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Vegetables production and marketing: practice and perception of vegetable seed producers and fresh growers in Nepal

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Abstract

Background: Seed sector in Nepal has high comparative advantage, and the Government of Nepal has also emphasized to develop and strengthen seed supply system in Nepal. However, it has been facing different types of limitations and risks at different levels of the vegetable seeds system in Nepal. Therefore, this paper analyzes overall existing vegetable seeds production environment, its marketing practice and perception of seed producers and users in Nepal.

Methods: Using simple random sampling technique, a total of 275 seed producers and seed users were selected for the study purpose from four districts. Among them, 175 seed producers were from Rukum and Kavre; 100 seed users were from Rupandehi and Palpa. In addition, 75 seed companies/agro-vets/cooperatives/traders/service providers were selected purposely from all study districts. Indexing techniques, Chi-square test and willingness to pay using direct survey method were used to analyze the data.

Results: It was estimated that on average about 10–20% losses were observed in vegetable seeds from farm to wholesale due to poor drying, management and storage practices. The unfavorable environment immediately after harvesting and need to dry several times were ranked as first drying and storage problems, respectively. From the analysis, it was found that selection criteria for hybrid and open-pollinated were found significantly different among fresh vegetable growers. The reasons for choosing hybrids were due to their higher production, attractive fruits and more profit. The study reveals the mismatch between seed production and variety demanded by the fresh growers. Moreover, results on tendency of farmers to change preferred varieties and their willingness to pay additional price for high-quality vegetable seeds indicate the market potential for expansion of quality seed in the future.

Conclusion: It seems that the promotion of new post-harvest technologies to maintain dry chain throughout the vegetable seeds system that can provide higher return to the farmers would be easily accepted by the respondents. Therefore, the advantage of microclimatic diversity in hilly areas of Nepal and the seed grower's willingness to maintain good-quality seeds can be utilized to produce huge amount of seeds for the fulfillment of national demand in the plain areas as well as export, especially in SAARC countries.

Keywords: Vegetables, Seed, Farmer's perception, Drying and storage, Willingness to pay, Export and import

Background

Seed sector in Nepal has high comparative advantage, and the Government of Nepal has also emphasized to develop and strengthen seed supply system in Nepal [9, 13]. Vegetable seeds are recognized as lucrative enterprise for improving the livelihood of farmers and addressing the issues of self-sufficiency, food security and economic development of remote areas [3, 17]. Vegetable seeds give 3–5 times higher income as compared to alternative cereal crops, enabling farmers to buy at least three times more food as compared to growing traditional food crops

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on the same land [3]. Most of the studies reported that vegetable seed production is more profitable than food grain crops [5, 10, 24]. The cropping pattern in study area in upland area is mainly dominated by maize and included other crops like legumes, vegetables, wheat and vegetable seeds. In the lowland area, the cropping pattern was mainly dominated by rice and included other crops like wheat, potato, spring maize and vegetable seeds [20, 21].

The demand for quality seed is increasing day by day, presenting new challenges to meet the consumer's demands by taking competitive advantage in the context of international practices [22]. Major areas for producing vegetable seeds are focused in mid and high hills of Nepal. The hilly area of Nepal has microclimatic diversity to produce several kinds of vegetable seeds. Seed marketing is not yet specialized in the overall seed system. However, a few seed companies have initiated systematic marketing with proper grading, standard packaging and labeling for some vegetable seeds, but they have lacking research and development activities [15]. Marketing of quality seeds is constrained by the absence of well-established seed marketing companies and inadequate quality control services. The seed vision of Nepal (2013–2025) focuses on marketing of high yield and quality seeds across the country through strengthening of seed networks and seed supply channels in the public–private partnership modalities [13]. The organized vegetable production and distribution system from local to international level is necessary in the context of growing demand for quality vegetable seeds [14]. Nepalese vegetable seeds sector has been facing issues such as low level of knowledge and capacity at the farm level, dependency on middlemen for trading of product, inadequate market supports, weak input relationships, and limited learning and innovation at local level [17]. Price fluctuation, quality seed production (varietal purity, germination, viability, genetic stock used, drying, packaging), and demand for hybrid seed are also the major issues related to the vegetable seeds sector in Nepal. Moreover, limited numbers of seed storage and processing facilities, immature seed companies and mismatch between demand and supply of seeds are also the major constraints in vegetable sector. On this background, this paper focused to analyze overall existing vegetable seeds production environment, its marketing practice and perception of seed producer's and seed users in Nepal. This helps to harmonizing the policy for achieving strategic fits in the downstream and upstream part of the vegetables sector in Nepal.

Methodology

Selection of study areas, crops and sampling

Rukum and Kavre districts of Nepal were selected purposely for the analysis of seed producers, as these districts are major vegetable seed-growing districts of Nepal. From the selected districts, onion from Rukum and tomato, cucumber, French bean and okra from Kavre were selected. Similarly, for seed users Rupandehi and Palpa districts were selected representing Terai and hilly districts of Nepal. The study was focused at three levels: first at field level (seed producers, seed users, cooperatives), second at district level (agro-vets, district-level service providers, seed traders, cooperatives) and third at central level (seed companies, large agro-vets, central level service providers). A total of 350 samples were selected including seed producers (175), seed users (100) and seed companies/agro-vets/cooperatives/traders/service providers (75) for the study purpose. The details of the study area, population, sampling design and techniques are given in "Appendix 1".

Data analysis

Indexing techniques

Farmers' perceptions on the importance given to the different seed drying and storage problems were analyzed by using a 5-point scale of problems comprising very high importance, importance, medium importance, low importance and the very low importance by using 5, 4, 3, 2 and 1, respectively. This total score indicates the respondent's position in the continuum [4, 6]. The index of importance is computed by using the following formula:

$$\text{Iimp} = \sum (\text{si fi}/N), \text{ where, Iimp} = \text{Index of importance,}$$

$$\sum = \text{Summationsi} = \text{Scale value,}$$

$$\text{fi} = \text{Frequency of importance given by the respondents}$$

$$N = \text{Total numbers of respondents.}$$

Chi-square test

Considering the categorical nature of variables, Chi-square test was used was used to test the association between selection criteria of hybrid and OP vegetable seeds.

Willingness to pay

The maximum willingness to pay for high-quality vegetable seeds was calculated using directed survey method. It is psychologically motivated method which was used first time in 1954 by Stoetzel [18]. This method is cost and time-effective, and it has strong advantage in individual-level estimations [2]. Initially in the field, each respondent was asked the current price they had paid (based on actual quantity they had used in the last season) for vegetable seeds (crops and varieties specific). Then, we introduced the concept of quality seed and checked their understanding about seed quality attributes. After that, we described the actual standards of quality vegetable

seeds set by the government of Nepal to each individual respondent before asked them questions related to maximum willingness to pay. (1) Are you willing to pay additional price for good-quality vegetable seeds? If yes, (2) How much maximum price you are willingness to pay for quality seed/s? While asking, same quantity they had used in the last season was considered. The following formula is used to calculate the percentage of willingness to pay additional price for each vegetable seed.

$$\text{PCW} = \frac{(\text{CP} - \text{MWP}) * 100}{\text{CP}}$$

where PCW = percentage change in willingness to pay, CP = price paid for current vegetable seed, MWP = maximum willingness to pay for good-quality vegetable seed.

Results and discussion

Production environment of seed producers

Average area per household was 0.61 and 0.28 hectare in Kavre and Rukum districts, respectively. In the Kavre district, farmers have more upland[1] area compared to lowland.[2] However, in the case of Rukum, low and upland areas were more or less similar. On average, sampled farmers allocate 25–40% of their farm area to vegetable seed cultivation based on the types of crops. In the case of onion seed production in Rukum district, 80% of production was based on informal contracts with local traders and national-level seed companies, whereas in Kavre district for the remaining four crops, 100% production was based on informal contracts of CBOs with seed companies, agro-vets and traders. Most of the seed growers in the study area varied in knowledge of different aspects of seed quality. About 40.6, 71.4 and 43.3% of farmers had knowledge of field quality standards, isolation distances and presence of off-type plants, respectively. Those are the criteria set by the Nepali Seed Quality Control Center (SQCC) for maintaining seed quality standards [12, 16].

The onion and cucumber seed producers were using a single variety (Red Creole of onion and Bhaktapur Local of cucumber) for seed production. The Red Creole was planted in November to December at an altitude ranges from 850 to 1200 m from mean sea level, and it was harvested in May to June. The average minimum and maximum temperature was 13 and 24 °C, respectively. Similarly, Bhaktapur Local was planted in January to February at an altitude ranges from 700 to 1200 m from mean sea level, and it was harvested in May to June. The average minimum and maximum temperature was 17–19 and 22–23 °C, respectively. In the case of okra, tomato and French bean (FB), numbers of varieties cultivated for seed production in the study area were 2, 3 and 4, respectively. Even though the numbers of varieties ranged from 2 to 4, more than 80% of farmers were using single variety. Arka Anamika (93%) for okra, Chaumase (52%) for FB and Lapse (52%) for tomato have high market shares in the study area. Arka Anamika was planted in April to July at an altitude ranges from 700 to 1650 m from mean sea level, and it was harvested in August to October. Chaumase was planted in August to September at an altitude ranges from 750 to 1500 m from mean sea level, and it was harvested in October to December. Lapse was planted in May to June at an altitude ranges from 900 to 1500 m from mean sea level, and it was harvested in September to October. The average minimum and maximum temperature was same as cucumber for other three crops, namely okra, FB and tomato. The details of the production environment of vegetable seeds producers are given in "Appendix 2". Farmers were getting about 98% of source seed of onion from Government farms, whereas in the case of the remaining four crops, cooperatives were the major source (49.7%). About 16.6% of the farmers have been using their own previous year selected seed for seed multiplication programs. About 60% of the FB producers were using their own seed for its multiplication followed by tomato (26.7%), okra (6.7%) and onion (1.8%).

Major drying and storage problems of seed growers

The indexing technique was used to identify the major problems faced by farmers in drying and storage of vegetable seeds in the study area. Among the different problems, unfavorable environment immediately after harvesting was the major drying problem followed by direct sun drying that deteriorates the seed quality. In case of storage problems, "need to dry" several times was ranked as first followed by fluctuation in seed moisture content due to unfavorable environment, incidence of insect pests and lack of proper extraction and processing methods ("Appendix 3"). Timsina et al. [19] reported that the poor seed quality imposes large logistical costs on farmers could be reduced by utilization of desiccant bead drying and hermetic storage techniques.

Practice and perception on post-harvest function and marketing of vegetables seed

About 24% of onion seed producers tested seed before selling to end users. In the onion, some of the seed companies or traders were performing this function if they felt it to be necessary. However, in the remaining four crops, 100% of producers reported that seeds were tested before sale. This function was facilitated by cooperatives. One hundred percentage of the onion seed was tested in government laboratories, whereas

[1] It is un-irrigated and un-bunded land in Nepal as *Bari land.*

[2] It is irrigated and bunded land in Nepal as *Khet land.*

in case of remaining crops, 100% of seed was tested in private laboratories due to access and availability at the nearest point. In the study area, about 49.7% farmers had knowledge of safe moisture contents for storage. About 77% of the seed producers were using sun drying followed by more than one method (17%), which also includes sun drying. For tomato, drying inside of room (23%) was also the preferred method of drying for maintaining its quality. About 80% of the farmers were interested to introduce new methods of drying that can contribute to maintaining seed quality, whereas about 20% farmers were neutral in their response. Among all crops, 95% of onion seed producers sold seed immediately, followed by cucumber (47%), tomato (37%), French bean (33%) and okra (30%). About 93% of farmers practiced individual storage. Knowledge on hermetic storage (sealed storage) was found in 13% of farmers, which suggests a need to create awareness on hermetic storage practices in the study area. Almost all farmers were doing the sorting/cleaning activities of the seed, whereas only 68% of the farmers were following grading practices. About 63% of the farmers were doing bulk packaging. Most of the seeds produced and sold by farmers to traders or seed companies were sun-dried and packed in jute or polythene bags. More than 62% of the seeds in the study area were sold through contracts with different seed companies, traders and agro-vets via cooperatives followed by local traders (32%) and more than one option (5%). Only 0.6% of the farmers sold seed directly to seed companies. Ray et al. [11] reported that contract production systems increased the employment and improved rural economy of small farmers.

Future strategies of seed producer's

The results show that about 28, 58, 96, 95 and 99% of the respondents were interested in collective production, drying, packaging, storage and marketing of vegetable seeds in the future, respectively. It seems that the promotion of new post-harvest technologies that provide higher return to the farmers would be easily accepted by the respondents. Markelova et al. [8] carried out study on collective action in smallholders' market access and reported that collective action can bring advantages for small-holder marketing. Similarly, Kruijssen et al. [7] also indicated about many positive outcomes of collective action such as an access to markets, access to resources, increase bargaining power, risk reduction, achieve economies of scale, control of supply. When the individual behavior moves toward progressive coalition, then the innovation may translate into growth. If the innovation and the collective action are positive, then there are great possibilities of increasing growth in groups [1].

Land allocationn and varieties used by fresh vegetable growers

Average land holdings of fresh vegetable growers were 1.02 and 0.30 ha in Rupandehi and Palpa, respectively. Despite the smaller land holdings in Palpa district, the % area allocation for fresh vegetable production was higher, i.e., out of total land holdings, 23 and 50% of areas were allocated for fresh vegetable production in Rupandehi and Palpa, respectively. Among the different vegetable crops, the area allocated for onion (22%) was highest in Rupandehi followed by cucumber, tomato, FB (17% each) and okra (13%). In Palpa, the area allocated for tomato and FB was highest (33%), followed by cucumber and okra (13% each) and onion (6%).

Different types of varieties such as local, open-pollinated and hybrid have been grown in the study area. For onion and French bean, no hybrid varieties were used in the study area. Similar was the case for okra in Palpa. Most of the onion seed used in Rupandehi was from India. Timsina et al. [21] reported that one reason for the farmers in Rupandehi preferring to get onion seed from India was the lower price in comparison with Butwal and Bahirahawa. Besides, only one variety of Nepalese onion was available in the field, other qualities of imported onion seed such as good-sized bulb, no bolting (flowering) during its production and longer storage duration also motivated farmers choosing imported seeds. It clearly shows that the functional strategies in the upstream as well as market side of supply chain for the domestic onion seed do not match properly with the preference of the downstream part of supply chain [21, 16]. Knowledge of variety names of different vegetables varied in the study area, ranging from 43 to 93% depending on the crops. Varieties of onion such as Gauti, Gauran and Lanka in Palpa and AFDR were not cultivated in Rupandehi. Nasik was popular in Rupandehi, whereas AFDR was popular in Palpa district. In case of tomato, farmers were using about 37% unknown varieties with different names such as 9802, Nabin, Bombay, 509 JK and S-22. Among known varieties, Srijana was ranked first (33%), followed by Manisha (15%), Laxmi (6.7%), Winsari (3.3%), and Lapsegede, Gaurav and Raja (1.7%). Srijana was very popular in Palpa, whereas Laxmi was popular in Rupandehi.

Cucumber farmers were using about 20% unknown varieties with different names such as Local Chetai and Johapuri. Among known varieties, Bhaktapur Local was ranked first (56%), followed by Green Long (12%), VNR-128 (8%) and Ninja (4%). Only 15% of FB varieties used by farmers in the study area were unknown. Among the known varieties, Four Season (Chaumase) was ranked first (40%) followed by Trisuli (25%) and Kentucky Wonder (20%). For okra, none of the varieties were known by

Palpa farmers. Arka Anamika was the most popular okra variety in both Rupandehi and Palpa districts. Moreover, about 74, 57, 46, 36 and 58% of the respondents agreed on an increasing trend of area allocation for onion, tomato, cucumber, FB and okra, respectively, in the last 5 years, which indicates the potential for increasing demand for quality seeds in the coming days in Nepal.

Perception of vegetable growers on selection of seed type and their willingness to pay

Perceptions of farmers on selection of hybrid and OP varieties of vegetable seeds were taken. The Chi-square test was used to test the association between selection criteria of hybrid and OP vegetable seeds. Single respondents were given a chance to choose more than 1 option so the values presented in the table may overlap. From the analysis, it was found that selection criteria for hybrid and OP were found significantly different ($\chi^2 = 61.6$, $df = 6$ and $p = 0.000$). Results indicated that farmers were choosing hybrids mainly due to their higher production, attractive fruits and more profit, whereas the main reasons for choosing OPs were easy availability and preference given by the consumers (Table 1).

The major place to purchase commercial seeds for selected vegetable crops was from the private sector. About 87, 94, 85, 83 and 81% commercial seed of onion, tomato, cucumber, FB and okra, respectively, were obtained from private sources. The private sources included agro-vets, traders and seed companies. None of the farmers were getting commercial seed from the government except onion. Farmers were also using their own saved seed for fresh vegetable production in FB and okra. Seed from Indian markets was also another option for farmers in Rupandehi district or fresh vegetable production as it lies on the border with India (Table 2).

About 33% of the respondents were practicing germination tests of seeds before sowing to the field. More than 80% of farmers were aware about the populations of uniform and healthy plants in the field, whereas about 65% knew about off-type plants. The mean germination percentage of vegetable seeds was 77%; however, it varied from 2 to 98% with standard deviation of 17%. For all vegetable seeds, farmers were willing to pay an additional price if high-quality seed would be available in the market. Farmers in the study area were willing to pay 30, 33, 30, 31 and 23% higher price for onion tomato, cucumber, FB and okra, respectively. This indicates that the potential for market expansion for quality seeds in Nepal is immense (Table 3). Timsina et al. [20] reported that most farmers were willing to pay more for higher-quality seed of tomato. Moreover, farmers were willing to pay 30.5, 46.9 and 26.7 Nepali Rupees (NR) in tomato seed price for germination, vigor and purity of tomato seed, respectively, in order to increase each attribute by 1%.

Limitations and risk points for the vegetable seeds system in Nepal

Different types of limitations and risks were observed at different levels of the vegetable seeds system in Nepal. At the input level, issues included the quality of source seed that has been produced in different horticultural farms; limited technical knowledge with local agro-vets on quality of seeds; limited numbers of varieties used for seed multiplication programs; deterioration/resistance breakdown in source seed due to continuous use without maintenance; and supplying low-quality vegetable seeds to seed users. Fresh growers have reported that germination and vigor of vegetable seeds in the study area were poor and weak, respectively. This was found especially for open-pollinated seeds. In some cases, the emergence of seed in the field was zero. Moreover, they also

Table 1 Perception of farmers for selection of seed types ($n = 100$)

Reasons for selection	Hybrid	OP
Higher production	87.0	22.0
Attractive fruits	9.0	3.0
Quality seed	27.0	4.0
Availability	2.0	16.0
More profit	13.0	1.0
Less incidence of insect pests	10.0	12.0
Consumer preference	4.0	11.0

χ^2 value = 61.6, $df = 6$, p value = 2.0844E−11; response may overlap in different traits

Table 2 Sources of commercial seed for fresh vegetable production (%)

Crops	Rupandehi				Palpa				Total			
	Govt.	Private	India	Own	Govt.	Private	India	Own	Govt.	Private	India	Own
Onion	9.3	72.1	18.6	–	–	100.0	–	–	4.1	86.5	9.4	–
Tomato	–	90.0	10.0	–	–	97.1	2.9	–	–	93.8	6.2	–
Cucumber	–	63.6	36.4	–	–	100.0	–	–	–	84.6	15.4	–
French bean	–	75.0	8.3	16.7	–	91.7	–	8.3	–	83.3	4.2	12.5
Okra	–	80.0	13.3	6.7	–	100.0	–	–	–	80.6	12.9	6.5

Table 3 Farmers' willingness to pay additional price (%) for quality seed

Crops	Rupandehi ($n = 60$)	Palpa ($n = 40$)	Average
Onion	29.3	31.6	30.4
Tomato	28.1	37.3	32.7
Cucumber	27.4	32.5	29.9
French bean	31.0	30.2	30.6
Okra	29.7	15.3	22.5

complained about the unavailability of preferred varieties in time. Inadequate technical support services from government offices, low levels of technical knowhow and awareness on improved seed production, scattered production, low levels of commercial farming, limited research on vegetable seeds production, and weak production planning based on demand were the major challenges at the production level. At the postproduction level, various issues were noted in the postproduction of vegetable seeds, such as absence of collective marketing in full phase; inadequate market information system; low levels of post-harvest knowledge; poor post-harvest handling by transporters in large-sized packages; absence of vertical integration; quality debate between traders and farmers; and high moisture absorption during transportation in gunny bags to the destination market.

It was estimated that on average about 10–20% losses were observed in vegetable seeds from farm to wholesale due to poor management and storage practices. Most of the seed companies and agro-vets thought that if seeds were dried, the quality would deteriorate automatically due to poor storage systems. Cleaning and sorting were the only processing activities adopted so far by seed growers before selling to traders. In the case of onion, dipping in water to sort out immature seed and other inert materials was the major practice before drying and selling seeds, which was a potential cause of reduced seed quality [21]. It was reported that a combination of high temperatures (> 37°C) during drying of wet seeds could further damage the seeds, causing reduction in quality of seed lots [19].

Conclusions and policy implications

This study was carried out to know the current status of vegetable seed production, distribution and use in Nepal. About 80% seed production in Rukum district was based on informal contracts with local traders and national-level seed companies, whereas in Kavre district 100% production was based on informal contracts of community-based organizations (CBOs) with seed companies, agro-vets and traders. Most of the seed growers in the study area have varying knowledge of different seed quality aspects. Almost all farmers were doing sorting/cleaning activities, whereas only 68% of the farmers were following grading practices. The USAID funded Horticultural Innovative Lab Project has been creating awareness to maintain the quality of seeds through proper drying and storage practices. It has initiated the concept of the "dry chain," which means "make it dry and keep it dry" throughout the whole seed chain [19]. In the alternative of dipping seed in water, we can promote manual winnowers. We can improve the quality of vegetable seeds in two ways in Nepal, first improving the genetic quality from research stations and second increasing physiological quality such as vigor and germination through adopting proper drying and storage methods. From the above results and discussion, it seems that promotion of new post-harvest technologies that provide higher return to the farmers would be easily accepted by the respondents. The economic opportunity to introduce modern drying and packaging technology to obtain greater benefits in seed systems is reported, but it was varied in different business models. The sharing of positive net income and negative net income for different actors in different models was different, but seed users' benefits were similar and the largest in all business models due to minimization of losses from poor germination and a yield increment using higher-quality seed [23]. Local, open-pollinated and hybrid seeds are being using in the study area. Until 2016, single hybrid variety of tomato is released among all vegetable crops in Nepal. Whereas higher preference of farmers on hybrid varieties of tomato (77%), okra (48%) and cucumber (39%) is observed. Therefore, supply of good-quality hybrid seed based on farmers demand is required to meet the demand of downstream part of the seed chain. Moreover, results on tendency of farmers to change preferred varieties and their willing to pay about 30% higher additional price for high-quality vegetable seeds, indicating the market potential for expansion of quality seed in the future by improving percentage of vigor, germination and purity in the seed. Further, it is suggested to carry out feasibility study and identify the policy environment for joint venture among national and international seed companies for import and export of vegetable seeds including hybrid.

Authors' contributions

KPT was the lead investigator and the initiator of the study also responsible for literature search and write-up. GPS was responsible for the overall study design and provided critical feedback on the manuscript. Both authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

Consent for publication
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Ethical approval and consent to participate
Oral informed consent was obtained from each respondent from each of the participating households and stakeholders.

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Appendix 1: Details of the sample design and sampling techniques

District	Crops	Target population	Sample	Category	Sampling techniques
Rukum	Onion	300	55	Seed producers	Purposive and simple random sampling
			15	Cooperatives, traders, agro-vets and service providers	Purposive
Kavre	Cucumber	200	30	Seed producers	Purposive and simple random sampling
	Tomato	40	30	Seed producers	Purposive and simple random sampling
	French bean	132	30	Seed producers	Purposive and simple random sampling
	Okra	45	30	Seed producers	Purposive and simple random sampling
			12	Cooperatives, agro-vets and service providers	Purposive
Rupandehi	Fresh vegetables	390	60	Veg. growers	Purposive and simple random sampling
			10	Cooperatives, agro-vets and service providers	Purposive
Palpa	Fresh vegetables	107	40		Purposive and simple random sampling
			10	Cooperatives, agro-vets and service providers	Purposive
Kathmandu valley			15	Seed company, cooperatives, agro-vets and service providers	Purposive
Others			10	Service providers	Purposive

Seed producers (no) = 175; seed users (no) = 100; seed companies/agro-vets/cooperatives/traders/service providers (no) = 75; total sample for study = 350

Appendix 2: Production environment of vegetable seeds producers in the study area

District	Crops	Varieties	Altitude from mean sea level (m)	Growing seasons	Temperature[a]	
					Minimum average (°C)	Maximum average (°C)
Rukum	Onion	Red Creole	850–1200	November–December to April–May	13	24
Kavre	Cucumber	Bhaktapur Local	700–1200	January–February to May–June	17–19	22–23
	Tomato	Lapse	900–1500	May–June to September–October	17–19	22–23
		CL cross	700–1900	February–April to May–September	17–19	22–23
		Srijana	1300–1400	March–May to July–December	17–19	22–23
	French bean	Four season (Chaumase)	750–1500	August–September to October–November–December	17–19	22–23
		Trisuli	750–1300	August–September to October–November–December	17–19	22–23
		Kentucky wonder	1100–1300	August–September to October–November–December	17–19	22–23
	Okra	Arka Anamika	700–1650	April–July to August–October	17–19	22–23
		Kavre selection	1100–1650	May–June to September–December	17–19	22–23

[a] Average data recorded from subtropical vegetable seeds production center Musikot, Rukum and spices development center, Panchkhal, Kavre

Appendix 3: Major drying and storage problems in the study area

Description	Onion ($n = 55$)		Tomato ($n = 30$)		Cucumber ($n = 30$)		French bean ($n = 30$)		Okra ($n = 30$)		Overall ($n = 175$)	
	Index value	Rank	Index value	Rank	Index value	Rank	Index value	Rank	Index value	Rank	Index value	Rank
Problems in/during drying												
Unfavorable environment immediately after harvest leading to low seed quality	2.5	I	2.5	I	3.0	I	2.9	I	2.9	I	2.7	*I*
Seed damage in direct sun drying	1.6	II	2.0	II	1.6	II	1.8	II	1.9	II	1.7	*II*
Bird/insect damage during drying by hanging above fire (*Aageno*) or window	0.2	III	0.7	III	1.6	II	1.0	III	1.2	III	0.8	III
Problems in/during storage												
Need to dry several times	2.6	II	2.8	I	3.0	I	2.5	I	2.7	I	2.7	*I*
Fluctuation in seed moisture content due to unfavorable environment	2.7	I	1.4	III	1.2	III	1.9	III	1.9	III	2.0	*II*
Infection/incidence of insect pests and effects on health of stored seeds	1.2	IV	2.2	II	1.8	II	1.7	III	2.2	II	1.7	III
Post-harvest loss due to lack of proper extraction and processing	1.4	III	0.7	V	1.0	IV	0.9	IV	0.9	V	1.1	IV
Losses due to rats and other animal damage	1.0	V	0.9	IV	1.0	V	1.5	IV	1.0	IV	1.1	IV

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