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Reveiw

An introduction to mechanization in potato farming

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ABSTRACT

Potato is an important vegetable crop of India; this crop is an essential aspect of food security of India and South Asia. After review Uttar Pradesh has been identified as leading potato producing state in India followed by West Bengal. Raised bed and ridge planting is common method of sowing of potato in India. Minimum tillage systems give better yield for potato crop due to improved physical, hydro-physical and biological properties of soil. Semi-automatic and automatic potato planters machinery is very popular in India for sawing. However intercrop potato + sugar cane planter is very popular in Uttar Pradesh and northern India. The maximum yield per hectare for potato crop has been found in Uttar Pradesh and West Bengal. Potato production in India has been continuously increasing from year 2013 to 2019. Similarly potato consumption was also continuously increasing from year 1994 to 2013. This resulted in improved farm machinery and processing equipment in potato farming. This paper highlights few details of the advancement in mechanization of potato farming.

Keywords: Potato; potato planter; production; minimum tillage systems

INTRODUCTION

Total production of potato up to 2009-10 was from about 18,35,000 hectare sown area and production was about 3,65,77,000 MT and based on this productivity of potato was about 19.9 MT per hectare which is maximum among all vegetable crops as reported by Mandhar (2014). In India potato is leading vegetable crop in Uttar Pradesh, Haryana, Rajasthan, Uttaranchal, Himachal Pradesh and Jammu and Kashmir. India accounted for 14 per cent of vegetable production in world up to 2009-10.

But still exports of Indian potato are not reaching to world vegetable market. The mechanization of potato crop was started in year 1978 by Central Potato Research Institute, Jalandhar, Punjab by fabricating a tractor-operated potato planter and potato digger (Mandhar 2014).

Chain of mechanization in potato farming

Following procedures are required for potato farming and in this farm mechanization is used (Mandhar 2014):

After preparation of field raised beds or by marking ridges are made. Potato was initially planted with the help of potato planter. It was initially animal drawn implement now it is rotating sector type planter suitable for making ridges and potato planting in these ridges.

As a second step there is a cleaner/grader for potato harvesting and sawing developed by CIAE Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh. They developed a dust-free cleaner (900 kg/hectare). The dust emission could be reduced to the acceptable limits (10 mg/cubic m) by using this cleaner. Equipment may also be utilized for treating potato seed in seed treating drum of Andhra Pradesh Agricultural University, Hyderabad, Andhra Pradesh. It consists of a drum mounted on a frame at 40^{o} and operated manually by a crank handle. It is used for thorough mixing of chemicals with seeds before sowing as plant protection measures.

As a third step potato digger is used which is animal drawn or tractor-mounted designed by Punjab Agricultural University, Ludhiana, Punjab. Animal

drawn potato digger is single row animal drawn digger consisting of a V-shaped blade or ridger-shaped bottom with welded extension rods on the wings. These rods help in separation of soil and dirt from the potato tubers. This implement is suitable for digging potato tubers after removal of vines from the field. Tractor-mounted potato digger is suitable for digging and exposing tubers from two rows. Two V-shaped blades with round bars at the rear are mounted on cultivator frame with provision for adjustment of row to row distance. The lifter rods help in separation of soil and potato tubers.

· Similar tractor-mounted potato digger elevator is rear-mounted single row unit consisting of digging blade, endless rod chain conveyor and gauge wheels. The elevator is driven by tractor PTO. It is suitable for digging and exposing tubers.

· As a fourth step, fruit and vegetable washing machine developed by PAU, Ludhiana is used for washing the potato. It is a stainless steel portable mechanical washing machine suitable for a wide range of potatoes. This machine is further used for peeling potatoes.

Soil tillage for potato farming

The importance of zero tillage for potato crop was demonstrated by van Ouwerkerk and Boone (1970). Zero-tillage plots potatoes have to be grown on a ridge which requires loosening of a considerable part of the top soil. Potato and sugarbeet harvests entail an intensive loosening of the top soil necessarily followed by a superficial levelling treatment with a rigid-tined cultivator. A pore space in the field soil below 7 cm is not changed essentially in the course of time in the zero-tillage plots. Conventional tillage results in clearly larger mean pore spaces in the soil but the fluctuations in time are also larger due to successive loosening by ploughing and compaction by traffic over the field.

Lesser tillage results in greater crop yield of the potato and with the application of stubble of corn and wheat in potato field during sawing resulting in increased productivity. *Trichoderma harzianum* is a fungus that is also used as a fungicide and its effect in the potato yield was found to be not significant which requires further research (Jadoski et al 2012).

Rusu et al (2009) described the need of minimum tillage system in potato farming and it was chosen as paraplow + rotary grape, chisel + rotary grape and rotary grape. The experimental variants were studied in the 4-year crop rotation as corn – soybean – autumn wheat – potato/rape. An improvement in physical, hydro-physical and biological properties of soil was observed together with the rebuilt of structure and increase of water permeability of soil. The minimum tillage systems ensure an adequate aerial-hydrical regime for the biological activity intensity and for the nutrients solubility equilibrium. The plant material remaining at the soil surface or superficially incorporated has its contribution to intensifying the biological activity being an important resource of organic matter. The minimum tillage systems rebuild the soil structure improving the global drainage of soil which allows a rapid infiltration of water in soil. This results in more productive soil, better protected against wind and water erosion and needing less fuel for preparing the germination bed with an 82.4-93.4 per cent in potato yield (Rusu et al 2009).

Peters et al (2004) reported that 3-year crop rotation combined with minimum tillage reduced potato diseases caused by *Rhizoctonia solani* and minimum tillage did not affect disease caused by other soil-borne pathogens.

As per Roder et al (2009) there was increase in *Persicaria runcinata* in the potato crop which was attributed to the use of metribuzin, cutting of rhizomes by plough or spade, high inputs of fertiliser and continuous cultivation of potato by the farmers. Metribuzin though reduced the growth of *P runcinata* but was not able to fully control it. Metribuzin is a very effective and affordable for weed management for small potato farmers but for perennial weed species there is need of further research combining mechanical and chemical methods with cropping strategies.

The influence of minimum soil tillage systems on weed density, frequency of phytopatogenous agents and crop production of soybean, wheat, potato, rape and corn was demonstrated by Rusu et al (2006). The influence of soil tillage systems is seen in total number of weeds/m^2, floristic composition and the percentage of different biologic groups of weeds or species. In hoeing cultures (corn, potato) the encroachment is even more intense by applying minimum tillage system namely with 22-78 per cent than the conventional system. The most numerous weeds were annual monocotyledonated (*Echinochloa crusgalli* and *Setaria* sp) and perennial dicotyledonated (*Convolvulus*

arvensis). The productions registered in minimum tillage working represented were 66 to 91 per cent in potato.

Potato planters

Potato is one of the most important crops and its planting can be easily mechanized. Potatoes are generally planted on ridges with a spacing of 0.6 meters. Traditionally the ridges are made by animal drawn ploughs and seed potatoes sown manually on ridges. Now potato planters have become very popular in Punjab and Uttar Pradesh and the cultivation of potatoes is fully mechanized.

In semi-automatic transplanters the manual feeding of seed potatoes is done to the metering systems. In automatic planters the seed potatoes are pushed singularly by the metering systems from the seed box and dropped into the ridge through furrow opener.

Semi-automatic potato planter: Tractors-drawn two-row and four-row planters are having rotary cups/ sectors. The seeds are filled in the hopper. There is an opening at the bottom of seed hopper and a single layer of potatoes is available on the bottom trough. The operator sits on the seat and picks handful of potatoes from the seed hopper by both hands and drops single potatoes in the cups in the rotary metering disc divided in sectors/cups. The movement of cups/sectors drops the seed potatoes in delivery pipe and further in furrows inside the ridge. The metering disc is rotated by ground wheel through power transmission system consisting of sprocket, chain and gears. The ground wheel (drive wheel) is provided with a mechanism to change its diameter. The seed/tubes spacing is varied by changing the diameter of power/drive wheel.

The belt type semi-automatic potato planter is generally two-row planter as shown in Fig 1. There are two openings (on left and right side) of the seed hopper. The seed potatoes fall under gravity into seed cups moving on endless belts. The operator sits on the seat and regulates the feeding of individual seed/tuber in each cup. The movement of cups on the belt makes their fall into seed pipe. The seed tubers then fall into the ridge made by ridgers. The seed spacing is varied by changing the diameter of ground drive wheel.

Automatic potato planter: The automatic potato planter (Fig 2) has rotary picker wheels fixed on the sides of seed hopper. The picker wheel rotates with the rotation of the ground wheel. The cam-operated picker arms pick the seeds from the seed hopper and drop them into seed pipe. The seeds further fall in the furrow in the ridge.

The cup type automatic potato planter is provided with vertical bucket (cup) conveyor. The number of cup conveyors is equal to the number of rows to be planted by the planter. The conveyor picks

Fig 1. Semi-automatic potato planter

up potatoes from the adjustable opening near the bottom of seed hopper. Individual seed tubes are picked by the cups on cup conveyor and then dropped in ridge through the seed pipe.

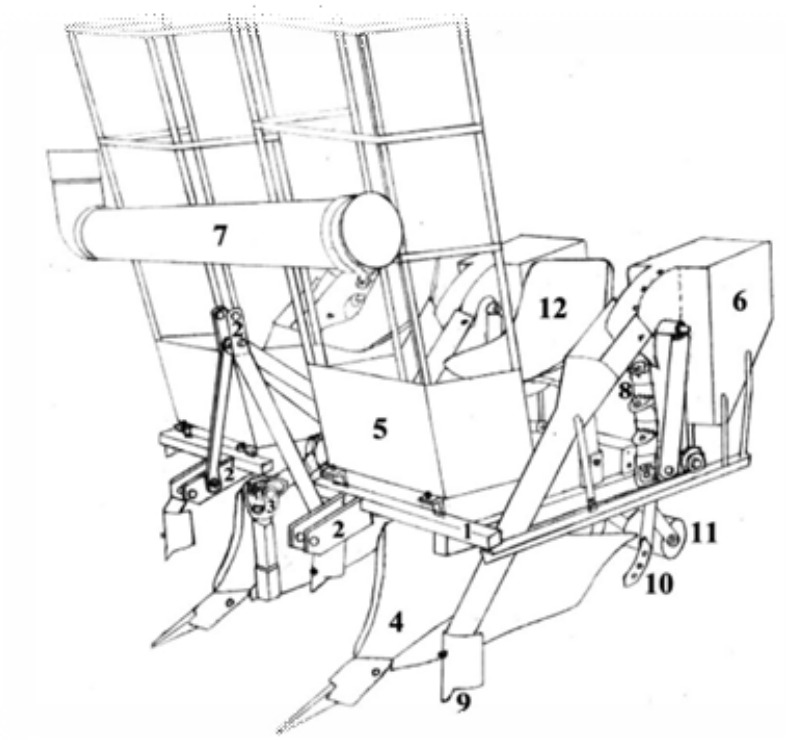
The seed spacing in most of the potato planters can be varied from 15 to 35 cm by changing the diameter of drive wheel. Two-row potato planter needs about 35 HP tractor. The speed of operation of the semi-automatic potato planter into the field is about 1 km/h. It needs frequent filling of the seed hoppers and the seed bags are to be stored at both ends of the field. The field capacity of a tractor-drawn two-row semi-automatic planter is about 0.1 ha/h. The field capacity of a tractor-drawn two-row automatic planter is about 0.4-0.5 ha/h. while working at 4-5 km/h. Semi-automatic planter (Fig 1) and automatic planter (Fig 2) are also available with fertilizer application systems.

Intercrop potato planters: Planting of potatoes can also be done with the other crops. Sugarcane cum potato planter was developed at ICAR- Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh. It is equipped with furrowers and ridge makers between the furrowers. It also consists of cutting unit for cane planting, potato seed tubes metering mechanization for potato planting, covering unit and insecticide application unit. These planters plant potato as intercrop with sugarcane. This all happens in a single pan of the planter machine (Fig 3).

These planters have three seed potato metering units and two sett cutting units. Two seed potato metering units are provided on the outer side of the machine and one is between sett cutting units. In onward journey, planter plants seed potatoes on left and central ridges and sugarcane setts in both the furrows. And in return journey, planter plants potato in central and right ridges and sugarcane setts in both the furrows. For activating and deactivating the outer side seed potato metering units, dog clutches were provided which are operated through lever. Picking and dropping of seed potatoes are automatic while seed cane is fed to the cutting unit manually.

Potato and sugarcane are the most important vegetable and sugar crops in India. The intercropping of these crops results in increased productivity per unit area and time for both these crops. An offset type digger for sugarcane + potato intercropping (SPIC) has been developed and tested in field conditions for mechanizing digging operation. This equipment besides being useful for potato digging performs inter-row cultivation of sugarcane crop. Power requirement of this digger is 35 HP with field capacity of 0.25 ha/h. Manpower requirement is 60 per cent lower as

Fig 2. Automatic potato planter



1. Main frame, 2. Three-point linkage, 3. Universal joint cross, 4. Furrow opener, 5. Seed cane tray, 6. Seed potato hopper, 7. Insecticide solution PVC container, 8. Seed potato metering cups, 9. Miniature furrower for potato planting, 10. Reversible shovels for soil covering over planted sugarcane setts, 11. Tamping roller for pressing the soil cover, 12. PVC seat

Fig 3. Schematic view of the sugarcane-cum-potato planter

compared to manual digging whereas tuber damage is less than 2 per cent (Singh et al 2007).

The mechanized harvest used a self-propelled harvester (da Cunha et al 2011). In the semi-automated harvest a digger mounted on tractor is used and potato is manually harvested. The cost of mechanized harvest is 49.03 per cent lower than the cost of semi-mechanized harvest. On average the harvester has a work for 23 workers in manual harvest. Mechanized harvest showed losses of 2.35 per cent of potato yield while the semi-mechanized harvest showed losses of 6.32 per cent.

Production of potato in India

There has been a steady increase in the area and production of potato over different plan periods. The increase was substantial between year 1997-2007 (IX and X plan periods). The productivity was stagnant between year 1992-2002 (VIII and IX plan periods) as per Chadha and Choudhary (2007). Uttar Pradesh is the leading state in area, production and productivity of potato followed by West Bengal and Bihar as shown in Table 1. Among the vegetables, India accounts for about 22 per cent in the world trade in horticulture the major items include potato as an important component of horticulture produce as reported by Mandhar (2014) and in Table 2. The total consumption of potato is also steeply increasing as shown in Table 3. Total sown area for potato crop is shown Figure 4 showing gradually increasing sowing area and yield index for potato farming in India and clearly asserting the same fact that which were shown in Tables 1, 2 and 3.

CONCLUSION

Advances in mechanization have brought potato production to the point where little manual labour is really necessary. The most important single consideration in the design, selection and management of potato machinery is that the damage to tubers is prevented. All these machines are slowly being adopted by farmers. Most of the machines are helpful in land preparation, timely planting, inter-row cultivation, spraying, harvesting, grading and seed treatment.

Table 1. State-wise production of potato in India

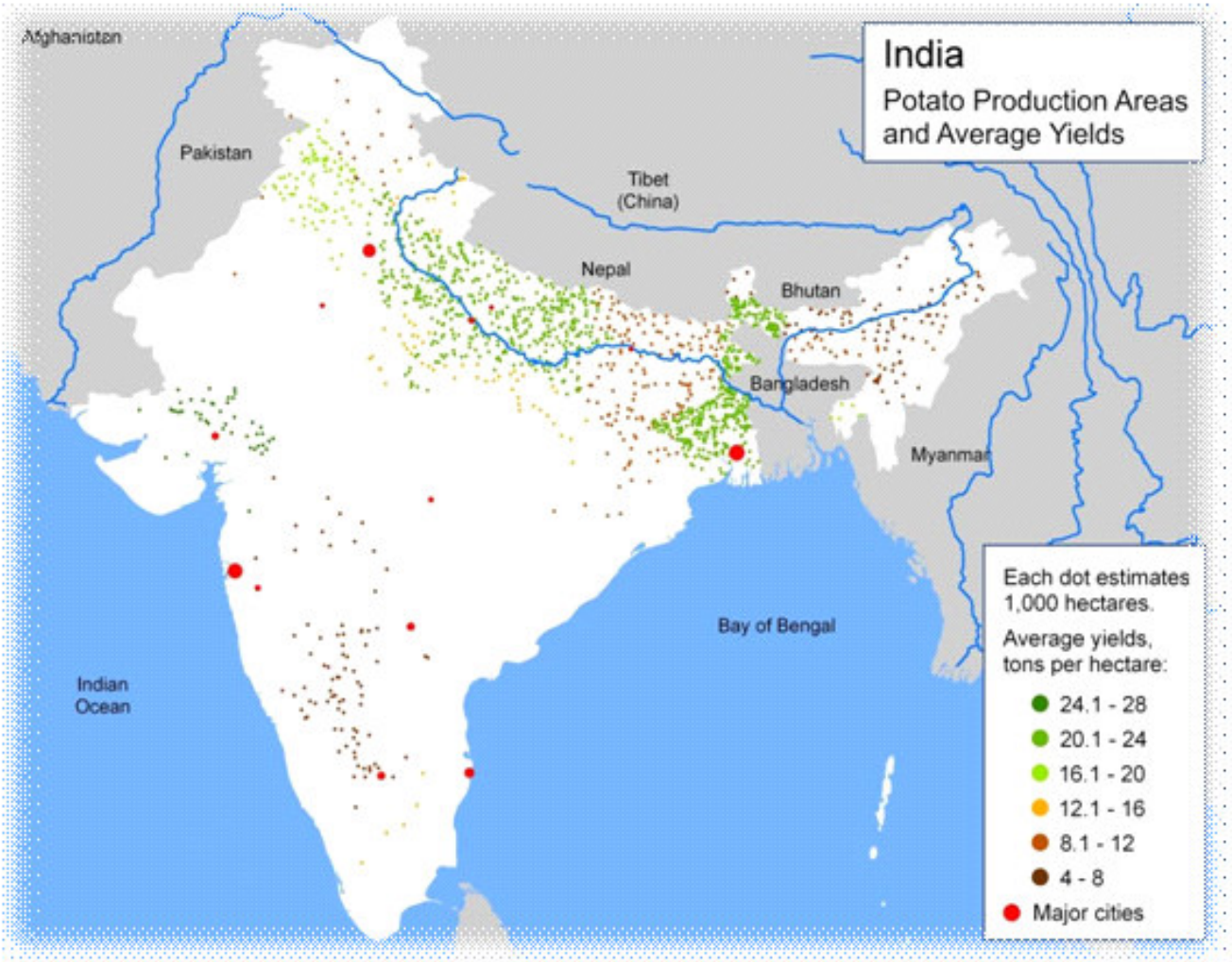
State	Area (ha)	Five year (2013-2018) average production ('000 MT)	Production (2017-18) ('000 MT)	Production (2018-19) ('000 MT)
Uttar Pradesh	5,40,800	14,727.68	15,555.53	15,812.62
West Bengal	3,70,000	10,663.82	12,782.50	12,782.00
Bihar	3,13,600	6,669.11	7,740.79	7,441.24
Gujarat	60,800	3,277.12	3,806.95	3,845.02
Madhya Pradesh	60,800	3,027.43	3,144.64	3,314.37
Punjab	83,100	2,366.17	2,571.04	2,716.33
Haryana	23,000	813.49	897.58	1,227.28
Assam	86,600	988.45	720.97	1,116.57
Jharkhand	38,200	659.73	690.23	683.44
Chhattisgarh	-	635.07	694.61	649.11
Karnataka	81,100	520.28	509.48	534.95
Maharashtra	-	323.61	259.22	514.92
Uttarakhand	-	388.58	362.16	362.16
Odisha	-	279.53	298.06	298.06
Rajasthan	-	201.19	278.52	279.54
Himachal Pradesh	-	214.18	198.66	197.72
Meghalaya	-	187.75	187.95	190.78
Tripura	-	145.98	144.53	140.06
Jammu & Kashmir	-	124.56	110.24	136.13
Sikkim	-	59.34	89.91	90.81
Tamil Nadu	-	95.76	67.66	74.86
Nagaland	-	64.35	65.02	65.02
Andhra Pradesh	-	50.25	68.29	48.85
Telangana	-	70.31	42.44	42.44
Kerala	-	8.13	7.50	6.75
Mizoram	-	1.56	0.93	0.93
Arunachal Pradesh	-	2.83	0.00	0.00
Others	-	14.69	14.61	17.05
Total	-	46,576.78	51,310.01	52,588.98

Table 2. Production, area and yield of potato in India (2013-2017)

Component	Total
2017	
Production (tonnes)	4,86,05,000.00
Area harvested (ha)	21,79,000.00
Yield (hg)	2,23,061.00
2016	
Production (tonnes)	4,37,70,000.00
Area harvested (ha)	21,30,000.00
Yield (hg)	2,05,493.00
2015	
Production (tonnes)	4,80,09,000.00
Area harvested (ha)	20,76,000.00
Yield (hg)	2,31,257.00
2014	
Production (tonnes)	4,63,95,000.00
Area harvested (ha)	20,24,000.00
Yield (hg)	2,29,224.00
2013	
Production (tonnes)	4,53,43,600.00
Seed production (tonnes)	32,38,400.00
Area harvested (ha)	19,92,200.00
Yield (hg)	2,27,606.00

Table 3. Year-wise (1994-2013) potato (fresh and processed) consumption (crop equivalent)

Year	Consumption (kg/capita/year)	Year	Consumption (kg/capita/year)
2013	24.40	2003	15.34
2012	24.14	2002	16.83
2011	23.27	2001	15.51
2010	21.63	2000	18.01
2009	21.43	1999	16.07
2008	21.81	1998	12.49
2007	17.92	1997	18.31
2006	18.65	1996	13.97
2005	18.89	1995	13.20
2004	18.62	1994	13.52



Source: https://www.potatopro.com/sites/default/files/pictures/india- potato-cultivation-by-region-1200.jpg

Fig 4. Potato production areas and their average yields

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