Agricultural Machinery in India: IPR Perspective*

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Agricultural machinery involves use of equipment and machines that are required to perform various crop production activities. The use of agricultural machinery leads to better utilization of inputs and improvement in agricultural operations, particularly in large scale crop production. Most of the earlier innovations in India in this sector were on tractors and drillers. There has been an increase in the innovations in machinery in the pre-harvest as well as post-harvest operations. The present study attempts to analyse patenting activity to identify current innovations on agricultural machinery in India. Analysis of published applications revealed that the area of irrigation and post-harvest processing had the maximum filing. In the case of granted patents, majority of the patents belong to the area of plant growth and post-harvest operations. The analysis reveals the specific patent portfolios and the scope of future innovations in the agriculture engineering sector.

Keywords: Agricultural machinery, intellectual property, patents, agricultural engineering

Agriculture in India is unique in its characteristics with 250 different crops cultivated in different agro-climatic regions. It is one of the most important sectors of the Indian economy, contributing to 18.5 per cent of the national income; about 15 per cent of total exports and supporting two-thirds of the work force.¹ Agricultural engineering inputs have played an important role in increasing production and productivity through appropriate mechanization. Inputs for production and post-production processes are necessary for timely field operations, conservation of water, to reduce losses and improve value addition in post-harvest operations, and enhance economic returns.² The agricultural equipment market in India was valued at Rs 299.1 billion in 2010 and has enormous potential for further growth. The increasing credit facility available to farmers and the benefits of productivity due to mechanization has created a demand for agricultural machinery.³ Agricultural machinery inventions in India can be traced back to the sixties when they were primarily on tractors and seed drills. Tractors, tractor drawn cultivators, threshers and ploughs continued to be the emphasis in the seventies. In the eighties, though, inventions were restricted mostly to tractors. In the nineties, seeders, tractors, plough and sprayers were the major inventions. From 2000 onwards inventions ranged from sprayers, threshers, harvesters, seeders, drilling machines, hoses, pumps to specialized machinery indicating an increase in mechanization in a wide range of pre-harvest and post-harvest operations.

As per the agriculture policy announced in the year 2000, mechanization in agriculture was encouraged to sustain increased yields, to conserve land and water resources, for more efficient use of inputs like seed, chemicals, fertilizers and energy, besides stating that it should involve environment friendly operations and improved safety. Timely operations and improvement in process and techniques result in reduction in quantitative and qualitative loss. The development of quick mechanical transportation, cleaning and handling means would help in improved marketing of agricultural goods.⁴ In this policy, optimal use of irrigation potential, high priority for rural electrification and setting up of agro-processing units, and creation of off-farm employment in rural areas were identified as sectors which shall provide a thrust to mechanization.⁵ The policy also stipulated the need for building modern infrastructure to bridge the gap between the irrigation potential created and utilized. It also outlined modernization of irrigation infrastructure including drainage, evolving and implementing an integrated plan of augmentation and management of national water resources. Development of marketing infrastructure and

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techniques of preservation, storage and transportation with a view to reducing post-harvest losses, the establishment of cold chains and provision for pre-cooling facilities were priority areas.

It has been seen that efficient machinery helps to increase productivity by about 30 per cent as it helps the farmers to raise a second crop making agriculture lucrative. The development and introduction of high capacity, reliable and energy efficient equipment is important for optimal use of inputs (Table 1).

Agricultural machinery is a major thrust area in the XI Five Year Plan. Mechanization of horticultural crops, harvesting, threshing and straw management, post-harvest management, improving safety, use of agriculture machinery in rural programs, etc., are important areas. The use of combine harvesters, threshers and other power-operated equipment has increased tremendously throughout the country. The Northern states of Punjab, Haryana and Uttar Pradesh have achieved a faster growth in mechanization over the various five year plans. It is recognized that availability of mechanical power and improved equipment has enabled states like Punjab and Haryana to achieve high levels of land productivity. The Western and Southern states of the country also show an increase in mechanization with a growing awareness among farmers about the advantages of mechanization. However, in the North Eastern states due to the socio-economic conditions, increased cost of transport, lack of manufacturing industry as well as machinery, topography and the lack of institutional financing, the pace of mechanization has been slow.

India contributes significantly to the worldwide farm equipment market. The tractor industry is the largest in the world accounting for one third of the global production. The tractor industry comprises of fourteen players with some of the prominent companies like Mahindra and Mahindra Ltd, Tractors and Farm Equipment Ltd and Punjab Tractors Ltd. Several strategies and programs have been adopted by Indian Government for the promotion of eco-friendly and selective agricultural equipments. The Farm Machinery Training, Testing & Demonstration Institutes (FMTTIs) together have tested one hundred and sixty machines of various categories, including tractors, power tillers, combine harvesters, reapers, rotavators and other implements.

These joint efforts made by the Government and the private sector have led to increased mechanization over the years. Farmers have been provided financial assistance for owning a wide range of agricultural equipment namely, tractors, power tillers, bullock/tractor drawn implements, reapers, threshers, irrigation equipment, hand tools, etc. Further, new equipments such as precision planter, zero-till drill, seed cum fertilizer drill, raised bed planter, improved weeder, plant protection equipment, harvesting and threshing machines, drip, micro-sprinkler and sprinkler irrigation equipment are also available. The manufacture of basic agricultural implements is largely by village artisans and tiny units, small scale industries and the State Agro-Industrial Development Corporations. Medium scale industries produce diesel engines, electric motors, irrigation pumps, sprayers and dusters. Complex products such as land development machinery, tractors, power tillers, post-harvest and processing machinery and dairy equipment are manufactured by large players in the organized sector. These firms typically have large manufacturing facilities, in-house research and development facilities or have joint ventures with advanced countries for technology upgradation.

Several traditional processes of agriculture have been transformed with the advent of mechanization. Modern seed drills and planters replace the traditional methods of sowing and planting. Use of diesel and electric motors and pumps is now well established for irrigation of farm land. Similarly, the activities pertaining to plant protection, harvesting and threshing are being automated, largely with the help of sprayers and tractor mounted equipment, respectively.

### Table 1 Economic advantage of mechanization (in per cent)

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Increase in productivity</td>
<td>12-34</td>
</tr>
<tr>
<td>Seed-cum-fertilizer drill facilitates</td>
<td></td>
</tr>
<tr>
<td>Saving in seeds</td>
<td>20</td>
</tr>
<tr>
<td>Saving in fertilizer</td>
<td>15-20</td>
</tr>
<tr>
<td>Enhancement in cropping intensity</td>
<td>5 – 22</td>
</tr>
<tr>
<td>Increase in gross income of the farmers</td>
<td>29-49</td>
</tr>
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Source: Report of the sub-group on agricultural implements and machinery for formulation of IX Five Year Plan, Govt of India

### Mechanization in Pre-harvest Operations

Tractor and tractor related innovations, equipment and tools for planting and soil preparation and irrigation form an important component of pre-harvest operations. The most common plant growth related equipment and tools are related to sowing and
planning. Mechanical transplanter for rice and vegetable crops are popular with farmers. Long handle tools and power weeder for weeding and interculturing, manual and power operated sprayers and dusters for application of chemicals have been commercialized. Different type of sprinklers, drippers and emitters are part of irrigation machinery. Micro-irrigation, in both its drip as well as sprinkler modes, helps to increase water use efficiency; reduce energy requirement, weed problems, soil erosion and cost of cultivation. Among the two micro-irrigation methods, research on sprinkler irrigation is less advanced as compared to drip irrigation. Sprinkler irrigation has been identified as an emphasis area for R&D development. The evaluation of optimum spacing arrangements of sprinkler heads, promoting use of plastic impact sprinklers, design and development of low cost hose drag system and design and development of small scale mechanized sprinkler systems such as travelling rain gun, side roll and centre pivot suitable to Indian conditions have been accordingly identified.

Mechanization of Post-harvest Operations

Threshing, grading, milling and storage are critical to ensure regular and quality goods to the market. In post-harvest operations, automation is used for harvesting, proper threshing, post-thresh cleaning, rolling, milling, drying and safe storage in the case of food grains. For fruits and vegetables, pre-harvest treatments, harvesting, pre-cooling and washing, surface drying, cold storage facilities, safe transport and safe handling operations are very important. Cereal crop harvesters are used on a large scale and include various designs of vertical conveyor reaper windrowers and combine harvesters. Tractor mounted digger-elevators for groundnut and tuber crops, spike-tooth and raspbar-type threshers for cereal crops and crop specific threshers for major crops such as soybean, groundnut and sunflower have been developed and commercialized. Reapers powered by engines, power tillers and tractors have been developed and introduced for harvesting wheat, paddy, soybean, ragi and mustard. Walk behind and self-propelled reaper harvesters facilitate quick harvesting. Traditional threshing by animal treading has been replaced by power threshers. Pedal operated paddy threshers reduce drudgery and have become popular in India. Automatic modern mills, roller mills, modern packaging techniques in case of cereals and processing units for pulses, and driers form an important part of processing.

There are both public and private institutions involved in the innovations on agriculture machinery. Organizations such as the National Innovation Foundation (NIF) and Grassroots Innovations Augmentation Network (GIAN) have helped in filing patents for rural innovations and identified commercial mechanisms for efficient transfer of technology. So far there are no studies available in India on the patenting activity in agricultural machinery. Differences in cultivation practices and regional aspects necessitate changes in the makeup of agricultural machinery. The development of innovations in agricultural machinery, in tune with these requirements, would help pre-harvest and post-harvest operations in Indian agriculture. The present study attempts to analyse the current trends in patenting on agricultural machinery in India.

Collection and Analysis of Patent Data

Three large areas of patenting identified related to agricultural machinery in India are (i) irrigation, (ii) plant growth related and (iii) post-harvest processing. Although tractor inventions are the largest category over the years, this study focuses on growth of machinery in other areas. The above areas have been identified based on the ongoing effort to create an agriculture invention resource for India. In order to understand the type and growth of innovations in India in these three areas, information on applications and granted patents were obtained from the Indian Patent Office weblink and Official Weekly Publications of the patent office for the last 6 years i.e., from Jan 2005 to Dec 2010.

Irrigation largely involves micro-irrigation and macro-irrigation components. The keywords used to identify, locate and collect patents related to this area were: irrigat+, drip, sprinkler, emitter, pump, tensio+, humid+ and pipe. Machinery related to plant growth is largely used for planting, ploughing and tilling processes. The keywords used here were: tiller, cultivator, harvest, planter, plow, plough, nutria+, germina+, and greenhouse. Post-harvest processing area includes harvesting and processing operations. The key words used were: harvest+, thresh, cut, roll, mill, grind, dehusk, deseed, deshell, store and transport. A total of 547 hits were obtained from all the three areas. The abstracts and additionally in some cases the claims of patents were screened to remove...
any non-agriculture machinery related patents. The final number of patent applications for irrigation, plant growth related machinery and post-harvest processing were 89, 72 and 232 respectively. There were 286 hits obtained in case of granted patents for all the three areas. These were screened for non-agricultural machinery patents. There were 20 granted patents in irrigation, 42 in plant growth related machinery and 80 in post-harvest processing. Statistics were compiled for year wise, assignee wise distribution of the published applications in the three categories and with respect to granted patents the assignee wise statistics were compiled for the three areas. The general prosecution time taken for applications to be granted in these three areas in India was ascertained by calculating the difference between the date of filing and the date of grant. From the assignee wise statistics the percentage for individual, company and institution were calculated. Finally, the major focus areas for recent innovations were identified.

Results obtained from Analysis of Data

Published Patents: Most Prolific Area

Analysis of the published applications from 2005 to 2010 indicated that among the three areas, post-harvest processing is the major area of filing followed by irrigation (Fig. 1). A gradual increase in the number of patents was also observed in both the areas. The number of published applications related to plant growth was few in comparison. The number of publications for post harvest processing was highest during 2009 with 49 patent applications. Irrigation related patents also recorded the highest number of publications in the same year. In plant growth related machinery, the number of published applications was generally constant in the years 2006, 2007 and 2008 with 14 applications in each year.

Type of Applicants

The data also indicated that companies and individuals filed the largest number of applications across the areas of post-harvest processing, irrigation and plant growth related machinery. Of the 405 published applications filed across all the three areas, companies and individuals filed 147 and 148 of the published applications, respectively. In comparison, institutions represented 27 per cent of the total filing (Fig. 2).

Assignee wise distribution within each area reveals that though institutions have less patent publications in total (Fig. 2), they are the major applicants in the case of post-harvest processing (with 87 published applications). Companies have the largest number of published applications for the plant growth related machinery (Fig. 3).

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Companies: Holders of Maximum Number of Granted Patents

Assignee wise analysis reveals that the companies have the highest grants followed by the institutions (Fig. 4). Distribution of granted patents for the given areas revealed that though institutions hold a smaller number of patents compared to companies, they have the highest number of granted patents in the area of post-harvest processing with 39 grants, whereas, companies have the largest number of granted patents for the machinery related to plant growth (Fig. 5). This is similar to the distribution in case of published applications (Fig. 3).

Patent filing in irrigation was dominated by Netafim Ltd with patents mainly on irrigation pipes. There were six Indian patents granted on drip irrigation system, dripper, automated irrigation system, pumps and sprinklers. Among the Indian companies, Jain Irrigation Systems Ltd was prominent in filing. Other Indian applicants included Council of Scientific and Industrial Research (CSIR) and Indian Institutes of Technology (IIT) along with a few individuals. Two companies, E I Du Pont de Nemours & Company and Design Technology & Irrigation Limited jointly hold the patent no 219990 on an irrigation device comprising a container for water consisting of a plurality of surfaces. Solar-powered drip irrigation is known to be useful in raising the economic potential in crop production and also has environmental benefits. So far, there are two applications 1167/MUM/2009 and 1456/CHE/2009 on solar powered irrigation systems, both by Indian individuals.

In case of plant growth related machinery, Yanmar Agricultural Equipment Co Ltd and Klimrek IE BV were the major patent holder companies. Most patents of Yanmar are on rice planting equipments. The Indian institutes, Indian Council of Agricultural Research (ICAR) and CSIR have patents on seeder and planters. Two such patents 41/DEL/2006A and 141/DEL/2006A are on seeder cutter planters and ratoon management respectively. There is one granted patent on multicrop dryland seeder (198798) of IIT and one on sugarcane planters (213535) of United Phosphorus. The Central Sericultural Research Institute has been granted patents on mulberry cuttings (217062) and environator (216222).

Patents on post-harvest processing were for general tools or for specific operations. Among the companies Bentle Products AG and Buhler AG, and among the institutions ICAR and CSIR hold a large number of patents. Indians are the major innovators in this sector. Besides crop specific inventions there were also significant applications filed on tools for processing. For instance, 1773/CHE/2008A describes a device to monitor stored grain insects in bag stacks, 00531/KOL/2004A describes a LCD moisture meter for jute/cotton, 25/DEL/2005 a storage device enhanced period storage of agro products and 1131/DEL/2005A on solar cum electrical dryer with agricultural waste as third source of energy etc.

In India, individuals and institutions file a larger number of patent applications as compared to companies in the three areas. Among institutions, patents are filed by major Indian governmental research institutes such as ICAR, CSIR and IIT. Among the Indian companies, Jain Irrigation and United Phosphorus Limited are the major companies with patenting activity. With respect to foreign companies, Deere and Company, Kubota Corporation, Yanmar Agricultural Equipment Ltd, Reckitt Benckiser (UK) Ltd, Norma Germany GMBH are the major assignees.
Taking into account the total number of grants so far, analysis of the prosecution time in general reveals that it takes two to ten years for a patent to be granted with an average of four to five years.

Current Innovations in Agricultural Machinery

Inventions in the irrigation area are largely related to micro-irrigation and show an increase over the years since 2005. Patents filed are mostly on irrigation systems and devices. Drippers, sprinklers, emitters and hoses are the common inventions in this sector with drippers accounting for the highest number of applications among them. The innovations in drippers relate to bottle drippers (236/MUM/2005A), variable droplet irrigator (IN/PCT/2002/01048/KOL) and disc shape dripper (498/DELNP/2007A). Inventions on irrigation pipes, tensiometers and pumps can be considered as the second level of innovation in the area. One of the interesting inventions identified was on the method of making drip irrigation pipes (2566/MUM/2009A). Automation of irrigation systems also seems to have significant potential in future innovations. One recent patent application describes automation for communication system between control units for irrigation devices (261/DELNP/2010A).

In the macro-irrigation sector, inventions are on pumps, channels and pipes. Among these pumps are predominant. Some of the interesting inventions under development are a device and method that protects three phase agriculture field water pump sets (850/CHE/2006A), automatic pumping system for skimming wells and a development of a feasible technique for fresh water skimming automatically (2957/CHE/2007A). Inventions on irrigation pipes, tensiometers and pumps can be considered as the second level of innovation in the area. One of the interesting inventions identified was on the method of making drip irrigation pipes (2566/MUM/2009A). Automation of irrigation systems also seems to have significant potential in future innovations. One recent patent application describes automation for communication system between control units for irrigation devices (261/DELNP/2010A).

In the area of plant growth related machinery, most inventions are on planters, cultivators and ploughs. The planter inventions are mostly crop specific including rice, sugarcane, vegetables and cotton. The major crop specific planters are the rice planters. The inventions range from those operable with a machine at the time of traveling, rice planting work and supply work of seedlings (for improving planting), to the effective use of vehicle space (IN/PCT/2002/01254/DEL) and multi-row planters (1336/DELNP/2009A). The second type of inventions is on seeder, nutrition and germination related equipments. A recent invention focuses on a multipurpose use of farm equipment which includes plowing, weeding, leveling, sowing and spraying either separately or all together (366/DEL/2008A).

Greenhouse related inventions range from rails for moving a carriage in a greenhouse (2523/DELNP/2006A) to hydroponics based greenhouse application (3033/MUM/2009A). It is observed that similar to irrigation, in the area of plant growth related inventions there is increased interest in automation.

In the post-harvest processing area, most inventions are on machinery related to tea, cotton, sugarcane, arecanut, cashew, coconut and cereals. In addition some inventions relate to jute processing. These inventions are filed either by individuals or by research institutions. The inventions related to tea are mechanized uniform spreading of tea leaves (32/KOL/2004A), shoot preconditioning device (1761/DEL/2004A), shoot sorter (2839/DELNP/2004) and sharpening of used/new tea rollers (394/DEL/2006 A). In case of cotton, inventions are on machinery related to seed delinting (1220/MUM/2001), stripper (18/MUM/2001), stalk compacting (826/MUM/2004) and spraying (732/MUM/2004). The typical inventions in case of sugarcane are roller mill (1049/MUM/2001), cutting machines (739/CHE/2007, 985/CHE/2008), straw cutter (750/DEL/2009A) and deskinning device (460/DEL/2004A). Peelers and cutters are the main inventions in case of coconut and arecanut.

Conclusion

According to the study, individuals and institutions have filed the highest number of patents in the areas of irrigation, plant growth related machinery and post-harvest processing. The present study also revealed that automation, crop specific machinery and energy efficiency are the current areas of emphasis for agricultural machinery inventions. Further studies on the commercialization of these inventions would reveal the impact on specific pre- and post-harvest operations.

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