's source of seed. The association between these variables was found to be highly significant, X^2 (6, N=100) =74.979, $p < 0.01$. Bonferroni correction was used for the post hoc analysis. The Bonferroni adjusted p value required for significance was 0.004167. The regular technician support was found to be significant with self-retained and CBSP seed source. The rare technician support was found to be significant with the AKC seed source and the never technician support was significant with all seed sources.

74.5% of farmers who self-retained the seeds never received the technician support and all farmers who purchased the seed from agro-vets never received technician support. 25% of the farmers who got the seed from AKC received regular technician support while 73.7% of farmers who got the seed from CBSP regularly received the technician support. In CBSP, farmers produce the improved seeds at farm level and are considered adopters.

As shown in Fig. 7, among those farmers who self-retain the seeds, 57% retain the selected grain before planting, 22% retain the selected ear at planting, 16% retain the selected ear at harvest and store separately while 5% follow other methods of farm retention.

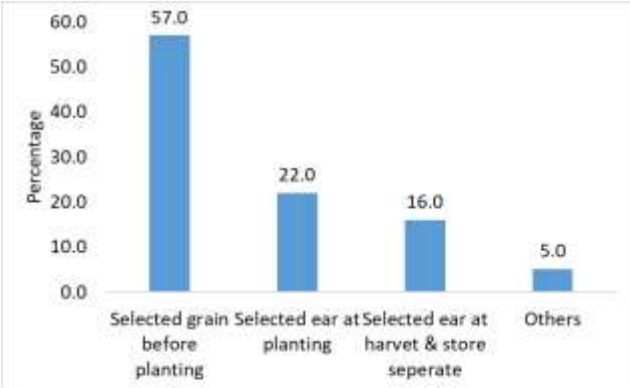

Fig. 7: Method of seed retention at the farm

Table 5: Source of seed across various frequencies of technician support

Frequency of Technician Support		Self-Retained	Agro-vets	AKC	CBSP	Total
Regularly	N	0	0	4	14	18
	%	0.0%	0.0%	25.0%	73.7%	18.0%
	Adjusted *p* Value	0.00000175	0.05871006	0.42649841	0.00000000	
Rarely	N	13	0	9	4	26
	%	25.5%	0.0%	56.3%	21.1%	26.0%
	Adjusted *p* Value	0.90561325	0.01677585	0.00261387	0.58488151	
Never	N	38	14	3	1	56
	%	74.5%	100.0%	18.8%	5.3%	56.0%
	Adjusted *p* Value	0.00014224	0.00034835	0.00105620	0.00000074	
Total	N	51	14	16	19	100

Table 6: Binary logit regression of factors affecting the adoption of the improved maize seeds

Variables	Coefficient	Significance Level	Exp (B)
Frequency of agriculture technician support	2.755*	0.019	15.726
Annual household income	0.000	0.210	1.000
Frequency of seed replacement with improved seed	1.755*	0.013	5.785
Education of the household head	0.320	0.787	1.377
Total land cultivated	0.017	0.680	1.017
Constant	-2.081	0.082	0.125

Adoption of the Improved Maize Seeds

A binary logistic regression was performed to determine the factors affecting the adoption of the improved seeds. The logistic regression model was statistically significant, X^2 (10) =48.937, $p < 0.0005$. The model explained 51.9% (Nagelkerke R^2) of the variance in the adoption of improved maize seeds and correctly classified 57% of cases. The frequency of the agriculture technician support and the frequency of seed replacement with the improved seeds were found to significantly determine the adoption of the improved maize seeds. Farmers receiving the regular technician support were 15.726 times more likely to adopt the improved seeds as compared to those who receive the technician support rarely or never. The odds of the frequency of seed replacement with improved seeds every year was 5.785 times greater for the adopters as compared to the non-adopters.

An independent samples *t*-test was performed to test the hypothesis that the adopters and the non-adopters were associated with statistically significantly different maize productivity. To meet the assumptions of independent sample *t*-test, maize productivity was transformed using natural logarithms. Thereafter, the assumption of homogeneity of variances was tested and satisfied via Levene's *F* test, F (98) = 0.478, p = 0.491. This study found that adopters had statistically significantly higher maize productivity compared to the non-adopters, t (98) = -2.458, p = 0.016. Back transformation was done to report the mean difference. 57 respondents were non-adopters and had the mean productivity of 1784.90 kg/ha whereas 43 respondents were adopters and had the mean productivity of 2243 kg/ha. This shows that adopters have 458.10 kg/ha higher productivity than the non-adopters.

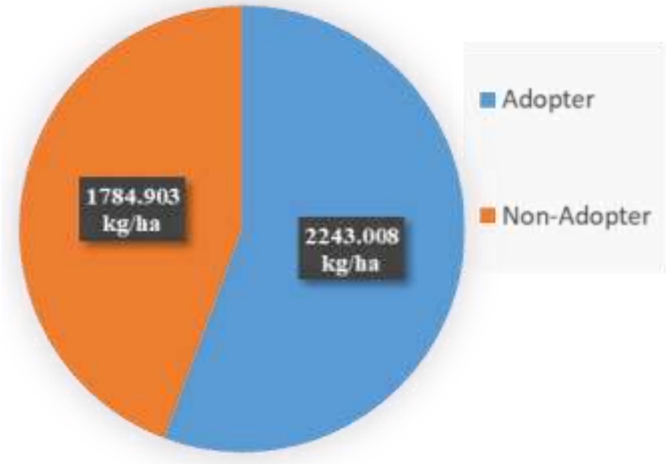

Fig. 8: Productivity of maize among the adopters and non-adopters

Problems of maize cultivation and constraints of adoption of improved seeds

Index score method was used to rank the constraints on adoption of improved seeds by the farmers. Lack of timely availability of improved seed was ranked the major constraint with an index score of 0.872. It was followed by the higher price of the improved seed, smaller landholding of the farmers, greater pest problem & shorter storage life and the lack of information about the improved seeds. The problems in maize cultivation were also ranked by the index score method. Lack of irrigation facility was ranked as the most important problem with an index score of 0.963 while market-related problems were the least important with an index score of 0.179. Table 8. shows the various problems in maize cultivation on the basis of their ranking by the respondents.

Table 7: Constraints on adoption of improved maize seed

S. N	Constraints on adoption of improved seed	Index Score	Rank
1	Lack of timely availability	0.872	I
2	Higher price	0.736	II
3	Small Landholding	0.624	III
4	Pest infestation & storage	0.386	IV
5	Lack of Information	0.382	V

Table 8: Problems in maize cultivation

S. N	Problems in maize cultivation	Index Score	Rank
1	Lack of Irrigation facility	0.963	I
2	Lack of inputs	0.759	II
3	Lack of labor at peak time	0.696	III
4	Problems of diseases and insects	0.649	IV
5	lack of agricultural technician support	0.417	V
6	Lack of agricultural machineries and tools	0.339	VI
7	Market related problems	0.179	VII

Conclusion

The huge yield gap of maize in Nepal shows the immense possibility of increasing the production of maize. However, for the realization of this opportunity, it is essential to use the improved and high yielding seeds by the farmers. Farmers used the improved seeds only, local seeds only or the combination of both improved and local seeds for the maize cultivation. The productivity of maize and the annual household income were found to be substantially greater for the farmers using the improved seeds rather than the local seeds. However, the adoption of improved seeds is lower in Nepal. The adoption is found to be significantly higher among those farmers who receive the agriculture technician support regularly and those who replace the seeds yearly. There is a significant statistical association between the frequency of seed replacement and the frequency of technician support. Thus, the majority of the farmers receiving regular extension services were found to be the adopters. Lack of timely availability and the higher price of the improved seeds and small land holding of the maize farmers were major constraints for the adoption of improved seeds. Thus, it is very crucial to improve and strengthen the seed production and supply system in order to ensure the timely availability of improved seeds to the farmers at a reasonable price.

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