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Quality Seed Accessibility Index: A Case Study from a Village in Western Rajasthan

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ABSTRACT

The availability of quality seeds for sowing is a critical factor affecting crop production. A Seed Accessibility Index was developed to assess the extent of accessibility of quality seeds by farmers from formal and informal sources. The study was undertaken in Jodhpur district in western Rajasthan involving a sample of farm households (60), representatives from Rajasthan State Department of Agriculture (2), Rajasthan State Seeds Corporation (RSSC) (1), Rajasthan State Seed and Organic Production Certification Agency (1), National Seeds Corporation (1), private seed dealers (5) and private seed companies (PSCs) (5). Accessibility Index (AI) was found to be highest (86.67%) for farm saved seeds (carrot, onion and garlic) indicating that the seeds/planting material in these crops were easily and timely available, affordable, credible and performed as expected without any cases of spurious seeds. In case of seeds purchased from market, timely availability was not an issue but the seeds of desired variety were not always available. The probability of crop failure on account of spurious seeds was found to be higher in those crops for which farmers were completely dependent on market. PSCs and dealers' agreed that probability of cases of spurious seeds was 2-3 per cent. However, the economic loss caused to those farmers who suffered crop loss because of spurious seeds is huge. Price of seeds purchased from market was found to have less AI (62.33) indicating that seeds are no more a cheaper input in agriculture. The farmers' practice of higher seed rate than recommended, resowing for 2-3 times and complete dependence on market have led to increased expenditure on seed. The study indicated that the role and importance of informal seed sector (as in carrot) has been grossly underestimated or even overlooked by researchers and policymakers. On the other hand, the role of formal sector (especially PSCs) is overestimated and even glorified. It is also evident that high Seed Replacement Rate (SRR) in itself doesn't guarantee quality of seed and crop performance.

Keywords: Certified seed, Farm-saved seed, Farmer's rights, Seed Accessibility Index, Seed Replacement Rate, Truthfully labeled seed.

INTRODUCTION

Seed is the basic and indispensable input in agricultural production. It is the cheapest among all inputs but the whole crop production and the response of other inputs (irrigation, fertilizers, pesticides, *etc.*) depend on its quality. It is estimated that good quality seeds of improved varieties can contribute up to 20-25 per cent increase in yield.

Before green revolution period, farm-saved seeds of cultivars bred and produced by farmers were the main source of seed in India. As a result of enactment of seed legislations and programmes aimed at building of institutional capacities from time to time, there has been a gradual shift from using farm saved seeds to purchasing high yielding varieties (HYVs) and hybrids from sources outside of their farm and community. During the green revolution period, seeds of HYVs of rice and wheat and hybrids of pearl millet, maize and sorghum were bred, multiplied and distributed by public sector institutions at affordable prices to the farmers while ensuring quality control at each level. The farming community and the nation as a whole were benefitted by these HYVs. The success of Indian green revolution was centered on development, multiplication, production, distribution and use of high yielding varieties. The frontline agricultural extension programmes in the country were initiated to popularize and disseminate the improved varieties among the farming community.

A major re-structuring of the seed industry was

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carried out by Government of India through the National Seed Project Phase-I (1977-78), Phase-II (1978-79) and Phase-III (1990-1991) which strengthened the seed infrastructure that was most needed and relevant around those times. This could be termed as a first turning point in shaping of an organized seed industry. Introduction of New Seed Development Policy (1988-1989) was yet another significant milestone in the Indian Seed Industry, which transformed the very character of the seed industry (SeedNet India Portal, 2017).

Seed industry in India at present is regulated through Seeds Act 1966, Seeds (Control) Order 1983 and New Policy on Seed Development (NPSD) 1988. NPSD liberalized Indian seed industry by allowing investment by foreign and domestic firms and lifting restrictions on import of germplasm and seeds. Since then, the role of private sector has increased substantially in terms of number of seed firms, investment in R&D, development of innovations, their protection through suitable IPR options and market/revenue share in domestic market and export (Manjunatha, 2013a; Manjunatha, 2013b).

The dependence of farmers on market for seeds has increased in the last few decades. Except in case of few self-pollinated crops where public sector organizations are serving farmers with good quality seeds, farmers are completely dependent on private seed companies (PSCs) for various other field crops, vegetable crops and crops of commercial interest. PSCs have acquired great control over the seed market through exclusive ownership and marketing rights over their proprietary hybrids and technologies.

Even in the present scenario, the formal seed sector (including both public and private sector) meets only 15-20 percent of the seed requirement of the farmers (MoA, 2012). Remaining 80-85 percent of seed requirement is being met by informal and farmer-to-farmer seed exchange mechanisms. The formal sector alone cannot completely fulfill the requirement of seeds of diverse crops in India. Informal sector has been, is and would remain as a strong pillar of Indian seed production and supply system. Hence, the role and importance of informal seed sector have to be recognized, strengthened and incentivized. The accessibility to quality seed has become a crisis for farmers in every season. The farmers face several problems in acquiring quality seed and incur heavy losses in farming when the seeds purchased turn out to be spurious seeds of low genetic purity. Therefore, assured availability of quality seeds to farmers at affordable prices is very important for attaining higher crop yield and sustained production. In this context, it was envisaged to measure the extent of availability and use of certified /quality seed by farmers. This research paper has the following specific objectives to measure the extent of accessibility to quality seed by farmers; and to estimate Accessibility Index for parameters affecting accessibility to quality seed.

METHODOLOGY

Locale of the study: The study was undertaken in Ujaliya village in Baori tehsil of Jodhpur district in the Rajasthan state of India. The village was selected purposively for the study. ICAR-Central Arid Zone Research Institute is working in the village since June 2015 through front line and field demonstrations, training and capacity building of farmers and farm women.

Research Design, Sampling Procedure and Data collections tools: The present study was carried out using ex-post facto research design. Sixty farm households were randomly selected from the village. Primary data were collected through personal interview method using pre-tested structured interview schedule. Focused group discussions and PRA techniques were also used to collect information pertaining to entire village. Two officers from Rajasthan State Department of Agriculture, one officer each from National Seeds Corporation (NSC), Rajasthan State Seeds Corporation Limited (RSSC), Rajasthan State Seed and Organic Production Certification Agency (RSSOPCA), five representatives of PSCs and five seed dealers were also personally interviewed for the study to supplement and validate the primary information. Total sample size for the study was 75. Primary data were collected from July 2015 to December 2016.

Variables and their measurement

Accessibility to quality seed is defined as the extent of access that a farmer has to the quality seed in terms of its timely availability in adequate quantities of required cultivar at affordable/reasonable prices from a credible source with assured crop production and returns. The scale developed by Manjunatha (2013c) and used in Manjunatha et al. (2015a) was used with certain modifications to measure “Accessibility to quality seed” by farmers in the present study. The scale consisted of following ten parameters. Each parameter was measured on a five point scale.

Timeliness in availability: It refers to the degree to which a particular preferred seed is available to the farmer in time. It was measured on a five-point continuum scale with scores of 5, 4, 3, 2 and 1 respectively for 'one month before sowing', 'one week before sowing', '3 days before sowing', 'Late (sowing season in full swing)' and 'very late' (after start of sowing season).

Availability of desired variety in adequate quantities: It refers to the degree to which seeds of particular varieties are available to the farmer in required quantities. It was measured on a five point continuum scale of 'adequate', 'adequate but have to be procured early', 'moderate', 'scarce' and 'very scarce/not available' with scores of 5, 4, 3, 2 and 1 respectively.

Proximity to seed source: It refers to the geographical proximity to seed sources/suppliers of seed of farmers' preference. It was measured on a five point scale of 'same/nearby village', 'nearby town/tehsil', 'district head quarters/city', 'selected cities/ towns' and 'far away cities' with scores of 5, 4, 3, 2 and 1 respectively.

Credibility of source of seed: It is the degree of trust that the farmer has on the seed producer/supplier. It was measured on a five point rating scale of 'very highly credible', 'highly credible', 'moderately credible', 'less credible' and 'least credible' with scores of 5, 4, 3, 2 and 1 respectively.

Price of seed: It is the amount/price in terms of rupees the farmer needs to pay in exchange for the seeds he/she purchased. It was measured as 'less costly', 'affordable', 'moderate', 'costly' and 'very costly' with scores of 5, 4, 3, 2 and 1 respectively.

Cultivation of Improved cultivars: It is farmer's perception regarding use of quality seeds of improved cultivar. It was measured using a five point scale of 'latest HYVs/ hybrids', 'popular variety', 'good variety but old', 'very old variety' and 'non-descript variety' with scores of 5, 4, 3, 2 and 1 respectively.

Physical and genetic purity of seeds: It is the perceived level of purity of seed (as expressed in terms of uniformity in crop growth and yield realized) that the farmer buys. It was measured as 'very pure', 'pure', 'moderately pure', 'less pure' and 'least pure' with scores of 5, 4, 3, 2 and 1 respectively.

Crop performance: It is the farmer's perception regarding the performance of seed in terms of crop yield. It was measured on a scale of 'very good', 'good', 'moderate', 'poor' and 'very poor' with scores of 5, 4, 3, 2 and 1 respectively.

Documentation of records (record keeping): It is the farmer's habit of keeping records pertaining to seed transactions. It was measured as 'always', 'often', 'sometimes', 'rarely' and 'very rarely' with scores of 5, 4, 3, 2 and 1 respectively.

Quality of farm-saved seeds: It is the farmer's perception on the degree of quality of farm saved seeds. It was measured on a scale of 'very good', 'good', 'moderate, 'poor' and 'very poor' with scores of 5, 4, 3, 2 and 1 respectively.

First nine parameters pertained to seeds purchased from market (formal sources including public and private sector), whereas last parameter pertained to farm-saved seed (informal seed sector).

Overall Accessibility Score: The overall accessibility score of each respondent was calculated by adding his/her scores obtained in all ten parameters. The respondents were classified into five categories based on their overall accessibility scores using mean and standard deviation.

Accessibility Index: It was calculated for each parameter of the accessibility to quality seed. It was calculated by using the following formula:

Accessibility Index = (Total obtained score/ Total achievable score)* 100.

Total obtained score for a parameter is the sum of scores obtained by all respondents (sample size = 60) for that parameter.

$$\text{Total Obtained Score} = \sum_{i=1}^{60} Xi$$

Where Xi is the score of ith respondent for parameter X and i = 1 to 60.

Total achievable score for each parameter is the product of sample size (= 60) and maximum possible score for that parameter on the scale (= 5). It is 300 (=60X5) and is constant for all parameters.

RESULTS AND DISCUSSION

The results and discussion are presented in the following sections:

Brief information on Agro-Eco System Analysis of Ujaliya village

The village has a total geographical area of 1317 hectares. A total of 418 families are residing in the village with a population of 1802 (Census 2011). The soil in the village is light textured and mostly rain-fed with severe problem of wind erosion. Soil is sandy in most parts and shallow gravelly soil exists all along the hill side. The depth of soil is shallow in most parts and medium in some parts of the village.

Table 1: Crops grown during agricultural years 2014-15 to 2016-17 in Ujaliya village

Season	Crops	Remarks
Kharif (Rainy season)	Pearl millet, green gram, moth bean (dew gram), cluster bean (guar), sesame (til), cotton, castor, carrot, onion, okra (ladies' fingers), chilly, brinjal.	Til is grown as mixed crop with pearl millet in dryland conditions. Moth bean is not a major crop. Okra, chilly and brinjal are mainly grown for domestic consumption.
Rabi (Post-rainy/Winter season)	Carrot, rapeseed and mustard, cumin, isabgol, onion, garlic, wheat.	Rabi cropping is practiced only by farmers with assured irrigation source. Carrot is a highly commercial crop and its sowing is done in multiple phases.
Zaid (Summer season)	Onion, seed onion, seed carrot, cucurbits, guar (vegetable purpose)	Seed of carrot and onion is produced by farmers for their own use as seed in the next season.

Preference of cultivars and source of seeds

The various cultivars grown in the village during agricultural years 2014-15 to 2016-17 and the source of seed are given in table 2. In case of pearl millet, majority of the farmers preferred hybrids and they purchased seeds from seed dealers, Rajasthan State Seeds Corporation (RSSC) and National Seeds Corporation (NSC). Composites such as CZP-9802 and Raj-117 were preferred for domestic consumption and fodder for animals in rainfed conditions.

Varieties and hybrids developed by public sector research organizations occupy major area under pearl millet in Rajasthan. However, both public sector organizations and PSCs have almost equal share in marketing and distribution (Manjunatha, 2015b). Varieties were popular in case of green gram, guar, moth bean and til. Seeds were purchased from RSSC, NSC and seed dealers.

Great variation was found in number of years for which these seeds were reused by farmers. Some farmers reused for more than 6 years whereas some farmers replaced seeds after every two years. Interestingly, some farmers also replaced these seeds every year. These farmers were under the impression that seeds have to be replaced every year irrespective of whether the cultivar is composite, variety or hybrid.

Some farmers were not aware whether the cultivar they cultivated was a variety or hybrid. Few farmers mistook varieties for hybrids. Few farmers also reported that some seed dealers sold varieties to farmers insisting that they were hybrids in case of self-pollinated crops such as green gram and guar. Whether such act was deliberate (to promote seed sales) or because of lack of knowledge is to be verified. However, the consequence was that some farmers replaced seeds every year even when it was not necessary.

Table 2: Preference of cultivars and the source of seed for various crops grown in Ujaliya

Crop	Major area under varieties/ hybrids	Major source of seed	Varieties/hybrids grown*
Pearl millet	Hybrids/varieties	Seed dealers, RSSC, NSC, RAU-Mandore, CAZRI	Public sector composites (CZP-9802 and RAJ-171) and hybrids (HHB-67 Improved, RHB-177), hybrids of PSCs (Pioneer, Pro-Agro, Gangotri, Bioseed, Avani, The Best Agro Seeds, Eknath).
Green gram	Varieties	RSSC, NSC, CAZRI, seed dealers, farm saved seeds	SML-668, GM-4, IPM 2-3, RMG-62, varieties of PSCs (Manak Hybrid Seeds, The Best Agro Seeds).
Guar	Varieties	RSSC, NSC, CAZRI, seed dealers, farm saved seeds	RGC-1017, RGC-936
Moth bean	Varieties	RSSC, NSC, CAZRI, farm saved seeds	RMO-435, RMO-40, RMO-225, RMO-257, CZM-2.
	Varieties	RSSC, NSC, RAU-Mandore, CAZRI, farm saved seeds	RT-127, RT-46
Castor	Hybrids/Varieties	Seed dealers	Western-6, Mahyco 409, Kanha
Cotton	Hybrids (Bt cotton)	Seed dealers	Hybrids of PSCs (Sriram, Rasi)
Carrot	Farmers' selections, Varieties	Farm saved seeds	Farmers' own seeds
Onion	Varieties, farmers' selections	Farm saved seeds	Farmers' own seeds
Garlic	Varieties, farmers' selections	Farm saved seeds	Farmers' own seeds
Cumin	Varieties	RSSC, NSC, RAU-Mandore, CAZRI, seed dealers	Public (GC-4), Private (Sardar, Avani)
Rapeseed and Mustard	Varieties/Hybrids	RSSC, NSC, CAZRI, seed dealers	Varieties of public (Pusa bold) and hybrids of private sector (Pro Agro, Manak, Avani).
Isabgol	Varieties	RSSC, NSC, farm saved seeds	Varieties of public sector (GI-2, RI-29)
Wheat	Varieties, farmers' selections	Seed dealers, farm saved seeds	Sharbati selection, Raj 3077, Raj 1482, Lok-1.
Taramira	Varieties	RSSC, NSC, seed dealers, farm saved seeds	Seeds sold by NSC (RTM-2002), Manak Hybrid Seeds

Note: (1) *The list of varieties/hybrids is not exhaustive. (2) RSSC = Rajasthan State Seeds Corporation; NSC = National seeds Corporation; RAU-Mandore = Rajasthan Agriculture University, Mandore Campus, Jodhpur; CAZRI = Central Arid Zone Research Institute; PSCs = Private Seed Companies. (3) Seed dealers include seed retailers. Seed dealers are not exclusively involved in sale of seeds. They are basically agricultural input dealers who also sell seeds.

In case of cotton, Bt hybrids produced and supplied by PSCs occupied the entire area. Farmers purchased seeds of cumin, rapeseed and mustard, castor and taramira from seed dealers, RSSC and NSC. RSSC and seed dealers (representing all PSCs) supplied large quantities of seed directly to farmers, followed by NSC. Rajasthan Agriculture University and CAZRI sold seeds of pearl millet, green gram, moth bean, guar, til, cumin and mustard in limited quantities. In case of carrot, onion and garlic, farmers preferred only farm saved seeds and never purchased seeds from public organizations and private seed dealers. Even in case of non-availability of their own farm saved seeds (due to poor quality or pest and disease infestation), seeds from other farmers in the village or nearby villages were purchased.

Few farmers in the village started carrot cultivation since 1998-99 because of demand in the market. These farmers procured carrot seeds from entrepreneurial carrot farmers in villages in and around Mathania town. From next year onwards, majority of the farmers with tube well irrigation started cultivating carrot. Carrot is a major commercial crop in the village at present. Majority of the farmers take up carrot seed production every year in limited scale to meet their own seed requirement in the next year. Some farmers who don't take up carrot seed production purchase seeds from fellow farmers. However, farmers repeatedly emphasized that they never purchased carrot seeds from market. The carrot grown in Ujaliya and surrounding villages is of very superior grade because of congenial climate and soil type. The carrot grown in the region is purchased from the traders directly from farmers and the produce is sent to markets in metropolitan cities such as Jaipur, Delhi and Mumbai at premium prices. The case of carrot illustrates that highly commercial crop production can also be taken up using farm saved seeds without being dependent on market for seeds.

Accessibility to quality seed by farmers

The distribution of farmers on various parameters of accessibility to quality seed is provided in table 3. Timely availability of seeds was not found to be a major problem for majority (90 percent) of farmers. Farmers were able to procure the seeds from public organizations (RSSC, NSC and CAZRI) or private seed dealers or used their own farm-saved seed. Seeds of pearl millet, cotton, mustard and castor are available well in time from private seed retailers/dealers located in Bhavad, Baori, Mathania and Jodhpur towns. However, availability of seeds of desired cultivars was an issue of concern. Forty percent respondents expressed that seeds of desired varieties were always scarce and not available. When farmers go to seed dealer and ask for a variety, dealer will supply the variety if it's available. Otherwise, dealer himself will recommend another variety saying that the said variety was found to perform excellently in other farmers' fields in the region.

Table 3: Distribution of farmers on various parameters of accessibility to quality seed

Timely Availability	f	%
Well in advance (at least before one month)	29	48.33
Available before 1 week of sowing	17	28.33
Available before 3 days of sowing	8	13.33
Late	4	6.66
Very late	2	3.33
Availability of desired cultivar in required quantities		
Adequate	8	13.33
Adequate but have to be procured early	9	15
Moderate	19	31.66
Scarce	16	26.66
Very scarce/not available	8	13.33
Proximity to seed source		
Locality /village	2	3.33
Nearby town/ tehsil	39	65
District Head Quarters	15	25
Selected cities/towns	2	3.33
Cities far away	2	3.33
Credibility of source of seeds		
Very highly credible	4	6.66
Highly credible	9	15
Moderately credible	25	41.66
Less credible	16	26.66
Least credible	6	10
Price of seeds		
Less costly	9	15
Affordable	10	16.66
Moderate	16	26.66
Costly	15	25
Very Costly	10	16.66
Use of improved cultivar		
Latest HYVs/hybrids	14	23.33
Popular variety	26	43.33
Good variety but old	12	20
Very old variety	6	10
Non-descript variety	2	3.33
Physical and genetic purity of seeds		
Very pure	6	10
Pure	14	23.33
Moderately pure	30	50
Less pure	8	13.33
Least pure	2	3.33
Crop Performance (as percentage of expected yield (EY)		
Very good (>80% of EY)	4	6.66
Good (60-80% of EY)	18	30
Moderate (40-60% of EY)	28	46.66
Poor (20-40% of EY)	4	6.66
Very poor (<20% of EY)	6	10
Quality of Farm Saved Seeds (as percentage of expected yield) (EY)		
Very good (>80% of EY)	30	50
Good (60-80% of EY)	24	40
Moderate (40-60% of EY)	4	6.66
Poor (20-40% of EY)	2	3.33
Very poor (<20% of EY)	0	0
Documentation and record keeping of seed related transactions		
Always	11	18.33
Often	10	16.66
Sometimes	19	31.66
Rarely	11	18.33
Very rarely	9	15

Note: All the parameters except 'Quality of farm-saved seeds' pertains to the seeds purchased from formal sector (both public and private sector).

Majority of the farmers (94 %) purchased seeds mainly from public organizations and seed dealers from nearby towns and cities. Few farmers purchased seeds of onion from Pune/Nashik in Maharashtra after every 6 to 8 years or whenever they felt that quality of farm saved seeds was not of the desired quality.

The farmers accord different degrees of credibility to various sources of seed based on their experiences over a

period of time. Sources of seed might be public, private, NGO/CBO, fellow farmer or his own farm-saved seed. For each crop, the farmer has a preference for certain source of seed over others because of high genetic and physical purity of seed and consequent productivity (Manjunatha, 2015a). In case of moth bean, farmers in Ujaliya preferred CZM-2 (CAZRI Moth 2) variety produced and sold by CAZRI. Though the same variety was sold by NSC, RSSC and few PSCs, they preferred to purchase directly from ATIC of CAZRI. For guar, the varieties bred by Rajasthan Agricultural University (Durgapura station) are very popular among farmers. Farmers preferred seeds produced by RAU or RSSC. In case of pearl millet, hybrids bred and produced by Rajasthan Agricultural University and few PSCs are preferred over other sources.

One major observation made by the researchers during interaction with the farmers was that majority of the farmers did not distinguish between the technology (variety/hybrid in this case) and the technology producer/supplier. For instance, when farmers were asked about the varieties and hybrids grown by them, majority of them were referring to the name of the organization or PSC who produced that seed or the seed dealer from whom they purchased the seeds. One reason for this is that even Private seed companies focus their company name (as brand name) more than the name of varieties and hybrids while marketing the seeds produced by them through seed dealers. The name of the company will be in bold and attractive letters and the variety name will be printed somewhere in the corner of the seed bag/packet in small letters. It is more so if private companies are producing the seed of a variety developed by public sector. For example, many private seed companies acquire the breeder/foundation seed of HHB-67 Improved for further multiplication and production as certified/truthfully labeled seed. HHB-67 Improved is a hybrid developed by Haryana Agriculture University, Hisar in Haryana, which is a public sector State Agricultural University. However, when private seed companies market seeds of HHB-67 Improved in seed bags, they highlight their company name and print HHB-67 Improved in small fonts in the lower side of the bag. Private seed companies also instruct seed dealers/retailers (through whom they sell their seeds) to sell these seeds to farmers by referring company name rather than by referring to variety/hybrid. Hence, dealers also sell these varieties/hybrids to farmers in the name of the company. Even farmers are so used to this that, they ask for seeds produced by a particular company rather than asking for a specific variety/hybrid. This practice defeats the very purpose of developing new cultivars, their notification and release. Each technology will have a name before it is released for commercial use. New cultivar is a technology and each cultivar has a name. Marketing strategy of PSCs to suppress/hide the name of variety and not acknowledging the real owner/proprietor of the technology has led to underestimating the contribution of public sector organizations that have bred the varieties.

Forty two per cent of respondents found the seed source to be moderately credible and thirty seven percent found it less to least credible. When spurious seeds purchased from dealers failed to either germinate, resulted in poor germination and crop stand ultimately leading to poor yield, none of the farmers got any compensation. When farmers reported cases of spurious seeds to dealer, the general reply from dealer was that there must be something wrong with the way farmers used the seed. The dealer also blamed on the soil, climate and other factors. When the crop fails, farmers can clearly pinpoint the reason behind the failure. Whether the crop failure was because of spurious seeds or other factors, farmers can understand. But dealers fail to accept this since accepting this will have financial implications on his trade. In some cases, private seed companies have the practice of replacing seeds if the seeds supplied by them failed to germinate. However, generally season would have lost to take up sowing again. Moreover, farmer would have invested in other cost of cultivation along with seeds. On account of spurious seeds, he ends up in economic loss. These incidents have led farmers to lose trust on seed dealers. State Department of Agriculture also compensated to the farmers only when crop failure was on a large scale involving large number of farmers.

Almost 42 per cent respondents found seed prices as costly to very costly. Farmers reported that price of seeds was high/very high in case of crops such as Bt cotton, cumin and pearl millet. In case of hybrids and proprietary technologies, private seed companies charge high prices on account of royalty/ trait fees. The price of hybrids is always higher than varieties. The price of seeds developed by public sector institutions was always affordable. However, over a period of time, farmers' preference for seeds sold by private sector has increased even if the same variety/hybrid was supplied by public sector institutions. Private seed companies are efficient at promotion, marketing and sale of their seeds. Paying a handsome commission ranging from 15-20% of seed sale price to dealers to push their seeds is one of their most successful marketing strategies. However, farmers were ready to pay higher prices for the seed if they were convinced of superior quality and higher yield.

Majority of the farmers grow the cultivar which has been found to perform excellently in the region in the past

several years. Hence, varieties which are more than five years old found to occupy major area under that crop. A new variety will be tried always by very few innovative farmers who afford to take risk. Once the new variety is found to be suitable and better performing, other farmers adopt these new varieties. The quick adoption of new varieties by farmers also depends on the availability of seeds. Seed production cycle (from breeder seed to certified/TL seed) generally takes three seasons/years. Hence, quantity of breeder seed indented and made available for seed production chain and the Seed Multiplication Ratio of that crop affect the distribution and adoption of new variety.

Fifty percent farmers shared that genetic purity of seeds (as expressed in uniformity of crop and yield realized) was moderate and 17 percent reported it to be less and least pure. Crop production depends on various factors such as soil, climate, irrigation, quality of inputs and management aspects. If seeds fail to either germinate, results in poor germination and crop stand ultimately leading to poor yield, these could be clearly attributed to spurious seed. It was found that 47 percent farmers realized only 40-60 percent of the expected yield and 30 percent of them could realize 60-80 percent of the expected yield as advertised by the seed producers through seed dealers or as printed on the promotion leaflets/pamphlets/brochure. Several instances of crop failure because of spurious seeds were reported in case of cotton, castor, pearl millet and rapeseed and mustard. Farmers expressed that probability of spurious seeds was higher in case of crops for which they were dependent on market and purchased seeds every year. PSC representatives and seed dealers agreed that probability of crop failure on account of spurious seeds ranged from 2-3 percent. However, such cases are not uniformly distributed. The crop, variety, seed lot, year and location of sowing wherein seeds turn out to be spurious is unknown and follows Poisson distribution. Statistically speaking, 2-3 percent looks insignificant but the financial loss caused to the livelihood of those farmers who suffered the crop loss because of spurious seeds is very significant. In some cases, farmers didn't even recover the cost of cultivation. The cases of spurious seeds were nil in case of farm-saved seeds (carrot, onion, garlic, til). A kind of social certification operates in case of farm-saved seeds since such seeds are either produced by farmers themselves or purchased from other farmers based on trust and credibility and seed exchange operates at a very smaller jurisdiction.

Instances of spurious seeds were also observed in case of seeds supplied by public sector organizations. Representatives from Rajasthan State Department of Agriculture, RSSC, RSSOPCA and NSC shared that it was mainly due to severe shortage of manpower to handle large scale seed production, multiplication, distribution and quality control. The responsibility of seed law enforcement is vested with the State Governments. Seed inspectors notified under the relevant provisions of the Seeds Act, 1966 and the Seeds (Control) Order, 1983, inspect the premises of seed distribution agencies to draw samples for testing (MoA, 2016c). However, majority of the States in India, including Rajasthan, do not have the permanent posts created for Seed inspectors. The general practice is that all officers in the State Department of Agriculture including and above the rank of Agriculture Officers (working for a cluster of Panchayats/sub-block level) are designated as Quality Control Officers for all agricultural inputs (seeds, pesticides, fertilizers, etc). The shortage of staff (against sanctioned strength) was reported to be very high in Seed Certification Agencies.

It was interesting to note that the quality of farm saved seed was found to be good and very good by 90 percent farmers. Farmers in the village take up seed production of carrot, onion and garlic every year in small scale for their own use in the next season. Hence, farmers take due care in producing these seeds. Farmers never purchased seeds of carrot from public organizations or private dealers. However, farmers changed the carrot seeds after every 3-4 years by exchanging or purchasing from other farmers to prevent genetic deterioration due to inbreeding. All the farmers expressed that quality of carrot seeds produced by them was far superior to those seeds available in the market.

In the present conditions, farmers purchase seeds of many crops from market. There are chances of crop failure because of spurious seeds. Several cases were reported wherein seeds of a particular variety purchased from a dealer failed to germinate on the field of all those farmers who purchased seeds from him. In such cases, all the aggrieved farmers can claim for compensation from the organization/dealer who sold the seed. In such cases, documentation and record keeping acts as critical evidence in support of claiming compensation. Records such as receipt of seed purchase, date of sowing, germination percentage and other information help in strengthening the claim of compensation. There is a need for awareness building among farmers on these aspects. Most often, seed is supplied by the same dealer who supplies pesticide and fertilizer. The dealer is both the money-lender and buyer of the produce. Farmers who take everything on credit have neither the option of choosing brands or asking for the bill, which is essential in order to claim compensation in case of failure of crop expression (CSA, 2014).

Overall Accessibility Score

The distribution of farmers based on the overall accessibility scores is presented in table 4. None of the farmers were found to have very high level of seed accessibility scores. The majority of the respondents (63%) have medium level of accessibility to quality seed and 17 percent farmers have low and very low accessibility.

Table 4: Distribution of farmers based on overall accessibility scores

Categories	f	%
Very High (Above Mean+2SD)	0	0
High (Between Mean+1SD & Mean+2SD)	12	20
Medium (Between Mean-1SD & Mean+1SD)	38	63.33
Low (Between Mean-1SD & Mean-2SD)	8	13.33
Very low (Below Mean-2SD)	2	3.33
Total	**60**	**100**

Today seed is unavailable both in quantity and quality. All the public sector institutions, seed corporations and private companies put together do not supply more than 18 % of the total seed requirement. The truthful labeling clause under the Seed Act permits companies to sell any seed without certification by the seed certification agency. Fly-by-night seed companies have mushroomed in several parts of the country, taking advantage of seed shortage, and are packing whatever seed they can collect from threshing mills, market yard floors, etc. (CSA, 2014). The dependence of farmers on the market can be gauged by the fact that even in crops like groundnut and paddy where varieties are popular, and in dryland crops like pulses, millets where good varieties are available, farmers who can reuse their own seed by saving selectively, farmers prefer to buy seed. An approximation says in highly self-pollinated crops like black gram and green gram where only varieties are prevalent and seed can be reused, there is a market for about 10,000 tons/yr in one state. In groundnut which is also a self-pollinated crop, the requirement is much higher. Farmers standing in long queues and agitating for the seed has become a common sight. All this market is mostly from the regular growers who can reuse the seed from their previous crop. Due to the demand, the companies are purchasing the seed from commercial crop, packing and selling them as seed (CSA, 2014). WTO and UPOV endorse and are pushing nation states to grant intellectual property rights over seeds and related technologies. In addition to IPRs, acquisitions and mergers are leading to global consolidation of seed industry. Today, less than 7 corporations control 71 percent of the global seed market. Situation in India is not very different. Farmers are fast losing their sovereign rights over seeds and are left with residual rights which are granted under PPVFRA 2001 (Ramanjaneyulu, 2015).

Quality Seed Accessibility Index

Accessibility Index (AI) for each parameter of the accessibility scale is given in table 5.

Table 5: Accessibility Index for various parameters of accessibility to quality seed

Parameter	Mean score	Accessibility Index	Rank
Quality of farm saved seed	4.37	87.33	I
Timeliness in availability	4.12	82.33	II
Adoption of improved cultivar	3.73	74.67	III
Proximity to seed source	3.62	72.33	IV
Adequate quantity of desired variety	3.28	65.67	V
Physical and genetic purity of seed	3.23	64.67	VI
Crop performance (yield)	3.17	63.33	VII
Price of seeds	3.12	62.33	VIII
Documentation and record keeping	3.05	61.00	IX
Credibility of seed source	2.82	56.33	X
Total composite score	3.45	69.00	

Note: All the parameters except 'Quality of farm-saved seeds' pertains to the seeds purchased from formal sector (both public and private sector).

High AI for quality of farm saved seeds (carrot, onion, garlic) indicated that seeds of these crops were timely and easily available, affordable, credible, physically and genetically pure and performed as expected without any cases of crop loss. In case of seeds purchased from market, timely availability and proximity to seed source were not issues of concern. Farmers were even cultivating latest HYVs and hybrids. However, seeds of desired variety were not always available. The performance of seeds purchased from market was also not always satisfactory.

Even in the present scenario, the formal seed sector (including both public and private sector) meets only 15-20 percent of the seed requirement of the farmers (MoA, 2012). Remaining 80-85 percent of seed requirement is being met by informal and farmer-to-farmer seed exchange mechanisms. However, the role and importance of informal seed sector has been overlooked, neglected and even belittled by the agricultural researchers and policy makers. On the other hand, the role of formal seed sector has been overestimated in the literature and policy documents. Within the formal sector, attempts are being made to glorify the role of private seed companies to further their interests of privatization and liberalization of Indian seed sector. The unnecessary importance attributed to the concept of Seed Replacement Rate (SRR) proves this point. The concept of SRR is built on the hypothesis that farm saved seeds are inferior to the seeds developed by formal sector. This may not be always true. Though certified/quality seeds are meant to be superior,

there are inefficiencies owing to shortage in infrastructure and man power in seed production and supply chain. On the other hand, there are several instances wherein farmers are reusing seeds for several years without any significant decline in yield and quality. The public organizations (NSC, SSC, etc.) and private seed companies organize their seed production on the fields of registered growers and contract farmers. Advising farmers not to reuse their own seeds but to purchase seeds supplied by formal sector (also produced by farmers) every year from market (that's what SRR means) to ensure quality is an attempt to completely privatize seed sovereignty and national food security. The irony is that even public sector researchers and policymakers have fallen prey to this concept knowingly/unknowingly. For instance, the National Seeds Policy 2002 has stated "enhancing Seed Replacement Rates (SRR) to achieve the food production target" as one of its objectives (NSP, 2002). Focusing attention on increasing SRR without addressing weak quality control mechanisms in Indian seed multiplication and distribution system will defeat the very purpose of ensuring quality seeds by formal sector.

Many farmers, Farmers' Organizations and Civil Society Organizations even consider the concept of SRR as redundant. It is a fallacy to say that enhancing seed replacement can result in increased production which also requires farmers to purchase seed every year only from traders and not from other farmers. Annual purchase of seed from seed farmers is not considered as seed replacement. The seed supplied by traders is also grown by and purchased from farmers. It is obvious that a passage through the hand of traders cannot enhance the yield (Ramarao, 2015). The case of Bt cotton clearly illustrates the deep chasm between dejure and defacto status of erosion of farmers' rights in India. With more than 90 percent sown cotton area under Bt cotton hybrids, SRR is close to 100 percent. The reason is that all the Bt cotton cultivars in the market are hybrids and farmers have to replace seeds every time they take up cotton production. Since farmers cannot save seeds, they can neither save and reuse nor exchange or barter these seeds. On the other hand, it is assumed that increasing SRR will increase the productivity of crops. Bt cotton productivity in India should have been highest with SRR of 100 percent but its productivity is 483 kg/ha which is much lower than 1570 kg/ha in China, 859 kg/ha in USA, 544 kg/ha in Pakistan and world average of 691 kg/ha (USDA, 2016). India is the only country that cultivates hybrids, while rest of the world grows only varieties and all the 23 countries that have better productivity than India also grow only straight varieties. Though India ranks second in the world in cotton production after China even its best productivity of 560 kg/ha, places it at 24th rank in the list of 80 major cotton producing countries (Kranthi, 2012; ICAC, 2017). Unfortunately, instead of OPV India concentrated on hybrids which are de-facto terminator (Ramarao, 2015). India boasts of enacting the strongest sui generis system for protection of plant varieties through Protection of Plant Varieties and Farmers' Rights Act (PPVFRA), 2001. How will India uphold farmers' rights by not recognizing the role and importance of informal seed sector on one hand and laying undue policy emphasis on increasing SRR on the other hand is a moot question? Seed was 'community resource' carefully bred, conserved and evolved over thousands of years. Today the technological advances, market manipulations and the changing policies and legal systems have made it a 'commercial proprietary resource'. The process of modernization of agriculture has deskilled the farmers making them passive consumers of industrial products including seeds (CSA, 2014).

CONCLUSION

Farmers in the study village were completely dependent on formal sector (both public and private) for seeds of certain crops such as pearl millet, cotton, castor and rapeseed and mustard. Farmers associated seed quality with the name of the seed producer/supplier rather than with the name of the cultivar or the organization that bred the cultivar. Sale of varieties as hybrids by seed dealers and consequent seed replacement by farmers every year was found in case of self-pollinated crops such as green gram and guar. Carrot is the most important commercial crop in the village. None of the farmers in the entire village purchased carrot seeds from any external sources. They produced their own seed every year on small scale to meet their own seed requirement in the next season. Farmers reused carrot seeds for more than eight years successively (since they started cultivating until now) without any deterioration in quality and yield. The same was the case with onion and garlic. Accessibility Index (AI) was found to be highest (86.67%) for farm saved seeds (carrot, onion and garlic) indicating that the seeds/planting material in these crops were easily and timely available, affordable, credible and performed as expected without any cases of spurious seeds. In case of seeds purchased from market, timely availability was not an issue but the seeds of desired variety were not always available. The probability of crop failure on account of spurious seeds was found to be higher in those crops for which farmers were completely dependent on market. PSCs and dealers' agreed that probability of cases of spurious seeds was 2-3 percent. However, the loss caused to the livelihood of farmers who suffered crop loss because of spurious seeds is huge. The farmers' practice of using higher seed rate than recommended and resowing

for 2-3 times in arid zone coupled with complete dependence on market have led to increased expenditure on seed.

The study indicated that the role and importance of informal seed sector (as in carrot) has been grossly underestimated or even overlooked by researchers and policy makers. On the other hand, the role of formal sector (especially PSCs) is overestimated. It was evident that high Seed Replacement Rate (SRR) in itself doesn't guarantee quality of seed and yield performance. Ensuring adequate availability of location-specific varieties is more important than increasing SRR per se. Identifying, strengthening and incentivizing informal seed sector requires attention as the formal sector alone cannot fulfill the demand of seed requirement of farmers in this country.

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