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Innovative strategies for nutrient and disease management in *Solanum tuberosum* cultivation

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Abstract
Organic farming is a holistic approach to protect the environment and to maintain the soil fertility. Therefore, to minimize the use of NPK and to prevent the occurrence of blight disease in potato, a new method has been adopted in farmer field. In this method, the land is prepared by using 5 kg of Boron/ha instead of any chemical fertilizer along with vermi-compost @15 quintal/ha. The use of fungicide was superseded by cow urine, water and Jaggari for treating potato seeds. Potato seeds are treated for 12 hours with the mixture and kept under shade for drying before sowing. 25-30 Days after sowing (DAS), 12 litres of cow urine is dissolved in 150 litres of water for spraying 1ha area. 55 DAS, 1 ha land is again sprayed with the 5 kg curd of cow milk i.e. prepared with the insertion of copper coins in the mud vessel. 10 litres of water is mixed with curd and solution is prepared and used for spray. 70 DAS, spray is applied with the solution of 12 litres of cow urine prepared in 250 litres of water. It has been observed that the yield was enormous by this method. The reduction in investment cost is found as 39.07% and the increment in the production is found as 28.57% as compared to conventional method. This method enhances the phosphorus and nitrogen content in the potato. Therefore, this indigenous technology disseminated rapidly and popularized among other farmers in adjoining areas of Muzaffarpur and Samastipur district to enhance potato production organically.

Keywords: NPK, blight in potato, boron, DAP, cow urine, Jaggari

Introduction
Organic agriculture in India has its roots in traditional agricultural practices that evolved in countless villages and farming communities over the millennium. Total area of both organic & wild collection in India has increased from 2.57 million hectares in 2005 to 5.69 million hectares in 2013. India's total area under organic certification is 4.72 million hectares in 2013-14 and its global rank is 10th (Deshmukh and Babar, 2015) [3]. Over one billion people consume potato worldwide and it is the staple diet of half a billion people in developing countries. Potato ranks fourth in the world (325.30 million tons) with respect to food production (Mukul *et al*. 2013) [6] Potato (*Solanum tuberosum*) is the most important food crop of the world. Potato is a temperate crop grown under subtropical conditions in India. The potato is a crop which has always been the 'poor man's friend'. Potato is being cultivated in the country for the last more than 300 years. Potato is the fourth major food crop after rice, wheat and maize in Bihar. It occupies less than 5% of net sown area with production only 4th after rice, wheat and maize (Singh and Kumar, 2013) [11]. Under irrigation in temperate and subtropical climates, a crop of about 120 days can produce yields of 25 to 35 tons/ha (11 to 15.6 tons per acre), falling to 15 to 25 tonnes/ha (6.6 to 15.6 tons per acre) in tropical areas (FAO, 2008) [4]. The health-promoting effects of potatoes are also very promising for humans since a recent study showed that the consumption of unpeeled cooked potatoes improves the lipid metabolism and antioxidant status in cholesterol fed rats (Robert *et al*., 2006) [8]. Yellow-orange pigmented potatoes usually have high carotenoid contents, such as lutein, zeaxanthin, violaxanthin, and antheraxanthin (Brown, 2005; Andre *et al*., 2007). Onyeneho and Hettiaachchy (1993) [2, 1, 7] evaluated the ability to prevent soybean oil oxidation of freeze-dried extracts taken from the peels of six potato varieties. They found that the peels from red potatoes contained greater amounts of polyphenols than those from brown-skinned varieties. Rodriguez de Sotillo *et al*. (1994a; 1994b) [9, 10] also found high amounts of phenolic compounds in potato peels and confirmed the strong antioxidant activity of freeze-dried extracts of potato peel waste in sunflower oil. These findings therefore suggest the possible value of the potato peel in the prevention of oxidative rancidity of food oils. Potatoes are used for several industrial purposes such as for the production of starch and alcohol.

Potato starch (farina) is used in laundries and for sizing yarn in textile mills. Potatoes are also used for the production of dextrin and glucose. Potato is one of the main commercial crops grown all over the country. In Bangladesh, potato is mainly consumed as vegetable. Various other food items (Singara, Samucha, Chop, chips etc.) are also made from potato. Adequate supply of potato stabilizes the vegetable market all-round the year (Moazzem and Fujita, 2004) [5]. As a food product itself, potatoes are converted into dried products such as potato chips, sliced or shredded potatoes. The use of chemicals and fertilizers in the farming is affecting the human health and also abruptly decreasing the soil fertility. To overcome such problems the adaptation of organic farming is becoming a necessity to protect our environment. An innovative strategy has been adopted by Sri Dinesh Kumar a progressive farmer of Muzaffarpur, Bihar to improve the quality of potato and environmental performance. Organic farming in our country is getting popularity day by day due to its fruitful effect on human health and nature. Innovative strategies in potato cultivation through organic farming are needed because of higher consumption after wheat and rice.

Materials and Methods

The study has been conducted at Machhi village of Itha block, Muzaffarpur district of Bihar. Bihar lies in the tropical to subtropical region. Rainfall here is the most significant factor in determining the nature of vegetation. Bihar has a monsoon climate with an average annual rainfall of 1200mm. Bihar lies mid-way between the humid West Bengal in the east and the sub humid Uttar Pradesh in the west which provides it with a transitional position in respect of climate, economy and culture. The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from west to east. The study area lies between the latitude of 24°20'10" to 27°31'15" and longitude 83°19'50" to 88°17'40". The soil is mainly young loam rejuvenated every year by constant deposition of silt, clay and sand brought by different streams. This soil is deficient in phosphoric acid, nitrogen and humus, but potash and lime are usually present in sufficient quantity. The cold weather season, hot weather season and Southwest monsoon is observed in December to February, March to May and June to September respectively.

The use of NPK in Potato cultivation, is very high in conventional method. In this method land preparation has been done by 5 kg of Boron per hectare instead of other chemicals and fertilizers *viz.* urea, potash, zinc and DAP. After the land preparation with Boron 15 quintal vermicompost is applied to one hectare of land. The treatment of potato seeds has been done by using cow urine, Jaggari and water. Fungicide has been replaced by cow urine in the quantity of 25 litres per hectare for the treatment of potato seeds. 25 quintals of potato have been treated by the cow urine, water and Jaggari solution. The solution has been prepared using 25 litres of cow urine with 200 litres of water i.e. in the ratio of 1:8 (cow urine and water) in which 15 kg of Jaggari is dissolved in warm water & after cooling this mixture, it is added in urine solution and thoroughly mixed. Then 25 quintals of potato are added in the urine Jaggari solution and kept for 12hrs, and the left-over solution can be used again for next round of treatment. After the treatment, Potato is kept under shade for drying & sowing is done. Three times spray is done during entire period of potato cropping as shown in Figure 2. 25-30 DAS 12 litres cow urine is added with 150 litres of water then mixture is used for spraying 1 ha land. 55 DAS, 1 ha land is sprayed with 5 kg curd of cow milk i.e. prepared with the insertion of copper coins in the mud vessel. Copper coin is kept in the curd and curd is left for 10-12 days. Now coin is taken out side & and is mixed with 10 litres of water & solution is prepared like lassi. The butter is taken outside and it is used for removal of termites in vegetation. Now 15 litres of lassi is added in 200 litres of water & sprayed over 1 ha of land. 70 DAS, spraying is done with the solution of 12 litres of cow urine which is prepared in 250 litres of water.

Results and Discussion

The economical comparison in conventional and innovative method has been shown in Table 1. The consumption of DAP, Urea, Potash, Sulphur has been replaced in innovative method. The above chemical substitution has also lessened the labour cost. Application of compost (cow dung) has been superseded by Vermi-compost in innovative method.

Table 1: Economical Comparison between Conventional and Innovative method

S. No	Parameters	Cost (Rs/ha)	
		Conventional method	Innovative method
1.	Seed cost	25000	25000
2.	Seed treatment	900 (by 2 kg Bavistine)	Nil (Cow urine)
3.	DAP	4200	-
4.	Urea	2400	-
5.	Potash	1800	-
6.	Sulphur	1500	-
7.	Zinc	600	-
8.	Boron @5kg	600	600
9.	Compost (cow dung)	25000	-
10.	Vermi-compost (15 quintal)	-	900
11.	Sowing (by Potato Planter) & Coverage of potato tubers	2500	2500
12.	Chemical Applied with labour cost	1800	-
13.	Irrigation (4 times) with labour cost	12000	12000
14.	Spray with labour cost	4000	2000 (3 times)
15.	Harvesting including labour cost	11500	11500
Total Investment		93,800	57150
Total production (t/ha)		28	36

This method has been disseminated in around 500 farmers in nearby villages by innovative farmer. The reduction in investment cost is significantly higher and found as 39.07% and the increment in the production is found as 28.57%.

Summary and Conclusions

The crop is very healthy without any disease infestation & yield is up to the mark as compared to conventional method which uses NPK. The significant amount of reduction in investment cost and increment in production has given a way to farmers to adopt this new method for their economic growth. This method has also enhanced the phosphorus & nitrogen content in the potato. Blight disease infestation has also not been observed. The above advantages induced 500 farmers in the nearby villages to cultivate around 565 acres of land by this method.

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