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Research article

Production and distribution system of maize seed in Nepal

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ABSTRACT

This study analyses the gaps and issues in the production and distribution system of maize seed in Nepal. A total of 682 households were surveyed in 2017 by employing multistage random sampling with probability proportionate to size by representing different (tarai and hill) agro-ecological zones. Twelve focus group discussions (FGDs) and four key informant interviews (KII) were also carried out. Results showed that the old varieties like Rampur Composite and Manakamana-3 are still popular in the farmers' fields. The cost of seed production was about 48% and the profit of the producer was 18% of the consumer price. The share of wholesalers was 15% of the consumer price whereas it was 19% for retailer/agro-vet. The average total cost of production was found to be $1392/ha and gross income was $1925/ha with the 1.38 average B: C ratio; it is, therefore, a lucrative enterprise. Out of a total of 27 released varieties, only 12 varieties have been used in seed production. Results revealed that 83% of the farmers cultivate open-pollinated maize varieties whereas 17% of them cultivate hybrid maize varieties. Seventy-five per cent of seed was from a formal source. The maize productivity, hybrid maize area, and seed replacement were below the targets set in Nepals' National Seed Vision, a policy document of the government. Focus on the production of nucleus and breeder seed by Government research farms and use of these seeds by private seed companies and community seed producing groups to produce next generation foundation seeds are urgently required. Equally important is enabling private and community-based organizations to produce hybrid seeds of the crop.

1. Introduction

There are two seed systems recognized in Nepal: formal and informal seed systems. The informal seed system is characterized by farmers producing, preserving and sharing their own seed for subsequent planting, at times exchanging with and/or gifts from other farmers with very little involvement in the cash economy (Sthapit and Sah, 2002). In contrast, the formal seed system is characterized by a vertically organized production and distribution of tested and released/registered varieties by public and private organizations using agreed quality control mechanism (NSV, 2013). In Nepal, only about 8% of the total seed of different crops is supplied through the formal seed system (SQCC, 2011) and seed supply through formal channels is not well established (Sulaimana and Andinib, 2013). Linking formal and farmers' seed systems and improving the latter may in many cases be a more effective strategy to improve national and local seed supply than aiming only at improving the infrastructure and investment climate for the formal (private and public) seed sector (Almekinders and Louwaars, 2002). Timsina et al. (2012a) reported that more than 65% of farmers were using seed from informal sources while Sapkota et al. (2013) found that figure at 92.3 % of farmers.

The Seed Act 1998 (1st amendment 2008), Seed Policy 1999, Seed Regulation 2013 and National Seed Vision 2013–2025 are the seed legislation and policy framework that guide and regulate seed production and marketing in Nepal. These policy frameworks are responsible for ensuring production, processing, availability and supply of quality seeds in Nepal. Nepal Agricultural Research Council (NARC) is an apex body of agricultural research in Nepal. It has the mandate to produce breeder and foundation seed of maize. These foundation seeds are multiplied by maize seed producer groups and seed companies as improved seed, which ultimately reach maize growers. Until now the Government of

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Nepal has released more than 27 maize varieties (Table A1) and registered 58 hybrids (Table A2), while 14 are denotified (Table A3). Farmers preferred seed of improved maize varieties when community-based seed production (CBSP) was initiated in the hill of Nepal under the Hill Maize Research Project in 2000 (KC et al., 2013). During the HMRP period of 10 years, 174 CBSP groups and cooperatives were formed and seed production volume increased from 14 tons in 2000 to 830 tons in 2010 (HMRP-CIMMYT, 2010). HMRP, funded by the Swiss Government, resulted in higher investment into maize research over the period (Shrestha and Gairhe, 2016).

Remoteness, poor infrastructures, labor shortages, small quantities of seed at the producer level, and few private seed traders are inherent problems in maize seed production and marketing in the hill of Nepal (KC et al., 2015). Poor bargaining power of producers, low volume of production, inefficient intermediaries, poor marketing infrastructure, and price variation are the marketing problems in maize seed (Sapkota, 2017). KC et al. (2011) reported that the unavailability of quality improved seed, fertilizer and lack of an assured seed market impacts negatively on seed production and productivity. The adoption of the full package of practices including good quality seed is important to attain higher crop productivity (Timsina et al., 2012b). Furthermore, the productivity of maize in Nepal is very low compared to global yield; the wide yield gap can be attribute to various biotic and abiotic factors (Tables 1, 2, 3, 4, A1, A2, A3, A4, A5, A6, A7, A8, A9 and A10, Subedi, 2015).

More than two third's of Nepal's total maize cultivation area is still under open-pollinated varieties (OPVs) while the seed replacement rate (SRR) remains very low (15.3%). National Seed Vision (NSV) 2013 expects to increase SRR up to 32% for maize by 2025 (Table A4). In addition to this, there is an inherent limitation in the yield potential of OPVs. Yield of OPVs could not be increased beyond a certain level even with high inputs. Therefore, efforts to develop maize hybrids were initiated at the National Maize Research (NMRP) in the 1990s. Hybrids can give 25–30% higher grain yield as compared to the better OPVs. Requirement of yellow kernel maize for poultry feed is estimated to be 391538 mt and only 25% of this requirement is fulfilled by domestic production and the rest is imported from abroad. Agricultural Development Strategy (ADS, 2014) and NSV (2013) guided maize workers both from public and private sectors towards development and promotion of high yielding hybrids to boost maize production and productivity from the present maize production scenario in Nepal. About 1 billion tons of maize is produced annually in the world (FAO, 2016). Of the total production, 15% is estimated to be used directly for human consumption, and the other 85% for animal feed and processing (http://www.iita.org/maize; FAO, 1992; Brown et al., 1985). In Nepal, during 20 years period from 1994/95 to 2014/15, the growth rate of livestock population was accelerated from 0.73 to 1.23 % per annum (Upadhyay et al., 2017), which demands more raw materials such as maize for animal feed production. Out of the total maize used in feed production, 87% was imported from India each year by feed industries. Therefore, considering the tremendous increasing demand of maize at the industry level, emphasis should be placed on development and dissemination of maize varieties that can contribute to the feed security in Nepal (Timsina et al., 2016a). To address this issue, NSV (2013) envisaged an import substitution measure, namely the development and promotion of 12 and 5 maize hybrids by the public and private sector respectively by the end of 2025 in order to meet the increasing demand domestically.

The focus of the seed system in Nepal should be on the development of self-sustaining, farmer-centric enterprises that function well without external support (Gauchan, 2017; Spielman and Kennedy, 2016). The maintenance of the seed cycle is critical to sustain the seed system (Timsina et al., 2015, 2018). Moreover, investment in research and support services for improving access to seeds of desirable varieties in required quantities at reasonable prices to small farmers through improved distribution system, efficient marketing and effective quality assurance services should be given due consideration. However, information is limited about the seed system of maize in Nepal. Globally, maize has the most formal and advanced seed production and distribution system (Access to Seeds Foundation, 2016). This study is designed to identify the gaps and issues in the production and distribution system of maize seed in Nepal by posing the following research questions:

- Have the NARC developed maize varieties reached to the farmers field?
- Have different seed actors coordinated to maintain the seed cycle?
- Is supply of maize source seed consonant with the national seed policy?

2. Methodology

The study was based on both primary as well as secondary data. Primary data were collected in 2017 by the household survey, focus group discussion (FGD) and key informant interviews (KII). Secondary data were collected from the Nepal Agricultural Research Council and Ministry of Agriculture and Livestock Development, Nepal. Informed consent was obtained from each respondent and stakeholders while collecting the data.

Pretested questionnaires were used for household surveys of seed users; two districts from Tarai; Chitwan and Dang, and four districts from Hill: Khotang, Sindhupalchowk, Lalitpur, and Dadeldhura were selected based on area coverage of maize in Nepal. The target populations of the study districts were different and the sample was selected using multistage random sampling with probability proportionate to size. The detail of sampling is presented in Table 1 and the map of survey area is delineated in Figure 1.

A total of 12 focus group discussions were carried out from Baglung, Syanja, Kaski, Palpa, Gulmi, Salyan, Rukum and Bardiya districts for seed producers. Similarly, four key informant interviews were conducted from Chitwan, Kaski, Rupandehi, and Bardiya. The details are provided in Table 2.

Similarly, the KII was carried out with Unnati Agro-vet in Kaski, Acharya Agro-vet of Bardiya, a scientist from the NMRP, Rampur, and Chief, Regional Seed Testing Laboratory, Rupandehi, Bhairahawa.

3. Results

This section focuses mainly on maize varieties used for source seed production, price spread, comparative analysis on adoption of OPVs and Hybrid maize, and seed systems.

3.1. Source seed production and varieties

Breeder and foundation seed production of maize from NARC over 15 years is depicted in Figure 2. Overall, source seed production showed an increasing trend in the study periods. In 2005, breeder seed production was 2.14 tons which increased to 8.21 tons in 2019. Similarly, the foundation seed production was 58.97 tons in 2005 and increased to 83.29 tons in 2019. Besides, considerable amount of maize seed is being imported to Nepal (Table A5).

FGD revealed that the maize seed production group member ranges from 7 in Lumle to 211 in Salyan and some of the farmer groups were producing maize seeds from 2000 to till date. Commercialized open-pollinated (OP) varieties that dominated in the study area were Manakamana- 3, Manakamana- 4, Manakamana- 6, Rampur Composite, Poshilo Makai-1, Ganesh-2, Arun- 2, Arun- 4, Arun- 6.

The variety-wise seed production in the year 2017 is shown in Table 3. The result revealed that the share of Manakaman- 3, released in 2002, was highest, i.e. 87% of the total maize seed produced in the study area, followed by Arun- 4 and Rampur Composite. Similarly, Rampur Composite and Manakamana-3 were attributed prime importance while producing the breeder and foundation seed at NMRP (Table A6and Table A7).

Table 1. Details of sample selection.

S.N.	Agro-ecology	District	Location	Sample size
1	Tarai	Chitwan	Rapti, Khairahani, Kalika, Ratnanagar municipalities and Bharatpur metropolitan city	97
2	Tarai	Dang	Shantinagar rural municipality, Lamahi municipality, and Ghorahi sub-metropolitan city	143
3	Hills	Khotang	Rupakot Majhuwagadhi and Halesi Tuwachung municipalities	110
4	Hills	Sindhupalchowk	Indrawati Rural Municipality and Chatara Sangachowkgadi Municipality	111
5	Hills	Lalitpur	Konjyosom Rural Municipality	111
6	Hills	Dadeldhura	jayameru and Navadurga Rural Municipalities and Amargadhi municipality	110
Total				682

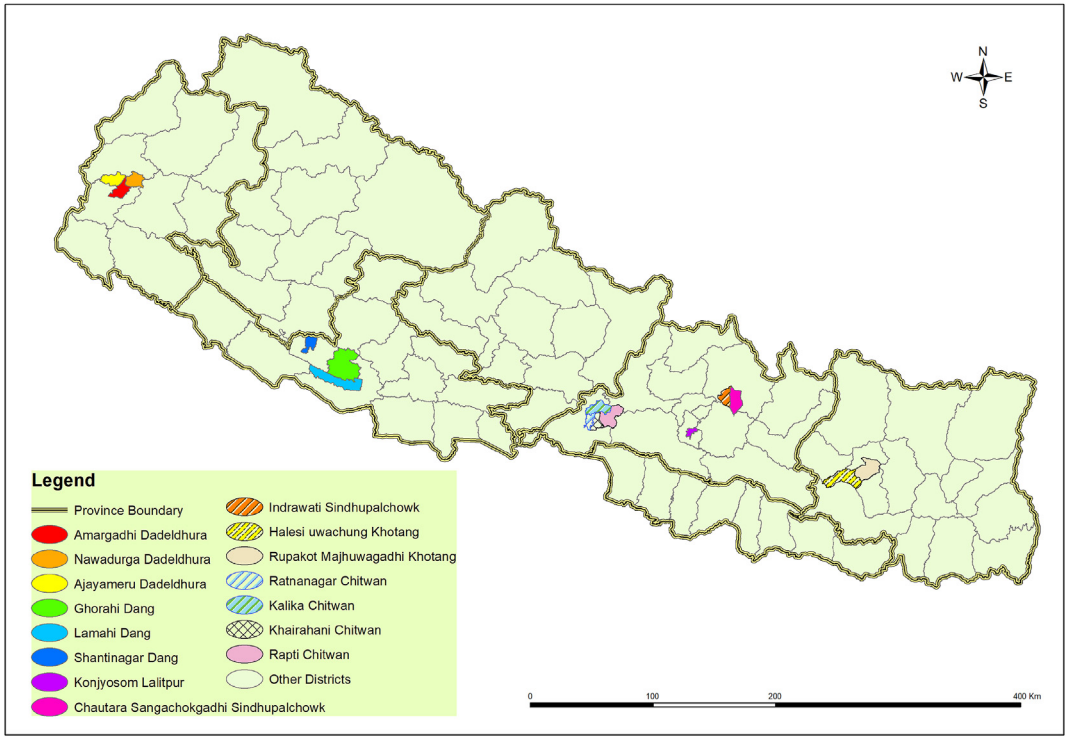

Figure 1. Map showing study location at survey districts.

Table 2. Details of focus group discussion.

S.N.	Name of group	District
1	Manakamana maize seed production group	Baglung
2	Lumle Gaun seed production group	Kaski
3	Aadarsa mahila krisak samuha	Kaski
4	Sundauli Krisak Samuha	Syanja
5	Pani Tanki Jaibik Bahu- Udesiya Krishak Samuha	Gulmi
6	Manakamana Bahu- Udesiya Krishak Samuha	Palpa
7	Pragatishil Krishak Samuha	Rukum
8	Sai Khumari Khadyanna Biu Utpadan Mahila Krishak Samuha	Rukum
9	Jansebi Krishi Sahakari Sanstha Ltd	Salyan
10	Saraswati Biu Utpadak Samuha	Salyan
11	Ganesh Baba Pragatishil Krishak Samuha,	Bardiya
12	Budhan Krishak Bahumukhi Sahakari Sanstha ltd.	Bardiya

3.2. Price spread and returns of improved maize seed in Nepal

The percentage of price spread in different stages of marketing is presented in Figure 3.

Results revealed that the cost of production (CoP) was about 48% of the consumer price. Similarly, the producer price was found to be 18%. The share of wholesalers was 15% and the share of retailer/agro-vet was 19% of the consumer price.

The total cost, gross income, and B: C ratio (gross income divided by variable costs) of improved maize seed system are shown in Table A8. The average B: C ratio was found to be 1.38, which demonstrates that the enterprise is profitable to undertake.

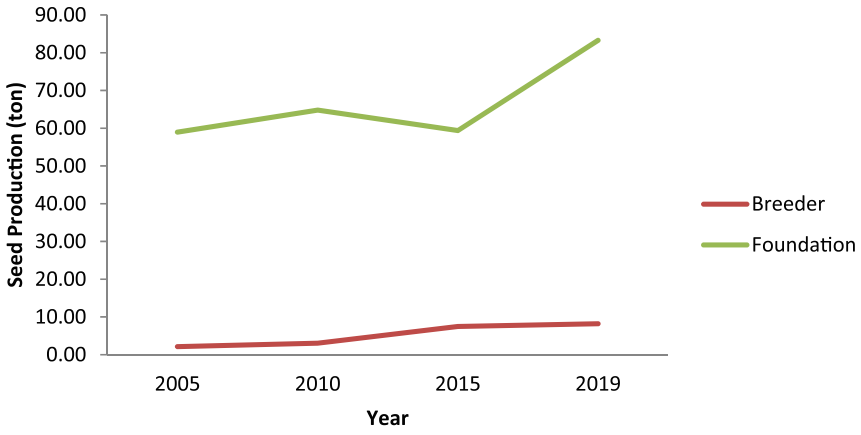

Figure 2. Trend of maize source seed production in NARC. Source: Monitoring and Evaluation Division, NARC.

Table 3. Variety wise seed production in the study sites in 2017.

Maize varieties	Released year	Production (ton)	Share (%)
Rampur composite	1975	2.7	2.73
Arun -2	1982	1.4	1.42
Mankamana- 3	2002	85.7	86.65
Ganesh-2	1989	0.7	0.71
Deuti	2006	1.85	1.87
Manakamana -4	2008	1.9	1.92
Manakamana -6	2010	0.3	0.30
Poshilo Makai -1	2008	1.0	1.01
Arun -4	2015	2.8	2.83
Arun -6	2015	0.55	0.56
Total		98.9	100.00

Source: Field Study, 2017.

3.3. Adoption of OP and hybrid maize

The adoption of OPVs and hybrid maize in the study area is presented in Figure 4. Overall, 83% of the farmers cultivate open-pollinated maize varieties whereas17% of farmers cultivate hybrid maize varieties.

3.3.1. Comparative adoption of maize OPVs and hybrid

The proportion of maize varieties that were dominant in the study area are shown in Figure 5. The results revealed that Rampur composite solely accounts for 38% and was the most dominant variety, followed by Deuti (18%), local varieties (17%), Manakamana- 3 (16 %) and others (10%). Others include Arun- 1, Arun-2, Arun- 4, Ganesh- 1, Shitala, Manakamana- 4 and Poshilo Makai- 1.

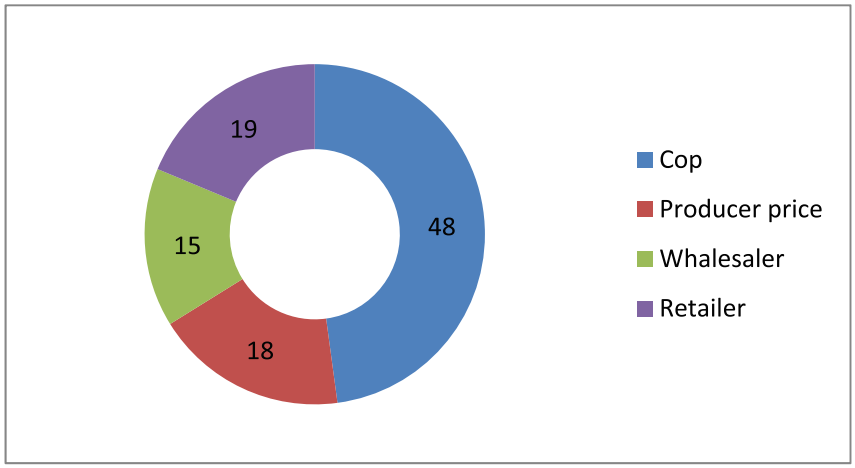

Figure 3. Share of price spread among different actors in maize seed.

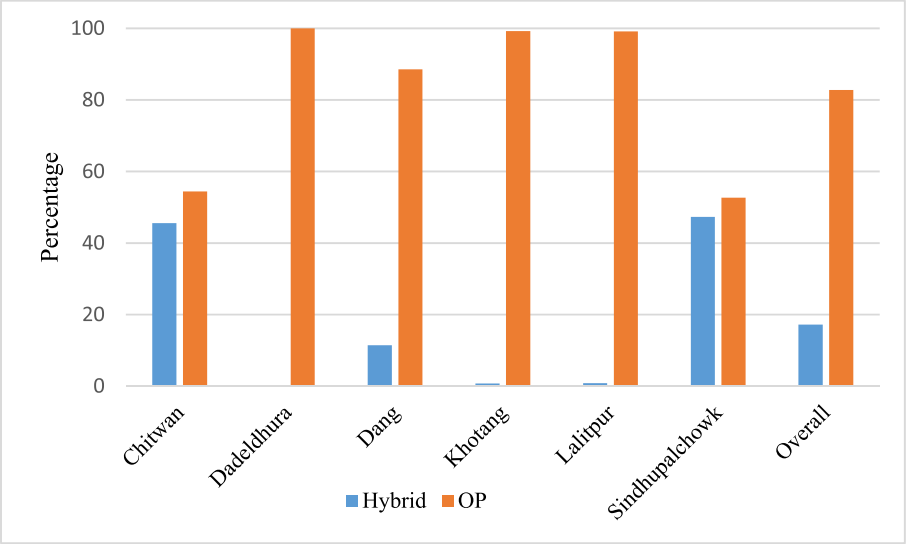

Figure 4. Maize OPVs and Hybrid comparison.

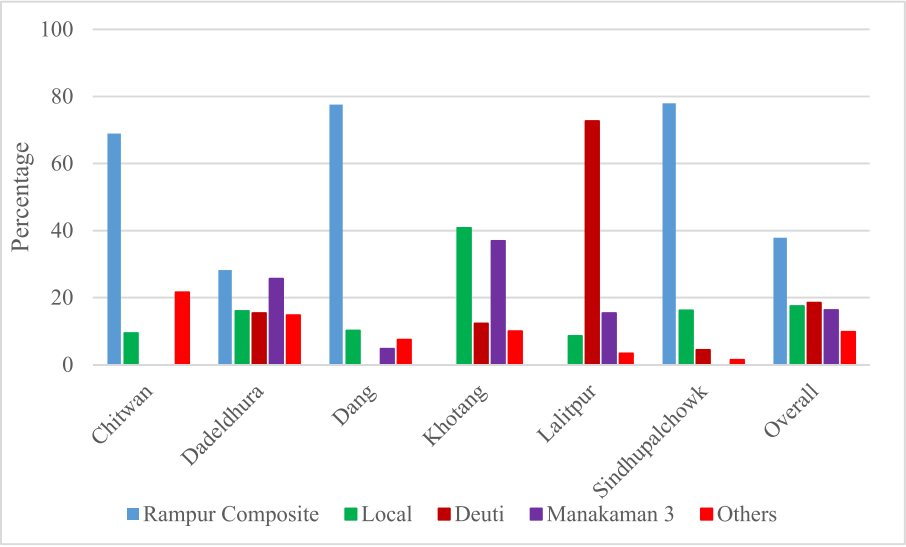

Figure 5. Dominant maize varieties in the study area.

3.4. Sources of seeds of maize varieties

Formal and informal sources of maize seed in the study area are presented in Figure 6. Overall, formal seed accounts for 75% and informal was about 25%. The formal seed system includes Government farms and offices, Seed companies, Agro-vet and I/NGO's. The informal seed system includes Own, neighbors, and relatives.

3.5. Challenges of maize seed producion and marketing

Maize seed production and marketing challenges perceived by different stakeholders are presented in Table 4.

4. Discussion

Study reveals that Manakamana- 3, Manakamana- 4, Manakamana- 6, Rampur Composite, Poshilo Makai-1, Ganesh-2, Arun- 2, Arun- 4, Arun- 6 were the major maize varieties. Rampur Composite, Arun- 2 and Manakamana- 6 were improved varieties popular in the western hills of Nepal (Lamichhane et al., 2015). The study by Upadhyay et al. (2020) found that Rampur composite and Deuti were highly preferred maize varieties among farmers, and Lamichhane et al. (2018) found positive relations with improved maize varieties and education in the hilly areas of Nepal.

It is clear that the maize varieties released 40 years back are still in the farmers' fields and not replaced by new varieties, which contribute to an increase in the adoption lags (Gairhe et al., 2017; Timsina et al., 2019). This is due to the unavailability of desired seed when the farmers need it. Manakamana- 3 is popular in mid-hill as it is white in color, has a tight husk cover and stays green stover with a yield potential of 5.6 ton/ha.

The adoption of maize varieties will be extensive if and only when the varieties are released with a package of practices, economic modifications as well as a market preference study (Timsina et al., 2012b). Availability of seed on time enhances adoption of improved maize varieties (Upadhyay et al., 2018). Farmers often complained that improved maize varieties of their choice are not available (Paudyal et al., 2001; Kaini, 2021). Even though NARC's cereal-breeding program is relatively strong, it has produced very few hybrid varieties (Stads et al., 2019). Agrovets supply a limited amount of hybrids and improved OPV maize seeds in comparatively accessible areas. Their interest, however, remains with hybrid seed, which has a higher profit per unit of seed sold (Paudyal

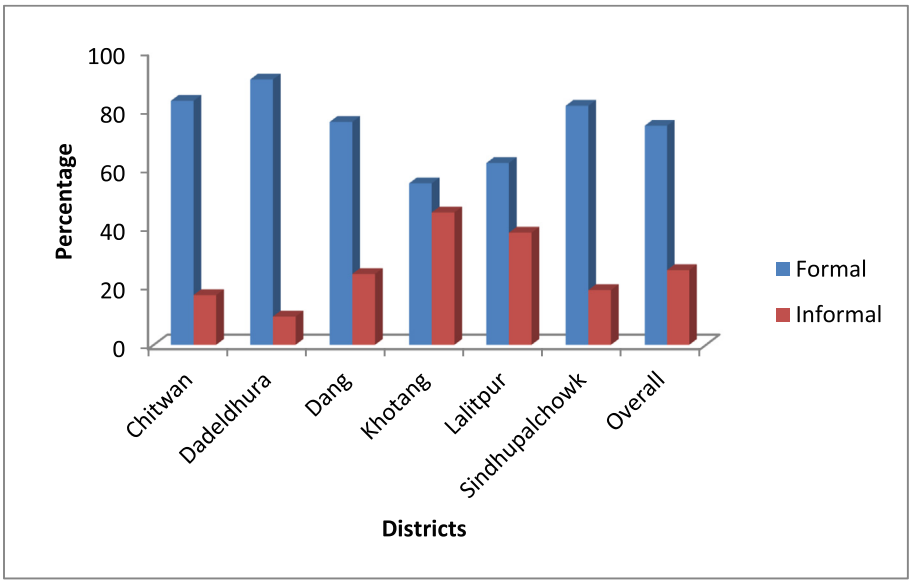

Figure 6. Sources of maize seed.

et al., 2001). McGuire and Sperling (2016) found that 18% of smallholder farmers in 6 countries bought maize seed from officially recognized agro-dealers. The purchase and use of Indian hybrids has been faciliated by open borders, higher productivity in comparison to improved ones, and an absence of regulatory mechanisms which would otherwise hinder the expansion of Nepalese hybrid maize.

Gaurav was the first single cross hybrid released by the Government of Nepal in 2003 (NMRP, 2004). Other single cross hybrids released in Nepal so far are Rampur Hybrid-2 (2012), Khumal Hybrid-2 (2014), Rampur Hybrid-4 (2016), and Rampur Hybrid-6 (2016) (Table A1). In addition to these, Rampur Hybrid-8 (2018) and Rampur Hybrid-10 (2018) were the registered hybrids supported by CIMMYT in Nepal (Table A2). However, the seed production of these hybrids is not satisfactory because of nicking problems in anthesis and silking of parents, insufficient information required for seed production research, poor coordination between private and government sector for hybrid maize seed production, over flow of multinational companies' hybrids, and limited national governmental support for hybrid maize research and seed production.

Seed production of hybrid maize is limited to the boundary of National Maize Research Program only for research purposes, and hybrid seeds from multinational companies are dominating the national seed market. On the other hand, none of the Nepalese seed companies are vigourously involved in hybrid seed production to date. Assurance of the buyback guarantee of the maize seed produced by the farmers or producers along with quality and quantity is a problematic issue that needs to be dealt with properly. One of the limiting factors for the low adoption of Nepalese hybrids by seed companies is the lack of information related to seed production research. Therefore, seed production research should cover female: male ratio, planting geometry, micronutrient and soil acidity management and plating time of inbreds and hybrids for gaining higher economic benefit. Recently, due to climatic factors (low temperature), problems like grain formation in tassel, sterile tassel, high NLB and aphid severity etc. were recorded in some multinational Indian hybrids like NMH-731 (Shrestha), Winner NMH-8352 (not registered) and CP-838 in the farmers' fields at Bara, Chitwan and Nawalparasi (Subedi, 2015; NMRP, 2020).

However, Lumbini seed company, Rupandehi, Unnat Kheti Sahakari, Maharanijhoda, Jhapa, Gorkha Seed Company, Dang, Panchashakti Seed Company, Dhangadi and Unique Seed Company and Dhangadi produced 22.5 mt F1 seed of RH-10 from 20 ha and has already sold to the maize growers. The male and female parents of RH-10 were incentivised as a subsidy support by NMRP, Rampur. (K.B., Koirala, Personal communication, August 30, 2020). Similarly, Khumal hybrid-2 is also being produced in Sindhulpalchowk, Dolakha, Gulmi, and Kavre of Nepal (Dhami, 2020 N.B., Dhami, Personal communication, July 1, 2020). In 2019–20, Nepali hybrid seed is planted in 30 ha and estimated to produce 180 ton of Nepali hybrid seed (Table A9). If all the F1 seed is used, that can only cover about 1% of total natioal maize area. Therefore, the production of seed of Nepalese hybrid varieties with the proactive involvement of private seed companies is urgent to scale up dissemination.

Source seed production showed increasing trends over the years. The foundation seed produced in the year 2019 can be planted to 4165 ha and can produce 6274 mt of improved seeds if a proper seed cycle is

Table 4. Challenges of maize seed production and marketing identified at various levels of supply chain.

Research Stations	Producers
Limited human resources in maize seed production High number of varieties but the land is limited as it is cross-pollinated; adequate land is required Damage due to parrots	Unavailability of uniform and quality source seeds on time Insufficient training on recent innovations in seed production Mismatch in demand and supply, and sold as food Weak linkage among seed actors Unavailability of technical service from seed testing center at the time of need
Seed testing lab	**Retailers**
Limited know-how of farmers for seed sampling High overload in the testing peak season Poor infrastructure Lack of incentives for the human resources working in the lab	No uniformity of maize seed prices Seed grading varies from farmer to farmer Farmers sometimes breach the contract

Source: Field Study, 2017.

maintained (Table A10). Such improved seed can cover more than 3 lakh hectares from the source seed produced in a single year, which is about 31% of total national maize areas. Besides the NARC's regular program, other projects are producing foundation seeds at different levels, and proper utilization of these seeds can cover more maize areas of Nepal. Seed cycle maintenance and proper distribution of these seeds not only increase the maize productivity but also help in import substitution. However, it is important to consider traits of farmers' preferred varieties (Timsina et al., 2016b). Nevertheless, the seed developed by the formal sector may have less desired characteristics to the farmers' seed in different ecological domains and socioeconomic settings (NSV, 2013; Urrea-Hernandez et al., 2016). So, there is an urgent need to maintain the seed cycle and proper distribution for the timely and quality seed availability of preferable traits to the farmers (Timsina et al., 2018; Gairhe et al., 2020).

Despite the high potential for maize seed production, the farmers are still deprived. A study by Joshi et al. (2012) found that no private-sector organizations demanded foundation seeds of any of the three major cereals for seed multiplication purposes either in hill or mountain, suggesting that seed business potential remains very weak in those areas. As such, external interventions are necessary for the initial period to stimulate the commercialization of the seed production process through a public-private partnership approach. The public and private partnership to produce, multiply and distribute seed is critical to maintain the seed cycle and provide it to the ultimate users (Gairhe et al., 2016, 2018).

Lacking crystal clear national policy to increase maize seed production activities and income of small holder farmers and facilitate functional relationships between the various actors of maize, low productivity, limited access to business development services, lack of linkages with external markets are major challenges in the maize seed value chain.

GoN should support the farmers to adopt modern technologies, high yield varieties seed and other inputs for commercial maize seed farming. Enhancing the capacity of the various actors in the maize seed value chain and facilitating linkage among them is a crucial turning point. Low access to finance for small holder farmers and other value chain actors is one of the major constraints in the seed sector business. So, different agencies having a strong background in promoting access to finance will need to link these seed production groups with local financial institutions/cooperatives with the concept of value chain financing.

Effective implementation of seed policy and seed legislation in all parts of the country (including remote hills and mountain) is needed to enforce seed quality control as well as regulate marketing and distribution of unregistered hybrids and varieties in the country (Gauchan et al., 2014).

Different seed policy instruments and strategies related to farmers' seed systems were issued by the Governement of Nepal, of which some are neutral and the majority are favourale to the informal seed system (LI-BIRD and The Development Fund, 2017). Even though ADS (2014) and NSV (2013) emphasized the development and promotion of high yielding hybrids by involving public and private sectors with the aim to boost maize production and productivity, the anticipated success has not been met. The maize productivity, hybrid maize area, and seed replacement rate are insufficient as envisaged by national seed vision. This was because there were not supporting programs to support the seed vision objectives.

5. Conclusion

Manakamana- 3 was the most popular variety in hill and Rampur composite was dominant in both hill and tarai. Results revealed that 83% of the farmers cultivate open-pollinated maize varieties whereas 17% of them cultivate hybrid maize varieties. It showed that there is a need for high yielding, open pollinated, improved varieties along with the development of the hybrid varieties to satisfy the needs of feed industries. Recently, some of the community-based seed production groups in Jhapa, Dhangadi, Dang and Rupadehi districts started to produce the hybrid seed of Rampur hybrid-8, Rampur hybrid-10 and Khumal Hybrid-2 through supports from NMRP. This can help to reduce the import of maize in coming years. The source seed production by NARC and other projects are trending upwards. Such seed cycle maintenance, proper distribution, and utilization of these seeds can cover more than the maize area of Nepal. Since there are no supporting programs to built the seed vision objectives and given the lack of clear policy, maize productivity, the hybrid maize area, and the seed replacement rate have fallen well short of what was expected according to the national seed vision. Therefore, the inclusion of private seed companies and CBSP groups/cooperatives in the subsequent stages of the seed cycle is most crucial. Similarly, capacity enhancement along with the infrastructure development to private and community-based organizations to produce hybrid developed by the national research system is urgently required to fulfill demand at both the farmer and industry level.

Declarations

Author contribution statement

Samaya Gairhe: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Krishna Prasad Timsina: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Yuga Nath Ghimire: Analyzed and interpreted the data; Wrote the paper.

Jeevan Lamichhane: Performed the experiments; Wrote the paper.

Subash Subedi; Jiban Shrestha: Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Appendices.

Table A1. Released maize varieties in Nepal.

S.N.	Maize Varieties	Year	Productivity (ton/ha)	Recommended domain
1	Khumal Pahenlo	1965	4.9	Mid Hill
2	Rampur Composite	1975	4.4	Tarai and Inner tarai
3	Arun 2	1982	2.2	Tarai, Inner tarai and foot hills
4	Manakamana 1	1987	4.0	Mid hills
5	Ganesh 2	1989	3.5	High hills
6	Rampur 2	1989	4.0	Tarai and Inner tarai
7	Arun 1	1995	4.00	Western Tarai and Mid hills
8	Ganesh 1	1997	5.00	High hills
9	Manakamana 3	2002	5.50	Mid hills of Eastern, Central and Western Development regions from 1000 to 1700 masl
10	Gaurab Hybrid Makai	2003	8.10	Tarai and Inner Tarai
11	Deuti	2006	5.70	Mid hills
12	Sitala	2006	6.08	Hills
13	Manakamana 4	2008	5.30	Eastern to western mid hills at altitude less than 1600 masl
14	Posilo makai 1	2008	5.30	Eastern to western mid hills at altitude less than 1600 masl
15	Manakamana 5	2010	5.27	Mid hills east of Karnali
16	Manakamana 6	2010	5.34	Eastern and mid-western hills
17	Rampur Hybrid 2	2012	3.55–7.0	Inner tarai and tarai east of Narayani river
18	RML 4	2012	2.5–3.0	Inner tarai and tarai east of Narayani river
19	NML 2	2012	2.0–2.5	Inner tarai and tarai east of Narayani river
20	Khumal Hybrid Makai 2	2014	8.5–9.08	Summer season in Mid Hills and winter season in tarai and Inner tarai
21	KYM 33	2014	2.50	Summer season in Mid Hills and winter season in tarai and Inner tarai
22	KYM 35	2014	1.50	Summer season in Mid Hills and winter season in tarai and Inner tarai
23	Resunga Composite	2014	5.20	Hills of Central and Western Region from 700 to 1400 masl
24	Arun 3	2015	5.40	Eastern tarai from mid far western region, inner tarai and mid hills
25	Arun 4	2015	3.90	Eastern tarai from mid far western region, inner tarai and mid hills
26	Arun 6	2015	4.20	Eastern tarai from mid far western region, inner tarai and mid hills
27	Rampur Hybrid 4	2016	6.95	Winter season in tarai and inner tarai upto 700 masl
28	Rampur Hybrid 6	2016	6.80	Winter season in tarai and inner tarai upto 700 masl
29	RML 32	2016		Winter season in Tarai and inner tarai upto 700 masl
30	RML 17	2016		Winter season in Tarai and inner tarai upto 700 masl
31	RML 4	2016		Winter season in Tarai and inner tarai upto 700 masl
32	Poshilo Makai 2	2018	4.50	Tarai, inner tarai upto 800 masl
33	Rampur 4	2018	5.40	Tarai, inner tarai upto 700 masl
34	Manakamana 7	2018	6.46	Mid hills from 700 to 1600 masl

Source: SQCC, 2019.

Table A2. Registered maize varieties in Nepal.

S.N.	Maize Varieties	Year	Productivity (ton/ha)	Recommended domain
1	Bayo 9681 F1	2010	6.5–8	Mid hills of central region during summer, eastern tarai during winter
2	Rajkumar F1	2010	8.0–9.0	Tarai, Inner tarai, river basin and valleys upto 700 masl
3	Nutan KH 101 F1	2010	6.5–8	Tarai, Inner tarai, river basin and valleys upto 700 masl
4	DKC 9081 F1	2011	10.0–12.0	Mid tarai for winter season
5	All rounder F1	2011	7.0–10.0	tarai area- winter and summer season
6	Bisko 940 F1	2011	7.13	Central tarai and hills
7	C 1921 F1	2011	5.14–7.5	Eastern and central tarai, river basin and upland of mid hills
8	CP 808 F1	2011	9.95	Eastern and central tarai
9	CP 666 F1	2011	6.97	Eastern and central tarai
10	Godawari 989 F1	2011	7.36	Eastern and central tarai, river basin and upland of mid hills
11	Early 2 F1	2011	5.69	Eastern and central tarai, river basin and upland of mid hills
12	Aditya 929 F1	2012	7.20	Inner tarai and tarai east of Narayani river
13	Pro Agro 4262 F1	2012	8.29	Inner tarai and tarai east of Narayani river
14	Bisko 940 New F1	2012	7.74	Inner tarai and tarai east of Narayani river
15	CP 838 F1	2012	7.11	Inner tarai and tarai east of Narayani river
16	10 V 10 F1	2012	7.46	Inner tarai and tarai east of Narayani river

(*continued on next column*)

Table A2 (*continued*)

S.N.	Maize Varieties	Year	Productivity (ton/ha)	Recommended domain
17	DMH 7314 F1	2012	6.66	Inner tarai and tarai east of Narayani river
18	DMH 849 F1	2012	6.85	Inner tarai and tarai east of Narayani river
19	MM 1107 F1	2012	9.00	Inner tarai and tarai east of Narayani river
20	Decalb Double F1	2012	6.79	Inner tarai and tarai east of Narayani river
21	NMH 731 F1	2012	7.92	Inner tarai and tarai east of Narayani river
22	Pioneer 3522 F1	2012	8.65	Inner tarai and tarai east of Narayani river
23	9220 F1	2012	7.67	Inner tarai and tarai east of Narayani river
24	TX 369 F1	2012	9.00	Inner tarai and tarai east of Narayani river
25	C 1946 F1	2012	9.70	Inner tarai and tarai east of Narayani river
26	Gulmi 2	2014	5.40	Gulmi and Arghakhanchi Districts from 700 to 1400 masl
27	GK 3140 F1	2016	6.40	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
28	GK 3114 F1	2016	6.50	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
29	NMH 713 F1	2016	6.30	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
30	NMH 1247 F1	2016	6.07	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
31	P 3396 F1	2016	6.29	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
32	3022 F1	2016	6.30	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
33	3033 F1	2016	6.40	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
34	Bisko X 81 F1	2016	9.60	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
35	Bisko 97 Gold F1	2016	8.20	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
36	900 M Gold F1	2017	6.50	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
37	Parwal F1	2017	6.10	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
38	PL 3300 F1	2018	8.48	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
39	PL 3331 F1	2018	9.01	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
40	HP 222 F1	2018	8.74	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
41	9784 F1	2018	7.81	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
42	951 Super F1	2018	7.27	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
43	P 3533 F1	2018	7.55	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
44	LG 33.01 F1	2018	8.10	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
45	Bisko Jambo 65 F1	2018	8.17	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
46	JKMH 502 F1	2018	7.09	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
47	Corn King 9522 (M9292), F1	2018	7.22	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
48	Supreem 9062 (Bikas) F1	2018	7.12	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
49	JM 1 F1	2018	7.21	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
50	JM 4 F1	2018	7.20	Inner tarai and tarai east of Narayani river upto 700 masl for winter season
51	Rampur Hybrid 8 F1	2018	7.56	Winter season in tarai and inner tarai upto 700 masl
52	Rampur Hybrid 10 F1	2018	8.05	Winter season in tarai and inner tarai upto 700 masl

Source: SQCC, 2019.

Table A3. Denotified maize varieties in Nepal.

S.N.	Maize Varieties	Year	Productivity (ton/ha)	Recommended domain
1	Rampur Pahenlo	1965	4.7	Tarai and Inner tarai
2	Kakani Pahenlo	1966	3	High Hills
3	Hetauda Composite	1972	4.3	Mid hills, inner tarai and foot hills
4	Sarlahi Seto	1975	4.1	Eastern tarai and inner tarai
5	Janaki	1978	6.5	Tarai
6	Makalu 2	1989	4	Areas like Lumle, Pakhribas and Mid hills
7	Rampur 1	1995	3.8	Western tarai and Mid hills
8	Super M 900 F1	2010	8.0–12.0	Mid tarai- winter and summer season
9	30 P 30 F1	2011	6.0–7.0	Mid hills of central region for summer season, tarai for winter season
10	30 B 11 F1	2011	8.0–9.0	Mid hills of central region for summer season, tarai for winter season
11	Big boss F1	2012	8.39	Inner tarai and tarai east of Narayani river
12	Pioneer 3785 F1	2012	8.45	Inner tarai and tarai east of Narayani river
13	DKC 7074 F1	2011	6.0–8.0	Mid hills of central region - summer season, mid tarai for spring season
14	TCS 9697 F1	2011	8.34	Central tarai and hills

Source: SQCC, 2019.

Table A4. Status and projected details of maize by national seed vision, 2013.

Particulars	Unit	Status			Projected		
		2001	2005	2010	2015	2020	2025
Scientifc manpower	no			5	7	10	15
Varieties released	no	15	17	23	28	35	40
Varieties registered	no			9			
Breeder seed production	mt	10.27	1	3	0.63	0.9	1.46
Foundation seed production	mt	202	110	65	37.53	54	87.6
Certified/improved seed production	mt	163	565	1592	2627	3780	6132
Improved area	ha	137	426	1069	1608	2035	2833
Yield	mt/ha	1.82	2	2.29	2.51	2.86	3.33
Hybrid area	ha			85000	120000	180000	250000
Hybrid seed	mt			1275	1800	2700	3750
Seed replacement	%	0.99	3.32	9.03	14.43	20.1	31.57
Maize production	mt	1510770	1734417	2019177	2288767	2687839	3234159
Area under production	ha	825980	850947	881352	910371	940345	971306

Source: National Seed vision 2013–2025.

Table A5. Import and Export of Maize seed in Nepal from 2014 to 2018.

Year	Import		Export	
	Quantity (kg)	Value (NRS)	Quantity (kg)	Value (NRS)
2014	1,515,037	243,147,281	1,460	48,245
2015	1,316,943	155,427,928	508	32,290
2016	1,654,043	265,825,460	15,455	385,211
2017	51,714,738	273,571,468	156	6,284
2018	1,478,421	265,059,053	240	28,339

Source: TEPC, 2018..

Table A6. Maize breeder seed (BS) production (mt) at NMRP Rampur from 2015/16 to 2018/19.

S.N.	Varieties	(2015/16)	(2016/17)	(2017/18)	(2018/19)
1	Rampur Composite	2.26	7.36	0.95	2.20
2	Arun-2	0.61	1.34	0.5	0.69
3	Arun-4	0	0.35	0.57	0.28
4	Manakamana-3	2.852	3.18	0.9	2.21
5	Deuti	0.250	1.23	0.1	0.74
6	Poshilo Makai-1	0.1	0.06	0.12	0.22
Sub-total		6.072	13.52	3.12	6.34

Source: NMRP, 2016; 2017; 2018; 2019..

Table A7. Maize foundation seed (FS) production (mt) at NMRP Rampur from 2015/16 to 2018/19.

S.N.	Varieties	(2015/16)	(2016/17)	(2017/18)	(2018/19)
1	Rampur Composite	10.0	13.01	20.05	19.7
2	Arun-2	4.30	3.93	3.25	6.9
3	Arun-4	0	0.50	0.7	1.28
4	Manakamana-3	10.948	11.10	12.79	12.97
5	Deuti	4.9	2.60	1.74	5.57
6	Poshilo Makai-1	0.14	0.11	0.06	1.24
Sub-total		30.288	31.25	38.56	47.66

Source: NMRP, 2016; 2017; 2018; 2019..

Table A8. Total cost, gross income and B: C ratio of improved maize seed production (Nepalese Currency Rs = NRs) (Seed, Fertilizer, labor and machine for land preparation, intercultural operations and harvesting cost included).

S. N.	Districts	Address	Total cost/ha (NRs)	Gross income/ha	B: C ratio
1	Baglung	Baglunj Municipality	244000	294000	1.20
2	Kaski	Anapurna Rural Municipality	144400	244400	1.69
3	Syanja	Kaligandaki Rural Municipality	177800	271133	1.52
4	Kaski	PokharaLekhnath Metropolitan	144960	244960	1.69
5	Gulmi	Ruru Rural Municipality	153000	207000	1.35
6	Palpa	Tansen Municipality	164900	248900	1.51
7	Rukum	Triveni Rural Municipality	65200	65700	1.01
8	Rukum	Musikot Municipality	174400	199400	1.14
9	Salyan	Sarada Municipality	209900	289900	1.38
10	Salyan	Dhorchaur Rural Municipality	90217	131883	1.46
11	Bardiya	Rajapur Municipality	129800	179800	1.39
12	Bardiya	Barbardiya Municipality	139300	163300	1.17
	Average		153156	211698	1.38

Source: Field Study, 2017 Note: $1 = NRs 114.95.

Table A9. Rampur Hybrid-10 (RH-10) seed production area (ha) in 2019/20.

S.N.	Company/Seed producer	Area (ha)
1	Lumbini Seed Company, Rupandehi, Bhairahawa	8
2	Unique Seed Company, Dhangadi	3
3	Gate Nepal, Banke	2
4	Gorkha Seed Company, Dang	5
5	Pavitra Seed Company, Surkhet	0.5
6	Panchashakti Seed Company, Dhangadi	1
7	Unnat Kheti Sahakari, Maharanijhoda, Jhapa	6
8	Madan Bhandari Memorial Academy, Morang	1
9	National maize Research Program	3.5
	Total	30

Note: Average seed productivity is 6 ton/ha..
Source: Koirala (2020)..

Table A10. Maize seed multiplication ratio in Nepal.

S.N.	Multiplication ratio
1.	Seed requirement for one hectare is 20 kg
2.	20 kg of Nucleus seed produced 500 kg of breeder seeds
3.	20 kg of breeder seed cultivated in 1 ha produced 800 kg of foundation seeds
4.	20 kg of foundation seed cultivated in 1 ha produced 1500 kg of improved seeds

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