



Economic Impact of Quality Seeds on Agricultural Productivity and Farmers' Income in India

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Abstract

This study examines the economic impact of quality seeds on agricultural productivity and farmers' income in India. Seed is the basic and primary input in agriculture and its quality directly affects germination, crop growth, uniformity, disease resistance, yield level and final production. The study highlights that quality seeds improve crop productivity by increasing germination capacity, maintaining genetic purity, reducing plant mortality and improving the efficiency of other inputs such as fertilizers, irrigation and labour. The analysis shows that higher yield potential, high germination capacity and genetic purity have a strong impact on crop productivity. The study also explains the role of seed replacement rate in improving crop performance, as replacing traditional or farm-saved seeds with certified and quality seeds can increase productivity across crops such as wheat, rice, maize, cotton, vegetables, pulses, oilseeds and millets. Quality seeds also improve farmers' income by increasing crop yield, marketable surplus, crop quality, farm profitability and income stability. However, the adoption of quality seeds faces challenges such as high seed cost, lack of awareness, limited rural availability, dependence on traditional seeds and fake or poor-quality seeds. The study concludes that strengthening seed certification, subsidy support, seed distribution channels and government programmes can improve farmers' access to quality seeds and contribute to agricultural growth, food security and rural economic development.

Keywords: Quality Seeds, Agricultural Productivity, Farmers' Income, Seed Replacement Rate, Certified Seeds, Crop Yield, Farm Profitability, Seed Certification, Indian Agriculture, Rural Development

Introduction

Agriculture is one of the most crucial sectors of the Indian economy as it sustains livelihood of a large number of people and also serves as a source of raw material for various agro-based industries. In this sector, seed is the basic and primary input as the entire process of crop production starts with the seed. The quantity and quality of seed has a direct impact on germination, plant growth, uniformity of the crop, resistance capacity, yield level and final production. Hence, quality seed availability and utilization is in addition to the other factors of production like land, irrigation, fertilizer and labour, essential for the economic performance of agriculture. The Indian seed industry also knows that adding another 15-20% to total agricultural production is possible through quality seeds, depending on the crop and other factors. Quality seeds are those that are physically



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pure, free from seed borne diseases, with high germination power and better adaptability to the local climatic conditions with high genetic purity (Morris, 1998). The use of quality seeds decreases the risk of crop failure and makes the crop more uniform and productive. This enables farmers to get more production from a given land area. This is an important issue in agricultural economics in relation to better utilization of limited resources for productivity improvement. Most of the farmers, particularly small and marginal farmers, have small holdings and so they cannot always raise their income by expanding their land holdings. In the view of these, boosting their productivity by adopting improved varieties, which are considered as better inputs, becomes a viable option to enhance farm income. To these, utilization of improved varieties, which are considered as better inputs to boost productivity, becomes a viable solution to improve farm income (Hanchinal, R.R. 2012).

Agricultural productivity and quality seeds have a close linkage. Good seeds enhance the stand, lower plant mortality, increase yield potential and make other inputs more effective. The use of fertilizer, irrigation, pesticides, and labour will be more effective when the seed itself has good productivity potential. This way, quality seeds serve as a stepping stone for effective farming. It also points out that crop improvement and the provision of good quality seed and planting material is required to combat environmental pressures and enhance crop production. This indicates that high quality seeds have a wider role than that of production growth, which extends to the agricultural sustainability and food security. The agricultural productivity will directly affect the income of farmers. As the use of good seed goes up yields go up and farmers have more marketable surplus once they have met the needs of their households. Increased production can lead to greater gross income, and higher quality crop can lead to increased market prices for farmers. Economic losses due to poor germination, poor plants, disease attack and low output can also be minimized with quality seed. In this way, the quality seeds can be considered as a risk-reducing economic tool. Reduction in production risk is as important as increase in income for farmers whose livelihood is mainly based in agriculture. FAO also points out that production gains from adapted varieties can boost farmers' incomes when there is a market linkage (Tripp, R. 2001).

The use of quality seed in India is very much associated with the rate of seed replacement, seed certification, distribution system of seeds, and the awareness of farmers. Seed replacement rate is the percentage of certified/quality seeds sown as opposed to farm saved seeds. The higher the seed replacement rate, the more improved seeds are being adopted. Many farmers, however, continue to use old or stored seeds for various reasons including the high cost of the seeds, scarcity of seeds, inadequate distribution system, limited awareness and distrust from fake or poor quality seeds. Such issues limit potential gains that might be realized from better seed technology. This is thus not only an agricultural problem but also an economic one concerning access to inputs, cost of cultivation, productivity and the income inequality among farmers, hence the study of quality seeds (Gadwal, V.R. 2003).



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Indian seed system comprises public and private sectors. The public institutions, agricultural universities, research centres and government agencies are very important to develop, certify and distribute quality seeds. Private seed companies also play significant role particularly in the hybrid and commercial crops. National Seed Policy focuses on ensuring high quality seeds to farmers by way of better distribution and efficient marketing. In this policy guidance, it is noted that seed availability is not just a technical issue but an integral component of the development strategy of agriculture. Quality seeds, if available at the right time, at local agro climatic and suitable prices, can complement productivity growth and farmer's income improvement.

In today's context, the economic significance of quality seeds increases due to the various problems encountered in Indian agriculture like the problem of rising input costs, climate change, fragmentation of land, pest attack and pressure for food production. Under these circumstances, quality seeds can assist the farmers to generate higher output with lesser resources. They may also contribute to diversification of crops, climate resilience and better market engagement. A sustainable seed system ensures farmers have available on time and at affordable prices, high-quality seeds of diverse varieties and crops. In this regard, improving the seed system can provide support to the agricultural growth, food security and rural-economic development. The relevance of the title Economic Impact of Quality Seeds on Agricultural Productivity and Farmers' Income in India cannot be denied for research as it relates the seed technology to the economic consequences. The study is concerned with the role of quality seeds in improving the productivity in crops, improving production efficiency, enhanced farm profit and farm income security. It also sheds light on the issues plaguing farmers with access to good quality seeds and how governmental policies can be helpful in enhancing seed availability. The study can contribute to the understanding of how a simple agricultural input such as seed can become a tool to enhance productivity, mitigate risk and benefit the economic standing of Indian farmers by examining these factors (Manjunatha et al. 2013).

Importance of Quality Seeds in Indian Agriculture

Seed is the primary and fundamental input in the process of crop production and hence quality seeds play an important role in agriculture in India. Seed is the key to any crop, especially its success. Irrigation, good seed quality and correct fertilizer application will not overcome poor quality seeds if they are used, as it will affect germination, plant growth, and final yield. The opposite of quality seeds are poor quality seeds, which have low germination potential, are genetically impure, are physically impure, susceptible to disease, and poor adaptability to local soil and climate. Thus, besides being a biological input, quality seed is an economic input which influences productivity, profit and stability in farming (Ali, A.A. 2016).

Quality seeds are more important in Indian agriculture as there are large number of small and marginal farmers who rely on quality seeds. The farmers have limited land for farming and cannot easily expand land area to increase income, so they must increase production on the land that they



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have. By providing better plant population, uniform crop growth and higher output, quality seeds contribute to improving crop yield per hectare. The Indian seed sector also recognizes that a good quality seed can account for approximately 15-20% of the total agricultural production depending on the crop and other conditions. This demonstrates that, quality seed is contributing directly to agricultural productivity and national food production. Quality seed can also help to make other agricultural inputs more efficient. Fertiliser, irrigation, pesticides, labour and modern farming practices produce better results with good genetic quality and physical quality of seed. Non-quality seeds may not react as desired to fertilizers or watering and waste money and resources. A good seed, on the other hand, will make farming more effective as it will make the inputs become better outputs. This is important economically because farmers invest a great deal in cultivation and good seed is an effective way of getting a return on their investment (Lipper et al., 2014).

Another crucial function of quality seeds is risk reduction. Unpredictable climate, diseases, pests and market fluctuations are frequently responsible for uncertainty for Indian farmers. Weak seed, disease or incompatible seed for local conditions entails a greater risk of crop failure. The use of quality seeds can mitigate this risk through improved germination, crop establishment, and disease and environmental stress resistance. FAO also states that high quality seeds and planting materials are essential for better crop production and addressing the increased environmental challenges. This way, quality seeds help farmers to enhance their production stability and reliability. The quality seeds are also directly related to farmers' income. Increased productivity translates to increased production for market. Increase in crop quality can also lead to better market price, particularly in crops where size, colour, grain quality and uniformity become important. Increased production and improved market value leads to improved gross income for farmers. Meanwhile, good quality seeds can minimize loss due to poor germination, disease and low yield. So, production and profitability can be enhanced with the use of quality seeds. FAO states that better production yields of adapted varieties can boost farmers' income if there are linkages with markets. Quality seeds are also a key component of food security in India. The need for food grains, pulses, oilseeds and vegetables and fruits grows with the growth of population. Coping with this ever increasing demand, agriculture needs to yield more with less land and less water. Use of quality seeds is essential to raise production levels without overloading natural resources. They also promote crop diversification as better varieties of other crops could enable farmers to change their cropping systems to more profitable and appropriate alternatives. So, the production of quality seeds is not only beneficial for the farmers' income but it is also beneficial for the national food security (Smale, M. 2006).

It is also seen in the policies of seed certification and replacement of seed quality. Certified seeds help farmers to get proper quality, purity and germination standard seeds. Seed replacement rate is an indicator that demonstrates the percentage of the seed planted that is of good quality and/or certified seed rather than farm-saved seed. Higher seed replacement rates tend to be a positive sign



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of the use of better seed technology. The National Seed Policy also places importance on the availability of good quality seeds to the farmers through better distribution and efficient marketing network. This demonstrates the importance of seed quality in agricultural development planning in India. The advantages of quality seeds can however be fully realised only if they are available at the right time, at affordable prices and suited to the local agro-climatic requirements.

There are still a lot of issues that the farmers are facing such as high cost of seeds, lack of awareness, delayed supply, fake seeds, and scarcity of certified seeds in the rural areas, etc. This is because these challenges limit the use of good seed and impact on agricultural productivity. Hence, there is need of enhancing seed production, certification, distribution and awareness among Indian farmers for boosting Indian agriculture. Overall, quality seeds have played crucial role in Indian agriculture as they are crucial for enhancing production risk, improving farmer's income, efficiency of inputs and productivity in production. They are the backbone of modern and sustainable agriculture. In a country like India, where agriculture is playing a major role in rural livelihood and country's food requirements, quality seeding is one of the best measures to enhance the performance of agriculture and economic status of farmers (Rao et al., 2017).

- **Studies on Quality Seeds and Crop Productivity**

Studies on quality seeds and crop productivity explain how the use of improved, certified and high-germination seeds affects agricultural output. Quality seeds are considered one of the most important inputs in agriculture because they determine the initial strength of the crop. If seeds have good genetic purity, physical purity, germination capacity and resistance against pests and diseases, then plants grow more uniformly and produce better yield. In this way, quality seeds directly influence crop productivity. The Indian Seed Sector also states that quality seed alone can contribute about 15–20% to total agricultural production, depending on crop and farming conditions. Research studies generally show that productivity does not depend only on land, irrigation or fertilizers; it also depends on the quality of seed used by farmers. When farmers use poor-quality or traditional seeds repeatedly, germination becomes weak, crop stand becomes uneven and yield potential declines. On the other hand, improved quality seeds help in better plant population, early crop establishment, disease resistance and better response to fertilizers and irrigation. Therefore, studies on quality seeds mainly focus on how seed quality improves per hectare production, reduces production losses and increases efficiency of other agricultural inputs. In Indian agriculture, the role of quality seeds is especially important because many farmers have small landholdings (Sidhwani, S.K. 1991).

These farmers cannot increase income by expanding land area, so they need to improve productivity from the available land. Studies related to quality seeds highlight that better seeds can increase output without requiring major expansion of cultivated area. Quality seeds also support crop diversification because improved varieties of cereals, pulses, oilseeds, vegetables and horticultural crops help farmers adopt more profitable farming systems. FAO also notes that high-



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quality seeds and planting material are necessary for improved crop production and for meeting environmental challenges. Thus, studies on quality seeds and crop productivity define quality seed as a foundation of agricultural growth. These studies show that seed quality affects germination, plant health, crop uniformity, yield level and final production. In the context of this research paper, this section helps to establish that quality seeds are not only a technical farming input but also an economic factor that improves productivity, reduces risk and strengthens farmers' income possibilities (Wimalasekera, R. 2015).

- **Studies on Seed Replacement Rate**

Studies on seed replacement rate examine the extent to which farmers replace their farm-saved or traditional seeds with certified, improved or quality seeds. Seed replacement rate is an important indicator of seed technology adoption. It shows how much of the total sown area is cultivated using quality seeds instead of old seeds saved by farmers from previous harvests. A higher seed replacement rate usually means that farmers are adopting improved varieties and certified seeds at a greater level. In simple terms, seed replacement rate measures the movement from traditional seed use to modern quality seed use. Seed replacement rate is important because repeated use of farm-saved seeds can reduce seed vigour, purity and productivity over time. When farmers continue using the same seeds for many seasons, the crop may become more vulnerable to diseases, low germination and reduced yield. Certified seeds help in maintaining genetic purity and better productivity. Therefore, studies on seed replacement rate mainly analyse whether farmers are adopting improved seed varieties and how this adoption affects production, productivity and economic return (Spielman et al., 2014).

Research on seed replacement rate has shown that it can be a key determinant of agricultural productivity and economic benefits. For example, a case study on mustard seed production in Murshidabad district of West Bengal found that seed replacement rate is an important factor for raising production, productivity and economic benefits. Another study on wheat in Amritsar district of Punjab reported that the seed replacement rate was 49.94% and it varied across farm categories, with small farmers showing lower adoption than larger farmers. This shows that seed replacement is also linked with farmers' economic capacity, awareness and access to certified seeds (Singh et al., 2023). In India, seed replacement rate is closely connected with seed availability, seed price, distribution network, government subsidy and farmer awareness. Small and marginal farmers often face difficulty in purchasing certified seeds due to high cost or lack of timely availability. As a result, they depend more on farm-saved seeds. Studies on seed replacement rate therefore also examine barriers such as lack of awareness, weak extension services, poor rural distribution, fake seeds and limited access to government seed programmes. The National Seed Plan also highlights improvement of seed replacement rate and distribution of quality seeds according to agro-climatic zones at affordable prices. Thus, studies on seed replacement rate are important for this research because they help to measure the real adoption



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level of quality seeds among farmers. These studies explain that productivity improvement is possible only when quality seeds are not just developed but also actually used by farmers. A high seed replacement rate reflects better adoption of improved seeds, while a low seed replacement rate indicates dependence on traditional seeds and possible productivity gaps (Chauhan, J.S. 2016).

- **Studies on Farmers' Income and Agricultural Inputs**

Studies on farmers' income and agricultural inputs focus on how different inputs used in farming affect the income level of farmers. Agricultural inputs include seeds, fertilizers, irrigation, pesticides, machinery, labour, credit and technology. Among these, seeds are considered the starting point of production because all other inputs work effectively only when the seed is of good quality. If seed quality is poor, then even high expenditure on fertilizers, pesticides and irrigation may not produce expected results. Therefore, studies on farmers' income and agricultural inputs examine the relationship between input use, cost of cultivation, productivity and profitability. Farmers' income depends on two major factors: cost of production and value of output. If quality inputs increase production more than the increase in cost, farmers' income improves. Quality seeds can increase farmers' income by raising yield, improving crop quality, reducing crop failure and increasing marketable surplus. However, if seed cost, fertilizer cost, labour cost or irrigation cost rises too much, profitability may decline even when production increases. Therefore, studies on agricultural inputs do not only look at production; they also study net income, input-output ratio and cost-benefit relationship (Debertin, D.L. 2012).

In the case of quality seeds, the income effect is both direct and indirect. The direct effect comes through higher yield and better crop performance. The indirect effect comes through better use of other inputs, lower risk of crop loss and improved market value of produce. FAO explains that production increases brought by adapted varieties can increase farmers' income when market linkages exist. This means that quality seeds alone are not enough; farmers also need access to markets, fair prices, storage, transport and credit facilities to convert higher production into higher income. Studies on agricultural inputs also show that farmers' income is influenced by the affordability and timely availability of inputs. If quality seeds are available late, farmers may miss the proper sowing period. If certified seeds are too costly, small farmers may avoid them and use saved seeds. If irrigation or fertilizers are not available, the full potential of quality seeds may not be achieved. Therefore, input coordination is very important. Quality seeds, fertilizers, water, labour and market access must work together to improve farm income. Thus, studies on farmers' income and agricultural inputs are highly relevant to this research paper because they connect seed quality with economic results. These studies explain that quality seeds improve productivity, but the final impact on income depends on input cost, output price, market access and farmers' ability to adopt improved technology. This section helps to show that quality seeds are not only a production factor but also a major determinant of farm profitability and rural economic development (Barrett, C.B. 2008)



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Quality Seeds and Farmers' Income

Quality seeds have a direct and meaningful relationship with farmers' income because the income of farmers depends mainly on production, quality of produce, cost of cultivation and marketable surplus. Seed is the first input in farming and the performance of all other inputs such as fertilizers, irrigation, pesticides and labour depends largely on the quality of seed used. When farmers use quality seeds, crop germination improves, plant growth becomes more uniform, disease resistance increases and yield potential becomes stronger. Due to this, farmers are able to obtain higher output from the same land area. The Indian seed sector also states that quality seed alone can contribute about 15–20% to total agricultural production, depending on the crop and conditions. Therefore, quality seeds are not only an agricultural input but also an economic instrument for improving farmers' income (Roy et al. 2021).

• Reduction in Crop Failure Risk

Quality seeds help in reducing crop failure risk because they have better germination capacity, genetic purity, disease resistance and adaptability to local climatic conditions. Poor-quality seeds may fail to germinate properly, produce weak plants or become easily affected by pests and diseases. This creates uncertainty for farmers and may lead to partial or complete crop loss. In contrast, quality seeds support strong crop establishment from the beginning, which reduces the chances of poor plant population and low yield. For farmers, especially small and marginal farmers, reduction in crop failure risk is very important because they have limited resources and cannot easily bear repeated crop losses. Crop failure risk is also connected with climatic uncertainty. Indian agriculture is still affected by irregular rainfall, drought, flood, temperature variation and pest attacks. Quality seeds, especially improved and climate-resilient varieties, help farmers face such conditions in a better way. When seeds are suitable for a particular soil, region and season, the crop becomes more stable and productive. This reduces the economic risk of farming. FAO also explains that high-quality seeds and planting materials are necessary for improved crop production and for meeting environmental challenges. Thus, quality seeds protect farmers from production uncertainty and help in securing their income (Kumar et al. 2023).

• Increase in Crop Yield

Quality seeds increase crop yield by improving germination, plant density, root development, disease resistance and overall crop performance. A crop grown from quality seeds has better chances of uniform growth, healthy flowering, proper grain formation and higher productivity. When the number of healthy plants per unit area increases, total production also increases. This is why quality seeds are considered one of the most economical ways to improve agricultural productivity. They allow farmers to produce more from the same land, water and labour resources. Increase in crop yield directly affects farmers' income. Higher yield means more produce for consumption and sale. For small farmers, even a moderate increase in yield can make a significant difference because their landholding is limited. Quality seeds also improve the effectiveness of



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other inputs. For example, fertilizers and irrigation give better results when the seed has strong yield potential. If the seed is weak, other inputs may not produce the expected benefit. Therefore, quality seeds work as the foundation for higher agricultural output and better income (Hampton, J.G. 2002).

- **Improvement in Marketable Surplus**

Marketable surplus refers to the quantity of agricultural produce left with the farmer after meeting household consumption, seed requirement, animal feed and other domestic needs. Quality seeds improve marketable surplus by increasing total production. When yield rises, farmers have more produce available for sale in the market. This directly increases their cash income. In rural economies, marketable surplus is very important because it determines the farmer's ability to earn money, repay loans, invest in the next crop and meet household expenses such as education, health and social needs. Quality seeds can also improve the quality of agricultural produce. Better size, colour, weight, grain quality and uniformity can increase the market value of the crop. This is especially important in commercial crops, vegetables, fruits, pulses and oilseeds where quality affects price. If farmers produce better-quality output, they may receive better prices from traders or markets. FAO notes that production increases from adapted varieties can raise farmers' income when market linkages are available. Therefore, quality seeds improve not only the quantity of marketable surplus but also its economic value (Timmer, C.P. 1997).

- **Effect on Farm Profitability**

Farm profitability means the net income earned by farmers after deducting the cost of cultivation from total revenue. Quality seeds positively affect farm profitability by increasing yield, reducing crop loss and improving produce quality. Although quality seeds may cost more than traditional or farm-saved seeds, they can generate higher returns if they result in better productivity and better market price. Therefore, the economic value of quality seeds should be measured not only by their purchase cost but also by their contribution to final income. Quality seeds also reduce hidden losses in farming. Poor-quality seeds may lead to low germination, re-sowing costs, increased pesticide use, uneven crop growth and lower yield. These factors increase cost and reduce profit. Quality seeds reduce such losses and make farming more efficient. When farmers get higher output with better input efficiency, their cost per unit of production decreases. This improves net returns and strengthens farm profitability. For this reason, quality seeds are considered a key factor in making agriculture more productive, profitable and sustainable. Overall, quality seeds improve farmers' income through four major channels: reducing crop failure risk, increasing crop yield, improving marketable surplus and enhancing farm profitability. They help farmers achieve better production from limited land and resources. In the Indian context, where many farmers face low income, small landholdings and high production risk, the use of quality seeds can play an important role in improving rural livelihoods and agricultural development (Narayanamoorthy, A. 2020).



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Quality Seeds and Farmers' Income Enhancement shows the direct relationship between the use of quality seeds and improvement in farmers' income. In this image, healthy crop growth, better yield and marketable produce can be linked with the economic benefits received by farmers. Quality seeds help in increasing production per hectare, reducing crop failure risk and improving the quality of agricultural produce. When farmers get higher yield and better-quality crops, they are able to sell more produce in the market and receive better prices. This increases their marketable surplus and improves net farm income. The image also reflects that quality seeds are not only useful for crop productivity but also for income stability, because they reduce losses caused by poor germination, disease and weak crop growth. Thus, this image represents how quality seeds can become an important tool for enhancing farmers' livelihood, profitability and rural economic development (singh and Singh 2017).

Seed Supply System in India

The seed supply system in India refers to the complete arrangement through which quality seeds are developed, produced, certified, processed, stored, marketed and finally delivered to farmers. This system is important because the availability of good seeds at the right time, in the right quantity and at an affordable price directly affects agricultural productivity and farmers' income. The Indian seed supply system includes both formal and informal sources. Formal sources include public seed agencies, private seed companies, agricultural universities, ICAR institutions, state seed corporations, seed certification agencies and licensed dealers. Informal sources include farmer-saved seeds, seed exchange among farmers and local village-level seed systems. The formal seed system is more important for certified and improved seeds, while the informal system still remains common among small and marginal farmers (Prasad et al. 2024).

• Public Seed Supply System

The public seed supply system is an important part of Indian agriculture because it helps in making certified and improved seeds available to farmers, especially for food crops and crops of national importance. Public seed supply mainly includes agencies such as National Seeds Corporation, State Seeds Corporations, State Farms Corporation, State Agriculture Departments, seed certification agencies and government-supported seed farms. These agencies are responsible for producing, multiplying, processing and distributing quality seeds to farmers. The public sector generally works with the objective of food security, farmer welfare and affordable seed availability rather than only profit-making. In the public seed supply system, seed production usually follows a systematic chain. First, breeder seed is developed by research institutions and agricultural universities. Then breeder seed is multiplied into foundation seed and foundation seed is further multiplied into certified seed. Certified seed is finally distributed to farmers for cultivation. This chain helps in maintaining the genetic purity and quality standards of seeds. SeedNet mentions that breeder seed is allotted to states and private seed companies from ICAR institutes and State Agricultural Universities for producing foundation and certified seed. The National Seeds



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Corporation is one of the major public institutions in India's seed sector. It works under the Government of India and plays an important role in the production and distribution of certified seeds. According to the National Portal of India, National Seeds Corporation undertakes production of certified seeds of nearly 600 varieties of 60 crops through registered seed growers. This shows that the public seed system has a wide role in supplying seeds of cereals, pulses, oilseeds, fodder crops, vegetables and other agricultural crops. The public seed supply system is especially important for small and marginal farmers because they often depend on government seed centres, cooperatives and subsidy schemes for purchasing certified seeds. Public agencies also help in seed distribution during special agricultural programmes, natural calamities and crop promotion schemes. However, this system also faces some problems such as delay in seed availability, limited quantity, weak storage facilities, poor last-mile delivery and lack of awareness among farmers. Therefore, strengthening the public seed supply system is necessary for improving seed replacement rate and agricultural productivity Khetarpal, R.K. (2004).

- **Private Seed Companies**

Private seed companies have become a major part of India's seed supply system, especially in hybrid seeds, vegetable seeds, cotton, maize, sunflower, horticultural crops and other commercial crops. These companies invest in seed research, breeding, production, processing, packaging, branding and marketing. Their role has expanded because farmers increasingly demand high-yielding, disease-resistant and market-oriented varieties. Private companies are generally more active in crops where profit margins are higher and farmers are willing to pay for hybrid or improved seeds. The private seed sector contributes to agricultural development by introducing new varieties, improving seed availability and expanding seed distribution networks. Private companies often work through distributors, dealers, retailers and field representatives. They also conduct demonstrations, farmer meetings and promotional activities to encourage adoption of their seed varieties. In many areas, private seed companies reach farmers faster than public agencies because they have strong marketing channels and commercial incentives. The Indian seed industry structure includes public sector seed companies, ICAR, State Agricultural Universities and private sector participation in breeder seed and quality seed supply. Private seed companies are also involved in seed multiplication after receiving breeder seeds from authorised institutions (Basant, R. 1995). In this way, the private sector does not work separately from the national seed system; rather, it works along with public research institutions, certification agencies and government regulations. However, the role of private seed companies also creates some challenges. Hybrid and branded seeds are often costly, which may limit access for small farmers. In some cases, farmers may face problems related to fake seeds, misleading claims, poor after-sale support or lack of transparency in seed performance. Therefore, regulation, seed testing, certification and compulsory labelling are important. The Seeds Act, 1966 regulates the quality of seeds sold or distributed to farmers through voluntary certification and compulsory labelling. Thus, private seed



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companies are important for innovation and wider supply, but their activities need proper quality control and farmer protection (Babu, A.S. 2026).

- **Role of Agricultural Universities and Research Institutions**

Agricultural universities and research institutions play a foundational role in the Indian seed supply system. Their main function is to develop improved crop varieties through scientific research, plant breeding, field trials and testing. These institutions create varieties that are suitable for different agro-climatic regions, soil types, rainfall conditions and farming systems. Without research institutions, the seed supply system cannot produce scientifically improved, high-yielding and disease-resistant seeds. The Indian Council of Agricultural Research and State Agricultural Universities are especially important in producing breeder seed. Breeder seed is the first stage in the formal seed multiplication chain and has the highest genetic purity. After breeder seed production, it is supplied to public agencies, state seed corporations and private seed companies for further multiplication into foundation and certified seed. ICAR-related seed programmes are mandated to produce breeder seed as per national requirements, augment quality seed production and develop region-specific seed technologies (Agrawal, R.L. 1995).

Agricultural universities also contribute through seed testing, seed technology research, training, extension services and farmer awareness programmes. They conduct field demonstrations to show farmers the benefits of improved varieties. They also guide farmers on seed treatment, storage, sowing methods, disease management and crop-specific seed practices. Krishi Vigyan Kendras, which are linked with agricultural research and extension systems, help in transferring seed-related knowledge to the field level. Research institutions also help in developing climate-resilient and disease-resistant varieties. This is very important in present Indian agriculture because farmers face challenges such as climate change, irregular rainfall, pests, diseases and declining soil health. Improved varieties developed by research institutions can reduce crop risk and increase productivity. Therefore, agricultural universities and research institutions act as the knowledge base of the seed supply system. They connect scientific research with practical farming and help in improving farmers' productivity and income (Sahoo et al. 2021).

- **Seed Distribution Channels**

Seed distribution channels refer to the routes through which seeds move from producers to farmers. These channels include government seed centres, state seed corporations, cooperative societies, agricultural input dealers, private retailers, farmer producer organisations, self-help groups, seed villages, Krishi Vigyan Kendras, online seed portals and direct sale by seed companies. A strong distribution channel ensures that quality seeds reach farmers before the sowing season, in proper quantity and at reasonable prices. In India, seed distribution takes place through both public and private channels. Public distribution channels generally include agriculture departments, government outlets, cooperatives and state seed corporations. These channels are important for providing subsidised seeds and ensuring availability of seeds for major food crops. Private



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distribution channels include company distributors, wholesalers, retailers and village-level dealers. These channels are usually stronger in commercial crops and hybrid seeds. Together, public and private channels create a wider seed distribution network for farmers (Kundu et al. 2019).

The effectiveness of seed distribution depends on timely supply, proper storage, transport, packaging, labelling and quality control. If seeds reach late, farmers may miss the correct sowing period. If seeds are not stored properly, germination quality may decline. If labelling and certification are weak, farmers may receive poor-quality or fake seeds. Therefore, seed distribution is not only a marketing activity but also a quality assurance process. SeedNet states that the Seeds Act regulates seed quality sold or distributed to farmers through certification and labelling, which shows the importance of regulation in distribution. Modern seed distribution channels are also changing with digital platforms, direct benefit transfer schemes and online seed availability systems. Some ICAR institutes have developed online seed portals to make seeds available to farmers and the government has also started seed hubs for quality seed production of pulses, oilseeds and millets. These new systems can improve transparency, reduce middlemen and make seed access easier for farmers. Overall, the seed supply system in India is a combination of research, production, certification, marketing and distribution. Public agencies support affordability and food security, private companies support innovation and wider market reach, agricultural universities provide scientific research and breeder seeds and distribution channels connect the entire system with farmers. A strong seed supply system is necessary for increasing seed replacement rate, improving crop productivity and enhancing farmers' income in India (Vernooy et al. 2022).

Challenges in Adoption of Quality Seeds

The adoption of quality seeds in Indian agriculture faces several challenges that directly affect crop productivity and farmers' income. One of the major challenges is the high cost of quality seeds, especially certified and hybrid seeds, because small and marginal farmers often have limited financial resources and hesitate to invest more money at the beginning of the crop season. Many farmers prefer cheaper or farm-saved seeds because they reduce immediate cash expenditure, even though they may result in lower productivity. Another important challenge is the lack of awareness among farmers regarding the benefits of quality seeds, seed certification, seed treatment, seed replacement rate and improved varieties suitable for local conditions. Due to limited extension services and weak technical guidance, farmers are sometimes unable to understand the long-term economic benefits of quality seeds (Prasad et al. (2024). Limited availability in rural areas is also a serious problem because quality seeds may not reach villages on time, especially before the sowing season and farmers may be forced to purchase whatever seeds are locally available. Dependence on traditional seeds further reduces the adoption of quality seeds, as many farmers continue using seeds saved from previous harvests due to habit, trust, low cost and easy availability. Although traditional seeds may be familiar, repeated use can reduce germination,



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purity and yield potential over time. Another major issue is the problem of fake and poor-quality seeds in the market, which creates distrust among farmers. When farmers suffer losses due to adulterated, expired or wrongly labelled seeds, they become less willing to purchase certified seeds in future. Therefore, high price, lack of awareness, weak rural distribution, dependence on traditional practices and fake seed problems together act as major barriers in the adoption of quality seeds and limit their positive impact on agricultural productivity and farmers' income (Bhardwaj et al. 2023).

Government Policies and Programmes

Government policies and programmes related to quality seeds play an important role in strengthening agricultural productivity and protecting farmers from poor-quality seed problems. The seed certification system ensures that seeds sold or distributed to farmers meet prescribed standards of genetic purity, physical purity, germination and quality; in India, seed quality is regulated through certification and compulsory labelling under the seed regulatory framework. Subsidy support for seeds is also important because certified and hybrid seeds are often costly for small and marginal farmers; therefore, government schemes provide assistance for seed production, seed distribution, seed processing, storage and strengthening of seed infrastructure and recent government information also mentions distribution of seeds at subsidised cost and incentives for seed production. The National Seeds Corporation plays a major role in the public seed supply system by producing and distributing certified seeds of different crops and its official profile states that it undertakes production of certified seeds of nearly 900 varieties of 80 crops including cereals, pulses, oilseeds, fibre, fodder and green manure crops. State-level seed programmes are also important because seed distribution and farmer support are implemented through State Agriculture Departments, State Seed Corporations, seed villages, seed hubs, cooperatives and local agencies; such programmes help in improving seed replacement rate, promoting quality seed production, providing region-specific varieties and ensuring timely supply of seeds before the sowing season. The Sub-Mission on Seeds and Planting Material also aims to expand certified and quality seed supply, improve seed replacement rate, strengthen farm-saved seed quality and modernise seed production, processing, testing and storage infrastructure. Therefore, seed certification, subsidies, National Seeds Corporation and state-level programmes together create an institutional support system that improves farmers' access to reliable quality seeds and helps increase agricultural productivity and farmers' income (Pattanaik, B.B. 2013).

Research Methodology and Criteria for Selection of Data

The present study is descriptive and analytical in nature and is based on secondary data. The data were collected from reports and publications of the Ministry of Agriculture and Farmers Welfare, Indian Council of Agricultural Research, Food and Agriculture Organization, International Seed Testing Association, National Seeds Corporation and other recognized national and international institutions. Relevant peer-reviewed journal articles, books, policy documents and research reports



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relating to quality seeds, seed replacement rate, agricultural productivity, farmers' income, seed distribution and government support programmes were also reviewed. The data were selected according to the following criteria: relevance to the objectives of the study, authenticity and reliability of the source, applicability to Indian agriculture, availability of complete information, comparability of indicators and relevance to quality-seed adoption and farmers' economic outcomes. Preference was given to official publications, peer-reviewed studies and recent reports. Earlier studies were included only when they provided important conceptual or historical information regarding seed systems and agricultural productivity. Sources containing duplicate information, unverifiable claims, incomplete data, promotional material or information unrelated to quality seeds and Indian agriculture were excluded. The indicators included in the tables were selected according to their relationship with germination, genetic purity, yield potential, seed replacement rate, crop productivity, marketable surplus, farm profitability, seed accessibility and government support. The percentage values presented as impact, income, challenge and support indices are comparative scores developed by the author on the basis of the selected secondary literature. These values represent the relative importance of different factors and should not be interpreted as official statistics or findings obtained from a primary field survey.

Legal and Regulatory Framework for Quality Seeds in India

The legal and the regulatory system governing the quality seed in India is composed of several Acts and Rules and Orders, which govern quality, certification, testing, sale and distribution of quality seeds. The primary objective of this framework is to ensure that seed is available to farmers in a reliable manner with the desired standards of germination, purity and quality. It also provides mechanisms for seed inspection, certification and regulation of seed dealers. Furthermore, the framework advances the interests of farmers and plant breeders, and the development and availability of improved plant varieties. The key Acts and Rules related to seed sector in India are:

1. The Seeds Act, 1966

In India one of the most important laws associated to seed quality is the Seeds Act, 1966. Its main objective is to regulate the quality of certain seeds offered for sale. It provides for minimum standards of germination and purity, Seed Certification Agencies, Seed Analysts, Seed Inspectors and seed-testing mechanisms.

2. The Seeds Rules, 1968

The Seeds Rules, 1968 have been framed for the implementation of Seeds Act, 1966. The following Rules set out the procedure required for seed certification, labelling, sampling, testing and the function of Seed Analysts and Seed Inspectors.

3. The Seeds (Control) Order, 1983

Sale and distribution of seeds is done under the Seeds (Control) Order, 1983. It has provisions about licensing of seed dealers, record keeping, display of seed stock and prices, inspection and regulation of seed-distribution activities etc.



4. Protection of Plant Varieties and Farmers' Rights Act, 2001

The aim of this Act is to protect plant varieties and to acknowledge the rights of farmers and plant breeders. It also promotes plant variety development and an institutional structure to register and protect new varieties.

5. Protection of Plant Varieties and Farmers' Rights Rules, 2003

These Rules are in implementation of the Protection of Plant Varieties and Farmers' Rights Act, 2001. They include provisions of procedure on registration of varieties of plants, applications, farmers' rights, breeders' rights and other administrative issues. In general, these Acts, Rules and Orders create the regulatory framework for seed quality maintenance, regulation of seed distribution, safeguarding farmers interests and encouraging the cultivation of trusted and better seeds in Indian agriculture.

Conclusion

The study concludes that quality seeds play a significant role in improving agricultural productivity and farmers' income in India. Quality seeds help in better germination, genetic purity, disease resistance, crop uniformity, higher yield potential and efficient use of inputs. Among the major quality seed factors, higher yield potential has the highest impact value of 94%, followed by high germination capacity at 92% and genetic purity at 90%, which shows that seed quality strongly influences crop productivity. The study also shows that seed replacement rate is an important factor in improving crop performance. Crops such as vegetables, cotton and maize show higher productivity improvement where the use of improved or certified seeds is greater. This indicates that replacing farm-saved seeds with quality seeds can increase crop yield and overall production.

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