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Kamal Kant
Department of Horticulture, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Sanjeev Kumar Gupta
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Ghanshyam
Department of Soil Science & Agricultural Chemistry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

AB Patel
Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Sanoj Kumar
Department of Agricultural Engineering, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Amit Kumar
Department of Animal Husbandry, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

R Vishwakarma
Department of Agricultural Entomology, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

RK Sohane
Director Extension Education, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Corresponding Author:
Kamal Kant
Department of Horticulture, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Influence of Varietal Replacement Demonstration on the yield and economics of Potato (*Solanum tubrososum*) cv. Kufri Pukhraj in Bhagalpur District of Bihar

Kamal Kant, Ghanshyam, Sanjeev Kumar Gupta, AB Patel, Sanoj Kumar, Amit Kumar, R Vishwakarma and RK Sohane

Abstract
Potato (*Solanum tuberosum*) is one of the important vegetable crops grown for fresh and processing purpose all over the India due to its wider adaptability under various agro-climatic conditions, which plays a major role in supplementing the income of small and marginal farmer of the Bhagalpur district of Bihar state. The present study was carried out at Bhagalpur district during *kharif* 2017-18 and 2018-19. Varietal replacement through Farmer FIRST Project were conducted on potato by the active participation of the farmers with the objective of improved technologies of potato production potential. The improved technologies consist improved variety (Kufri Pukhraj), balanced fertilizers (Soil test based) application and integrated pest and disease management, etc. The development of the agriculture is primarily depends on the application of the scientific technologies by making the best use of available resources. One of the major constraints of traditional potato farming is low productivity because of non-adoption of advanced technologies like improved varieties. To increase the production, productivity and quality of agricultural produce, varietal replacement are being conducted at various farmer's field. All the recommended practices were provided to the selected farmers. The data related to the cost of cultivation, production, productivity, gross return and net return were collected as per schedule and analysed. Result of the present study revealed the higher average yield in the varietal replacement demonstration was recorded (344.84 q/ha) as compared to farmers practice (224.31 q/ha) traditional adopted by the farmers. The percentage increase in the yield over farmer's 53.28 was recorded. The technology gap and extension gap were computed 54.46 and 120.12 q/ha respectively, along with 13.61 percent of technology index. The varietal replacement demonstration field gave higher average net return Rs. 420680.00 and B:C ratio is 1: 4.30. The result of the study indicated the gap existed in the potential yield and demonstration yield is due to soil fertility and weather conditions. Present result clearly show that the yield and economics of turmeric can be boost up by adopting recommended technologies.

Keywords: *Solanum tubrososum*, potato, Bihar

Introduction
Potato (*Solanum tuberosum*) is a major crop with a long history of cultivation in Asia and the Pacific. It is widely used as a tuber vegetable in India, whereas, it is very closely associated with culture in many of the South Pacific Islands. It ranks fourth after cassava and yam, in terms of total production, area and consumption (Poonia and Pithia 2011) [6]. Potato also known as Alu is a temperate tuber crop belong to the monocotyledonous family "Solanaceae" of the order "Arales" whose members are known as "aroids" (Henry, 2001) [11] and Van Wyk, 2005). Potato is believed to have originated in South Central Asia, perhaps in Eastern India or Malaysia (Sturlevant, 1919) [12]. All parts of the plant including corm, cormels, leaves and flowers are edible and contain abundant starch (Bose *et al*., 2012) [10]. Potato is a rich source of major components of the diet viz. proteins, minerals and vitamins. The nutritional value of a food depends upon its nutritional contents, digestibility and the presence or absence of anti-nutrients or toxic factors. Several authors have evaluated the chemical composition of whole corms and cormels of Potato (Surjit and Tarafdar, 2015) [14]. It has been observed that in spite of the fact that Potato are major vegetable crops, their nutritional value is high. Apart from the low fat content, the crop is nutritionally superior to other root and root crops in protein, mineral and vitamin contents (Onwueme, 1978) [13]. Investigation have shown that Potato contains digestible starch, protein of good quality, vitamin C, thiamine, riboflavin, niacin and high scores of proteins and essential amino acids. The crop is also very rich in dietary fibre, thus, it could be employed in the treatment of diseases such as obesity, diabetes, cancer and gastrointestinal disorders (Mukherjee *et al*., 2016) [15].

Potato is cultivated in an area of around 2142 thousand ha with an annual production of 51310 thousand tonnes and productivity is 24 thousand tonnes (NHB Database, 2018) [1] and the major Potato growing states are Uttar Pradesh, Bihar, Orissa, Maharashtra, Andhra Pradesh, West Bengal, Gujarat and Tamil Nadu. In Bihar state total area under potato is 304.78 thousand ha with a production of 7740.79 thousand tonnes (NHB Database, 2018) [1]. Potato is mainly grown as a major tuber crop in north Bihar areas like Nalanda, Muzaffarpur, Samastipur, Vaishali, East Chaparan, Madhubani, Shitamarhi, Bhagalpur and Begusarai districts in Bihar. Despite of the importance of this crop, its cultivation anywhere in India is generally a subsistent to commercial crop due to low productivity because of non-adoption of advanced technologies like improved varieties. To increase the production, productivity and quality of agricultural produce, varietal replacement demonstrations are being conducted at project area various farmers' field.

Material and Methods

The varietal replacement demonstration is an applied approach to accelerate the dissemination of proven technologies at project area farmer's fields in a full package and practice mode with an objective to explore the maximum available resources of crop production and also to bridge the productivity gaps by enhancing the production in national basket (Choudhary *et al*., 2018) [3]. To overcome the problems faced by the farmers in cultivation of potato, integrated crop management in potato was conducted by Farmers FIRST Project, Bihar Agricultural University, Sabour, Bhagalpur during *Rabi* 2017-18 and 2018-19 in five farmers of Bhagalpur district. In the demonstration, improved variety Gajendra was grown in 0.5 ha area each farmer with integrated crop management practices and the farmers practice traditionally in 0.5 ha area for comparison. The integrated crop management practices consisting the conjoint use 25 t/ha FYM with a balanced fertilization of 100:60:80 NPK kg/ha.

Improved variety of potato i.e. Kufri Pukhraj introduced under demonstration was released from a local selection from Kufri, Shimla area of Himachal Pradesh is able to yield 350-400 q/ ha. The tubers are non-acrid, well-shaped and generally devoid of cormels or propagules. Treated with fungicide namely, diathan M-45 and integrated pest management strategies were demonstration as per need.

Selection from local collections of Kufri, Shimla district, Average yield of 400 q/ha, potential yield Himachal Pradesh, released from Central Potato Research Institute, of 380.00 q/ha, matures by 100-120 days Shimla, Himachal Pradesh under the aegis of All India Co-Ordinated Research Project (AICRP) on Potato.

The Kufri Pukhraj variety was a local selection. Salient features of technology are canopy semi-compact, stem green with purple pigment highly scattered throughout, leaflet ovate-lanceolate, flower yellow, ovoid with shallow-medium eyes and yellow flesh, sprout purple, adaptability north Indian plains and plateau, maturity early to medium, average yield potential – 350-400 q/ha, storability- medium, reaction to diseases/pests – early blight resistant and late blight moderately resistant, consumer and processing quality- easy to cook, texture waxy, flavour mild, free from after-cooking discolouration, coloration on exposure to light, special attributes – early bulker, suitable for low input eco-system.

Responsive to recommended dose of fertilizer at irrigated conditions situation in *Rabi* season and field tolerant to pest and leaf blight disease with average yield of 344.84 q/ha potato (Kufri Pukhraj) may progressively commercialized in Bihar as well as in Jharkhand.

The technological interventions followed in farmers practice and demonstration is given in table 1. Before initiating the demonstration, the beneficiary farmers were given with skill training on various technological interventions to be followed in potato cultivation. The performance of crop was periodically observed by the scientists of Farmers FIRST Project, Bihar Agricultural University, Sabour, Bhagalpur and advisory recommendations were followed. During harvest, yield data was collected from both the demonstration and farmers practice. At the end, cost of cultivation, net income and cost benefit ratio were worked out. An average of cost of cultivation, yield and net returns of different farmers was analysed by the formula.

$$\text{Average} = (F_1+F_2+F_3\text{…….}+ Fn)/N$$

Where,

F= Farmer (s)

N= No. of farmers

In the present study, technology index was operationally defined as the technical feasibility obtained due to implementation of varietal replacement demonstrations in potato. To estimate the technology gap, extension gap and technology index following formula used as given by Samui *et al*., 2000 [8].

Technology Gap = P_1 (Potential yield) – D_1 (Demonstration yield)

Extension Gap = D_1 (Demonstration yield) – F_1 (Farmers yield)

Technology index = Potential yield – Demonstration yield/Potential yield X 100

B: C ratio = Net income (Rs/ha)/Cost of cultivation (Rs/ha)

Percent increase over farmer's practices = Improved practices – Farmers practices/ Farmers practiceX100

Results and Discussion

The economic indices depicted in table 2 showed that the average yield of potato variety (Kufri Pukhraj) were 344.84 q/ah and 346.24 q/ha during kharif 2017-18 and 2018-19 respectively under demonstrated technology however, under farmer's practices the average yield were found to be 224.31 q/ha and 226.54 q/ha during respective years. The average percent increases over local yield were 53.28. The results clearly indicated the positive effect of varietal replacement demonstration over the existing practices toward enhancing the yield of potato in the study area due to use of high yielding variety, timely sowing, balance dose of fertilizers, proper and timely irrigation, need based plant protection etc.

The result is in conformity with the finding of Tiwari and Saxena (2001) [9] and Tiwari *et al*., (2003). Yield of the varietal replacement demonstration and potential yield of the crop was compared to estimate the yield gaps which were further categorized into technology and extension gap. The data of table 3 depicted the technology gap in the demonstration yield against potential yield which is 54.46 q/ah during both the year and reflects the farmer's cooperation in carrying out such demonstrations with encouraging results in subsequent years. The technology gap observed may be attributing to the dissimilarity in soil fertility status, timely sowing and weather conditions. Similar finding was recorded by Mitra and Samjdar (2010) [5]. Further, the higher extension gap was observed. The extension gap ranged

from 120.12 q/ha during the period of study that emphasizes the need to educate the farmers through various means for adoption of improved production technologies to mitigate the extension gap. The data of table 2 reveals that as far as average economics of potato is concerned; gross cost, net income and benefit cost ration were Rs.517260.00.00/ha, Rs.420024.00/ha and 1: 4.31, respectively during 2017-18 and Rs. 519360.00/ha, Rs. 421335.00/ha and 1: 4.29, respectively during 2018-19 under demonstration plot. However, Rs. 336465.00. /ha gross cost, Rs. 239229.00/ha net return with 1: 2.46 benefit cost ration during 2017-18 and Rs. 339810.00/ha gross cost, Rs. 241785.00/ha net return with 1: 2.46 Benefit cost ratio observed during 2018-19 under farmer's practice. The superiority of recommended package of practices under varietal replacement demonstration over farmer's practice was also reported by Mitra and Samajdar (2010) [5] and Balai *et al*., (2012) [2]. From the finding of present study, it can be concluded that use of above prescribed technologies of potato cultivation can reduce the technology gap to a considerable extent resulting in to increased productivity as well as quality in Bihar. It requires collaborative extension efforts to enhance adoption level of location and crop specific technologies among of the farmers for bridging these gaps. Therefore, extension agencies in the district need to provide proper technical support to the farmers through various educational and extension methods for better potato production in Bhagalpur districts of Bihar.

Table 1

S. N.	Package of practices (Technology intervention)	Varietal replacement demonstration (Recommended package of practices)	Farmers practice (Local/check)	Gap
01.	Selection of variety	Improved variety (Kufri Pukhraj)	Unknown variety	Full gap
02.	Soil testing	Have been done in all the location	Not in practice	Full gap
03.	Seed rate	90 q/ha	90 q/ha	Partial gap
04.	Seed treatment	Seed treated with fungicide Dithan M-45	Not done	Full gap
05.	Spacing	70 cm x 60 cm	60 cm x 50 cm	Partial gap
06.	Application of recommended dose of fertilizer	120 kg N + 60 kg P_2O_5 + 80 kg K_2O per ha (50% N+ 100% P K at the time of planting and remaining 50% N applied at 40 days and 80 days after planting)	Imbalance and inadequate	Partial gap
07.	Application of vegetable special (micro-nutritional) Irrigation	Foliar spray of vegetable special (micro-nutrients) 75 g + 15 lit water + lemon + 1 shampoo (Rs. 1).	Not applied any micro-nutrient	Full gap
08.	Irrigation	Drip or furrow method of irrigation at once in a 7-11 days interval depend upon soil condition	Twice in a month	Partial gap
09.	Weed management	Pre-emergence herbicide pendimethalin @ 1.5 kg a.i/ha, followed by hand weeding depend upon weed intensity.	Weeding is not common	Partial gap
10.	Plant protection measures for control of insect pest and diseases	Need based application for control: Aphid and sucking pest-spraying with diamethoate (30 EC) 1.5 ml/L of water. Leaf eating catter piller: spray NPV (250 LE/ha). Blight, pyithium rot & leaf blight – Spraying of (COC) blitox 50 – 3 g/L of water	Plant protection is not common	Partial gap
11.	Harvesting	Manual	Manual	No gap

Table 2: Economics of varietal replacement demonstration of year 2017-18 and 2018-19

Variables	Yield (q/ha)			Cost of cultivation (Rs./ha)			Gross return (Rs./ha)			Net return (Rs./ha)			Benefit: Cost ratio		
Year	2017-18	2018-19	Average	2017-18	2018-19	Average	2017-18	2018-19	Average	2017-18	2018-19	Average	2017-18	2018-19	Average
Farmers practice	224.31	226.54	225.42	97236.00	98025.00	97630.00	336465.00	339810.00	338137.00	239229.00	241785.00	240507.00	1: 2.46	1: 2.46	1: 2.46
Recommended practices (Kufri Pukhraj)	344.84	346.24	345.54	97236.00	98025.00	97630.00	517260.00	519360.00	518310.00	420024.00	421335.00	420680.00	1: 4.31	1: 4.29	1: 4.30

* Sale rate – 1500/q

Table 3: Yield technology gap and technology index of varietal replacement demonstration

Variables	Yield (q/ha)	Increase (%) over farmers Practice	Technology gap (q/ha)	Extension gap (q/ha)	Technology index (%)
Farmers Practice	225.42	-	-	-	-
Recommended practices (Kufri Pukhraj)	345.54	53.28	54.46	120.12	13.61

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