Farm Power Availability on Indian Farms

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Manuscript received: August 26, 2014 Revised manuscript accepted: October 20, 2014

ABSTRACT

Mechanization has been well received in India as one of the important elements of modernization of agriculture. It is now recognized that availability of mechanical power and improved equipment has enabled States like Punjab, Haryana and Western region of Uttar Pradesh to achieve high levels of land productivity. Tractor growth in the country in terms of production and sale was many folds. A tractor could be found after every 27 ha cultivated area in span of 53 years. The results of the so many studies confirm that in those States where agricultural mechanization has made good progress, its benefits are being shared by all farmers irrespective of the size of their operational holdings and whether they own tractors and machinery or not. During last 53 years the average farm power availability in India has increased from about 0.30 kW/ha in 1960-61 to about 2.02 kW/ha in 2013-14. Over the years the shift has been towards the use of mechanical and electrical sources of power, While in 1960-61 about 92.30% farm power was coming from animate sources, in 2013-14 the contribution of animate sources of power reduced to about 11.80% and that of mechanical and electrical sources of power increased from 7.70% in 1960-61 to about 88.20% in 2013-14. Over the years the contribution of animate source of power, especially that of draught animals, has been going down drastically. This shows that the additional need of farm power is being met through mechanical and electrical sources. Productivity and unit power availability is associated linearly. It is also evident that farm power input has to be increased further to achieve higher food grains production, the composition of farm power from different sources to be properly balanced to meet of its timely requirements for various farm operations. Mechanization of cultivation of various crops has also shown a study increase over the years as the power availability on the farm increased.

Key words: Animate power, mechanical power, farm power availability, mechanization

INTRODUCTION

The technological improvements in Indian agriculture since mid sixties have brought about revolutionary increase in agricultural production. Interestingly, the growth rate of food grain production particularly in case of wheat and rice was much higher than the growth rate of population. The country was facing acute food shortages till eighties has now become not only self-sufficient but also a net exporter of foodgrains.The country witnessed unprecedented growth in agriculture that helped country to graduate from hunger to self-sufficiency in food grains by increasing the food grain productivity from 0.636 t/ha in year 1965-66 to 2.111 t/ha in 2013-14, resulting for export with surplus (Table 1). This growth is mainly due to the agricultural technology during green revolution period, which is back-up by agricultural scientists including agricultural engineering, supported by positive Govt. policy, liberal public funding for agricultural research and development and un-tired work of farmers and manufacturers of agricultural machinery. The increased use of purchased inputs in agriculture necessitated to raise their use efficiencies though mechanization of various farm operations. The factors that justify the strengthening of farm mechanization in the country can be numerous. The timeliness of operations has assumed greater significant in obtaining optimal

Table 1: Cropping intensity and power availability on Indian farms

Year	Cropping intensity (%)	Food grain productivity (t/ha)	Power available (kW/ha)	Power per unit production (kW/t)	Net sown area per tractor (ha)
1965-66	114.00	0.636	0.32	0.50	2162
1975-76	120.30	0.944	0.48	0.51	487
1985-86	126.80	1.184	0.73	0.62	174
1995-96	130.80	1.499	1.05	0.70	82
2005-06	135.90	1.715	1.49	0.87	45
2010-11	140.50	1.930	1.78	0.92	34
2011-12	141.50	2.079	1.87	0.90	31
2012-13	140.90	2.129	1.94	0.91	29
2013-14	142.00	2.111	2.02	0.96	27

Source: De et al. (2000); Agricultural Statistics at a glance, Agricultural Census; Singh and Garg (2002)

yields from different crops, which has been possible by way of mechanization (Singh, 2007). The quality and precision of the operations are equally significant for realizing higher yields. Thevarious operations such as land levelling, irrigation, sowing and planting, use of fertilizers, plant protection, harvesting and threshing need a high degree of precision to increase the efficiency of the inputs and reduce the farm losses.

The productivity of farms depends greatly on the availability and judicious use of farm power by the farmers. Agricultural implements and machines enable the farmers to employ the power judiciously for production purposes. Availability of adequate farm power is very crucial for timely farm operations for increasing production and productivity and handling the crop produce to reduce losses. With the increase in intensity of cropping the turnaround time is drastically reduced and it is not possible to harvest and thresh the standing crop, on one hand, and prepare seed bed and do timely sowing operations of subsequent crop, on the other hand, in the limited time available, unless adequate farm power and matching implement is available. Similarly for precision farming, increasing area under irrigation, conservation tillage, straw management and diversification in agriculture, more power is required.

Constraints in small farm mechanization

India is primarily an agrarian country with more than 60 per cent of its population being dependent directly or indirectly on agriculture. The Indian agriculture sector has made considerable progress in the last few decades with its large resources of land, water and sunshine. India produces all major crops to meet the requirement of food, fodder, fibre, fuel and inputs for its agricultural industry. India is presently the world's largest producer of pulses and the second largest producer of rice and wheat in the world. The country is also the second largest producer of sugar, after Brazil. The Department of Agriculture and Cooperation under the Ministry of Agriculture, Govt. Of India is the nodal organisation responsible for the development of the agriculture sector in India. The organisation is responsible for formulation and implementation of national policies and programmes aimed at achieving rapid agricultural growth through optimum utilisation of land, water, soil and plant resources of the country.

Agriculture is expected to grow at 4.6 per cent in 2014. Agriculture production of food grains this year is expected to break the 2011-12 record of 259 million tonnes (MT). More importantly, agricultural profitability has increased over the last decade with record increases in minimum support prices (MSP) for agricultural produce for all covered crops. MSP

increase in the past 10 years, between 2004-05 to 2014-15, vary from about 125 per cent for foodgrains such as wheat and paddy to over 200 per cent for pulses. India is also set to record the highest ever food grain production. The Government of India revised its estimate, stating that the country would collectively produce 264.28 MT of food grain in 2013-14 as compared to 257.13 MT last year.The increase in production of food grains was possible as a result of adoption of quality seeds, higher doses of fertilizer and plant protection chemicals coupled with assured irrigation and improved farm tools and equipment. Enhanced food production in the country is required to feed ever-increasing population in the country from same or shrinking land resources. This would demand to increased land productivity through timely performance of farm operations, better management of inputs and natural resources and efficient management of crops. Mechanization of farm operations through adoption of efficient farm machines in this context could play a very important role. Progress of agricultural development in India is presented at Table 2.

India has 159.20 million hectares of operated land owned by more than 137.80 million farm holders with average land holding size of 1.16 ha, medium to large group of farm holders own about 32% of total land. Medium and large farm holders could use improved agricultural machinery on ownership as well as on custom hire basis. Small farm holders due to their limited resources contribute to low productivity of land as they depend on traditional equipment and methods of crop cultivation. Because of the low productivity of their lands, they also use low amount of crop inputs and do not adopt high yielding varieties of the seeds. Since semi-medium, small and marginal farm holders own about 68% of land resources, they have important role to play in higher agricultural production. Mechanization of agriculture of small farm holders could be promoted by extending the benefits of improved agricultural machines to them through custom hire services with governmental efforts and development of entrepreneurs for providing custom services at affordable rates.

The Government of India realizes the importance of agriculture to the development of the nation and hence has adopted several initiatives and programmes for this sector's continuous growth. Notable among them are Rashtriya Krishi Vikas Yojana (RKVY); National Food Security Mission (NFSM); National Horticulture Mission (NHM); Gramin Bhandaran Yojana; Integrated Scheme of Oilseeds, Pulses, Oil palm, and Maize (ISOPOM), and lately the Sub-Mission on Agricultural Mechanization (SMAM) etc.

Table 2: Progress of agricultural development in India

Pre-Green Revolution Era (before 1965)	**Green Revolution Era (1965 – 1975)**	**Post Green Revolution Era (1975 onwards)**
Farming by traditional methods	HYVs, fertilizer, irrigation, chemical inputs	Use of more scientific methods/ machinery/ implements/ precision
Farm power availability was about 0.27 kW/ha	Farm power availability was about 0.47 kW/ha	Present farm power availability is about 2.02 kW/ha
Share of animate power sources was 98%	Share of animate power sources decreased to 62%	Share of animate power sources decreased to 11.8%
Low productivity of food grain (0.58 t/ha)	Productivity of food grain increased (0.95 t/ha)	Present productivity of food grain is about 2.11 t/ha
Enhanced production through increase in cultivated area	Enhanced production/ productivity through adoption of HYVs, fertilizer, irrigation and chemical inputs	Enhanced production/ productivity through adoption of improved farm machines / implements / precision in addition to adoption of other agricultural inputs

POWER SOURCES ON INDIAN FARM

The different sources of power available on the Indian farm for doing various mobile and stationary operations are mobile power viz. human (men, women, children), Draught animals (bullocks, buffaloes, camels, horses and ponies, mules and donkeys), tractors, power tillers and self-propelled machines (combines, dozers, reapers, sprayers etc.); and stationary power i.e. diesel/oil engines (for pump sets, threshers, sprayers and other stationary operations) and electric motors (for pump sets, threshers, sprayers and other stationary operations).

Agriculture has been the main occupation of the rural people and largely dependent on use of animate power sources. Human energy is predominantly used for all operations in agriculture. Before green revolution, animate energy had been widely used for various farm operations like seedbed preparation, sowing, inter-cultivation, harvesting, threshing and transportation to and from the field. Wider job opportunities in urban areas have set in a trend of rural youth preferring to take up other profession than cultivation. However, in specific situations as hill agriculture, plantations, tea industry etc human energy would continue to serve as principal source of energy. Even in specialized operations as rice transplanting, harvesting of cotton, horticultural and plantation crops, human power is the only source of energy. The labour/land ratio has been steadily increasing over time and thus technological changes through mechanization process have been land-saving in nature with focus on increasing land productivity. Mechanization process in India thus, did not follow the process of creating surplus labour from agricultural sector for consumption in the industrial sector, as had been in the cases of developed countries. The time series population and power of agricultural workers during the period 1960-61 to 2013-14 is given in Tables 3 and 4.

While the population of agricultural workers as percentage of rural population has gone down from about 69.4% in 1951 to about 55% in 2012 but in absolute terms, due to increase in overall population, the number of agricultural workers available in rural areas has increased from 131.1 million in 1960-61 to 272 million in 2013-14 and thereby registered an annual compound growth rate of 1.38% during the last 53 years. These agricultural workers are

Table 3: Farm power sources in India

Year	Population of farm power sources, million					
	Agricultural Workers	Draft animal power	Tractors	Power tillers	Diesel engines	Electric motors
1960-61	131.10	80.4	0.037	0	0.23	0.20
1970-71	125.70	82.6	0.168	0.0096	1.70	1.60
1980-81	148.0	73.4	0.531	0.0162	2.88	3.35
1990-91	185.30	70.9	1.192	0.0323	4.80	8.07
2000-01	234.10	60.3	2.531	0.1147	5.90	13.25
2010-11	263.00	53.50	4.207	0.3213	8.20	16.50
2011-12	266.08*	53.0	4.553	0.3621	8.30	16.70
2012-13	269.20*	52.8	4.858	0.4021	8.35	16.80
2013-14	272.00*	52.0	5.237	0.4409	8.45	17.00
CAGR, % :						
1960-61 to 1990-91	1.16	-0.42	12.27	6.25	10.66	13.12
1991-92 to 2013-14	1.54	-1.33	6.65	12.03	2.50	3.29
1960-61 to 2013-14	1.38	-0.82	9.79	9.30	7.04	8.74

*(CAGR = Compound Annual Growth Rate) *Estimated*

Source: Singh (2013); Singh et al. (2010); Singh et al. (2009); Live Stock Census; Tractor Manufacturers' Association (TMA); Power Tiller Manufacturers' Association (PTMA)

Table 4: Power available from different sources in India

Year	Power available from different power sources, million kW					
	Agricultural Workers	Draft animal power	Tractors	Power tillers	Diesel engines	Electric motors
1960-61	5.8	30.6	1.00	0	1.298	0.74
1970-71	6.21	31.39	4.38	0.054	9.52	5.92
1980-81	7.46	27.89	13.86	0.091	16.13	12.39
1990-91	9.17	26.94	31.11	0.181	26.88	29.86
2000-01	10.7	22.9	66.06	0.642	34.86	49.03
2010-11	13.15	20.33	109.80	1.799	45.92	61.05
2011-12	13.30	20.14	118.23	2.028	46.48	61.79
2012-13	13.46	20.06	126.80	2.252	46.76	62.16
2013-14	13.60	19.76	136.70	2.469	47.32	62.90

Note: 1 Human= 0.05 kW; draught animal = 0.38 kW; tractor = 26.1 kW; Power tiller = 5.6 kW; Electric motor = 3.7 kW; Diesel Engine = 5.6 kW

Source: Singh (2013); Singh et al. (2010); Singh et al. (2009)

engaged in different farm operations and depend on agriculture for their livelihood, even when they are not fully employed throughout the year. Due to too much involvement of labour in different farm operations, the cost of production of most of the crops in our country is quite high as compared to developed countries. Human power availability for agriculture had been 0.043 kW/ha in 1960-61 and reached to 0.096 kW/ha in 2013-14 registered an annual compound growth rate of 1.53% during the previous 53 years of time, Fig. 1. Share of agricultural workers in total power availability in 1960-61 was 14.7% reduced to 4.66% in 2013-14 (Fig. 2). Time series trend suggests that share of power from agricultural workers to total power available will further reduced in near future.

Draught animal power, available mainly as progenies of milch animals, has long remained an important source of tractive energy for production agriculture, rural agro-processing and transport in India and other developing countries of Asia, Africa and Latin America. Traditional agriculture in India largely depended upon this power source for farm operations like tillage, sowing, weeding, water lifting, threshing (by animal trampling), oil extraction, sugarcane crushing and transport. With modernization of agriculture production systems and use of mechanical power sources, draught animal use has drastically reduced in power intensive operations as water lifting, oil extraction

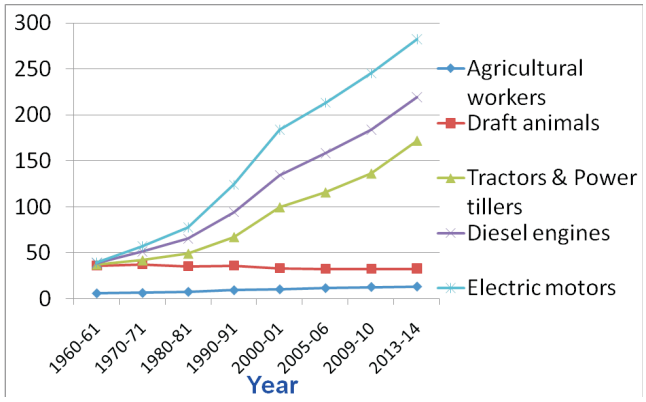

Fig. 1: Power available from different power sources on Indian farms

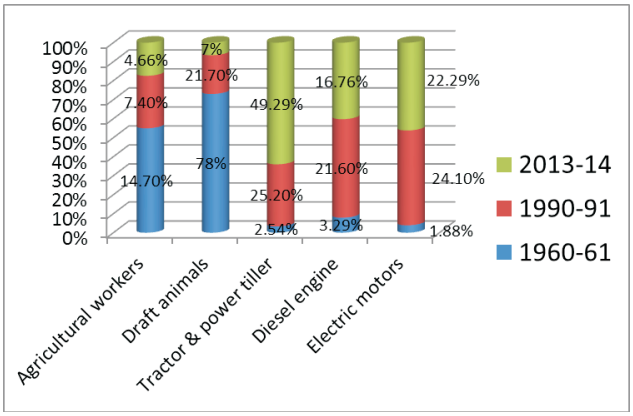

Fig. 2: Share of different power sources in total power availability

and threshing. The choice of farm power to be used for an operation is largely decided by the available time period, alternatives available (including custom hiring services) and associated economics. In sloppy hill regionsand on small farms machines like tractor or combine are difficult to operate, and thus draught animal use besides human is likely to continue as major power source. Increased cost of maintenance of animals has also brought in compulsions among the farmers to reduce draught animal ownership as far as practicable. Apart from the economic importance, livestock still continues to have symbiotic bond with rural people.

Draught animals, particularly bullocks, are still the predominant source of mobile power on about 60% of the cultivated area consisting of about 85 million ha. They are very versatile and dependable source of power and are used in sun and rain under muddy and rough field conditions. They are born and reared in the village system and maintained on the feed and fodder available locally. They are ideal for rural transport where proper roads are not available. They reduce dependence on mechanical sources of power and save scarce petroleum products. Their dung and urine are also used as indirect source of energy-farmyard manure, biogas. They also help in maintaining ecological balance. Under Indian conditions where majority of the people are vegetarian and even amongst non-vegetarians, majority of them don't eat beef, draught animals as by-product of milch animals; will continue to be available for draught purposes in future also. About 4-5 decades back most of the farm operations, water lifting, rural transport, oil extraction, sugarcane crushing, chaff cutting etc, were being done using draught animals only. But with the modernization of agriculture, development of concrete roads connecting village and availability of electricity in villages, most of the jobs earlier being done using draught animals, except field operations, are now being done using other convenient and cheaper options i.e. electricity and diesel. Over the years the annual use of draught animals is going down. While earlier a pair of animals was being used for about 1200-1800 hours annually, their average annual use has now come down to about 300-500 hour only, that too for tillage, sowing, weeding and rural transport. The time series population of draught animals during 1960-61 to 2013-14 is given in Table 3, which shows that the population of draught animals during the last 43 years has been going down. This declining trend of draught power was more visible especially in those states where the demand of tractors and power tillers has gone high. It has been observed that on an average a tractor is replacing about 5 pairs and power tiller about 2 pairs of animals. Draught animal population, mainly derived from bovines, was 80.40 million in 1960-61 and reduced to 52 million by 2013-14 with a negative annual compound growth rate of -0.82% during the period of 53 years. Share of draught animal power was 78% of the total farm power in 1960-61 reduced to 7% only in 2013-14. Draught animal power availability in India decreased from 0.229 to 0.224 kW/ha between 1960 and 1970. The power availability further reduced to 0.200 kW/ha in 1980, 0.162 kW/ha in 2000 and 0.14 kW/ha by 2013-14 (Fig. 1).

For meeting the increased demand of mobile power for timely farm operations and increased intensity of cropping (Table 1), additional power is available mainly from tractors and power tillers. Self-propelled reapers and combines also provide mobile power specially for harvesting operations. India presently is the largest manufacturer of tractor in the world. There are more than 20 manufacturers of tractors in the country producing about 60 models of tractors in different hp ranges. Tractor population in India has grown from 0.037 million in 1960-61 to 5.237 million units in the year 2013-14 at an annual compound growth rate of about 10 per cent during the last 53 years (Table 3). Farm power availability from tractor has consequently increased from 0.007 kW/ha in 1960 to 0.218 kW/ha in 1990 at an annual compound growth rate of 12.14%. The growth rate in the next decade decreased to 8%. Farm power availability in the year 2000 was 0.47 kW/ha, reaching to 0.97 kW/ha in 2013-14 at an overall growth rate of 9.80% during the last 53 years (Fig. 1). Power tiller, or two-wheel tractor, came in India with import of two units from Japan in 1961.There are mainly 2 manufacturers of power tillers in the country producing about 6 models in the range of 5.97-8.95 kW (8-12 hp). In addition to them there are many others who are importing power tillers and selling in the country. Contribution of tractors and power tillers was only 2.54% of the total farm power in 1960-61

increased to about 50% in 2013-14 (Fig. 2). Sale of tractors and power tillers has constantly increased during last 10 years with some exceptions (Fig. 3).

Stationary power sources in agriculture comprise of diesel engines and electric motors used for irrigation equipment, operating threshers and other stationary machines. Diesel engine and electric motor are widely used by the farmers mainly for lifting irrigation water, apart from operating stationary farm machines like threshers and chaff cutters. The populations of these prime movers have increased tremendously since the green revolution. Diesel engine population in the country increased about 37 times between 1960-61 and 2013-14 (Table 3), while the annual compound growth rate had been 10.66% during the period 1960-61 to 1990-91, with increased availability of electricity it reduced to 7.04% during the period of 1990-91 to 2013-14. Farm power from diesel engines increased from 0.009 kW/ha in 1960-61 to 0.247 kW/ha in 2000-01 and 0.335 kW/ha in 2013-14, registered an annual compound growth rate of about 7% during the last 53 years (Fig. 1).

The rural electrification programme launched by the Government of India in the mid-sixties undertaken through the Rural Electrification Corporation has helped in making available electricity to 18.5 per cent villages in 1970-71 and increased to 100% villages by 2004-05. Preferential supply to rural sector at subsidized price has led to rapid increase in use of electric motors in the agricultural sector. Electric motor population thus increased 85 times between 1960-61 and 2013-14 at an impressive annual compound growth rate of 8.7% (Table 3). Farm power availability consequently increased exponentially from 0.005 kW/ha to 0.445 kW/ha with an annual compound growth rate of about 8.74% during the same period (Fig. 1).

For adoption of higher level of technology to perform complex operations within time constraints and with comfort and dignity to the operators, mechanical power becomes essential. Thus, the extent of use of mechanical power serves as an indicator of acceptance of higher level of technology on farms. Over the years the shift has been towards the use of mechanical and electrical sources of power, while in 1960-61 about 92.30% farm power was coming from animate sources. In 2013-14 the contribution of animate sources of power reduced to about 11.80% and that of mechanical and electrical sources of power increased from 7.70% in 1960-61 to about 88.20% (Fig. 4). It is apparent from Table 1 that the cropping intensity increasing with increase in per unit

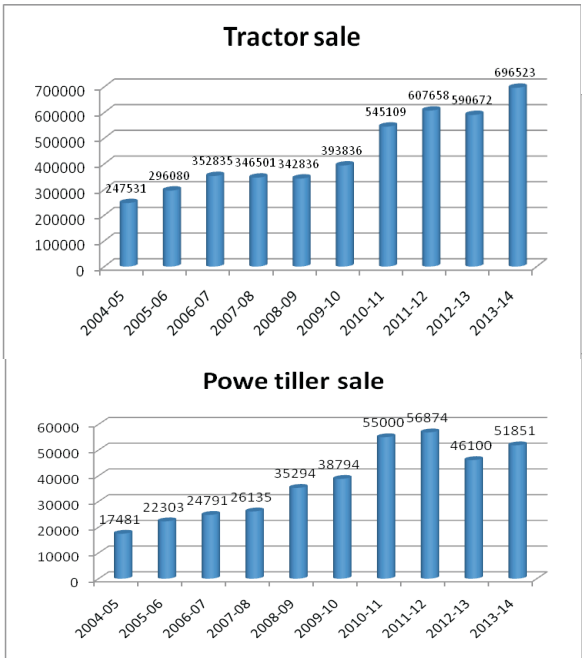

Fig. 3: Tracor and power tiller sales data for last 10 years

Source: Singh et al. (2009); Tractor Manufacturers' Association (TMA); Power Tiller Manufacturers' Association (PTMA)

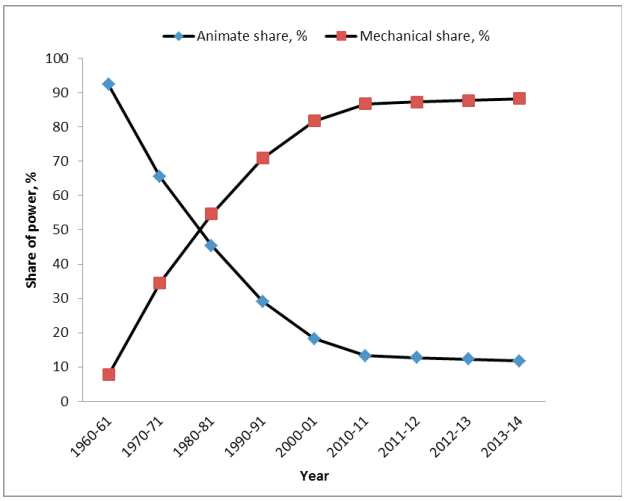

Fig. 4: Animate and mechanical power scenario in Indian agriculture

power availability. It was 114% with power availability of 0.32 kW/ha during 1965-66 that increased to about 141 per cent with increase in power availability of 2.02 kW/ha in 2013-14. Net sown area per tractor shows the reverse trend during the same period, which observed 2162 ha/tractor in 1965-66 reduced to 27 ha/tractor in 2013-14. Between 1960-61 and 2013-14, the growth rate in power was 3.81% to reach 2.02 kW/ha.

Farm Power Availability and Food Grain Productivity Relations

Food grains productivity in India has increased from 0.710 t/ha in 1960-61 to 2.21 t/ha in 2013-14, while farm power availability has increased from 0.296 kW/ha to 2.02 kW/ha during the same period (Fig. 5). Thus, food grains productivity is positively associated with unit power availability in Indian agriculture (Fig 6). The relationship between food grains productivity and unit farm power availability for the period 1960-61 to 2013-14 were estimated by linear function, with highly significant value of coefficient of determination (R^2):

$Y_{fgs} = 0.5512 + 0.8195x$; $R^2 = 0.990$

Where,

Y_{fgs} = food grains productivity, t/ha, and x = power availability, kW/ha

This indicates that productivity and unit power availability is associated linearly. It is also evident that farm power input has to be increased further to achieve higher food grains production, the composition of farm power from different sources

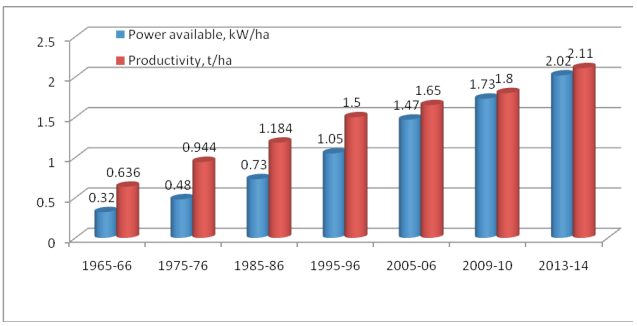

Fig. 5: Power availability and food grain productivity over the years

Source: Tyagi et al. (2010); Singh et al. (2010)

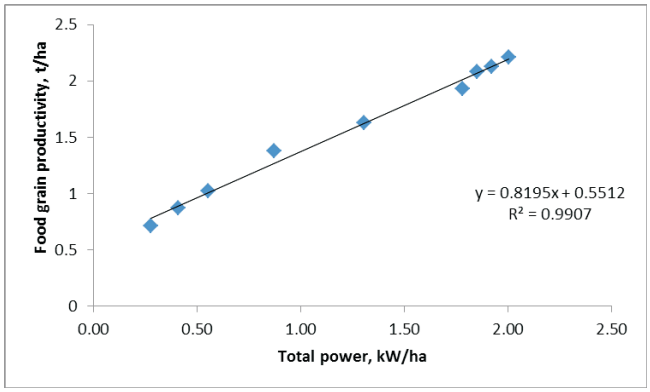

Fig. 6: Food grain productivity and power availability relations in Indian agriculture

to be properly balanced to meet of its timely requirement for various farm operations.

CONCLUSIONS

The source of farm power includes human, animal, tractors, power tillers, diesel engine and electric motor. Information about the availability of these power sources under time-series is very essential in planning and prediction of farm mechanization as this directly and indirectly provides vast potential for manufacturers, entrepreneurs, sales and repair etc. During last 53 years the average farm power availability in India has increased from about 0.30 kW/ha in 1960-61 to about 2.02 kW/ha in 2013-14. Over the years the shift has been towards the use of mechanical and electrical sources of power, While in 1960-61 about 92.30% farm power was from animate sources, in 2013-14 the contribution of animate sources of power reduced to about 11.80% and that of mechanical and electrical sources of power increased to about 88.20%. Food grains productivity is positively associated with unit power availability. It is visualized that the additional requirement of food grains in future will be met, to a great extent from the demand of mechanical power sources and matching farm equipment.

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