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An Analysis of Farm-Level Adoption of Improved Potato Production Technologies in Western Uttar Pradesh

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ABSTRACT

The adoption of improved potato technologies is vital for increasing potato productivity and farmers' income. Thus, this study attemptedto analyse the farm level adoption of improved potato technologies and also to identify the adoption constraints faced by farmers. The survey was conducted in Bulandshahar and Meerut districts of Uttar Pradesh by interviewing 85 randomly selected potato growers. The results revealed that there was very low adoption of some technologies and majority of farmers have medium level of adoption, which could be improved by organizing various extension activities like trainings, demonstrations, etc. There was very high incidence and intensity of adoption of improved varieties in the study locales; however, larger area was under old varieties, which should be replaced by new varieties that give higher yields and market demands. Government should take measures to ensure regular supply of quality seeds at prices affordable by all farmers' categories, since majority of farmers obtained seeds from non-reliable sources. Finally, the study recommended that emphasis should be put more on serious constraints like lack of credit, subsidy and trainings, high cost/unavailability of labor, production inputs and quality seeds, heavy incidence of diseases and insects, low market price and price fluctuation, for speedy dissemination and adoption of improved potato production technologies.

Keywords: Adoption, Improved technologies, Potato, Seeds, Constraint analysis

INTRODUCTION

India is predominantly an agriculture based country in which agriculture and allied activities contributes about 17 percent to the country's GVA and provides employment to about 54.6 percent of the population (DAC&FW, 2017a). Potato plays a very important role in Indian agriculture as potato alone contributes about 21 percent of the total vegetable area and 26 percent of total vegetable production of India (DAC&FW, 2017b). It is a nutrient-rich crop which provides more calories, vitamins and nutrients per unit area than any other staple crops, thus, it is consideredas one of the main staple crops for ensuring food and nutrition security (Knapp, 2008), especially for developing countries. FAO declaredpotato as the crop to address future global food security and poverty alleviation during 2008. As per FAOSTAT data for the year 2016, India with 43.77 million t is ranked second in potato production in the world, only behind China with 99.06 million t. However the productivity in India is still low when compared with most of the potato growing developed countries.

It is estimated that by the year 2050, India would require about 125 million t of potato from an area of 3.62 million ha with a CAGR of 3.2 % up to the year 2050. To achieve this, India has to harvest potato with an average productivity of 34.5 t/ha in 2050at a CAGR of 1.46% (CPRI, 2015). Increasing potato productivity from current status i.e., 20.55 t/ha (FAOSTAT) to 34.5 t/ha in 2050 would be a herculean taskfor potato R&D. Scientists working at ICAR-Central Potato Research Institute (ICAR-CPRI), India reported that at present level of farm management practices, India actually able to harvest only 42-45% of the achievable yield, which could be improved to 80 % by efficientand effective dissemination and implementation of improved technologies. Moreover, the information and insights of adoption studies are also vital for setting up research priorities, improving efficiency of agricultural research, extension services, and investment in new technologies. Many times, even if technologies are available, farmers are well aware about them and ready to adopt them; but still are not in a position to fully adopt them due to several constraints. Against this background, the present study was undertaken to analyse the farm level adoption of improved potato production technologies (IPPTs) in Uttar Pradesh (UP) state of India and also to identify the constraints faced by the farmers to adoption of the technologies.

MATERIALS AND METHODS

Sampling procedure and sources of data

Ex-post facto research design was implemented for the present study.The data used for this research originated from a survey of 85 randomly selected potato growers of UP (43 growers from Unchgaon, Jahangirabad and Syana blocks of Bulandshahar district and 42 potato growers of Kharkhoda,Macchara and Daurala blocks of Meerut district)conducted during 2018 for 2017-18 crop season. The survey was administered using a pre-structured interview schedule, which consisted of both close-ended and open-ended questions. UP state of India, was purposively selected since it is the highest potato producer in the country which produced about 13.85 million t of potato, i.e., nearly 32 percent of total potato production in the country (DAC & FW, 2017b). The average productivity of potato in UP is about 20.5 t/ha, which is at par with the National Average. However, with the

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favourable climate, abundant water resourcesand fertile soils, the state has a potential to further increase its potato productivity.

Measurement of variables and statistical analysis

In the first part of the study, we selected 13IPPTs recommended by ICAR-CPRI and other ICAR institutes, SAUs, etc. for the study areas. To study the extent of adoption of these selected improved technologies, simple descriptive statistics like frequency and percentage were used. The level of adoption of each respondent was analyzed using Adoption Index (AI) which was calculated by the following formula.

$$AI = \frac{\text{Total number of technologies adopted}}{\text{Total number of selected technologies}} \times 100$$

Subsequently, based on AI, all respondent farmers were categorized into three categories using Sample Mean ($\bar{x}$) and Standard Deviation (SD), *viz*., low ($<\bar{x} - SD$), medium (between $\bar{x} \pm SD$) and high ($>\bar{x} + SD$) level of adoption.

As quality seeds of improved potato varieties(IPVs) are the basic and crucial determinants of productivity and account for 30-50percent of the total potato production cost, the extent of adoption of IPVs were specially analyzed in the second part of the study. Two widely used indicators of adoption, namely, 'Incidence of adoption' which is the percentage of farmers growing IPVsand 'Intensity of adoption' which is the percentage of area planted to IPVs at a given time. Moreover, we also assessed the variety-wise adoption patterns and identified major sources of potato seeds in the study locales.

In the third part, we identified and ranked the adoption constraints faced by farmers using constraint statements which were categorized into four categories, *viz*., socio-economic constraints, technological constraints, environmental constraints and marketing constraints. The respondents were asked to indicate the extent of their agreement to each statement on a three point continuum scale. The ranking of constraints was done based on Weighted Mean Score (WMS) which was calculated by the formula WMS= $\frac{\sum F_i W_i}{\sum F_i}$ where, F was the frequency of farmers; W was weight of each scale; i =3 for most severe; 2 for severe and 1 for not severe).

RESULTS AND DISCUSSION

Extent of adoption of IPPTs and farmers' levels of adoption

The adoption of improved potato technologies is of paramount importance for increasing potato productivity for boosting up agricultural production and also for uplifting the living standard of the farming communities. The extent of adoption of 13 IPPTs were analysed and presented in Table 1.

Improved potato varieties and certified seeds: As the potato seed tubers get degenerated quickly, it is generally recommended that they should be replaced in every 3-4 years with quality/certified seedsto avoid progressive reduction in yield of the crop. In the study areas, we found that there wasvery high adoption of IPVs. Overall, about 78.8percent of the farmers planted only IPVsin about 79.3 % of the potato area and about 18.8 farmers adopted both improved and local varieties. However, it is evident from the table that in Meerut district, the adoption of IPVs was more in whichabout 97.6percent farmers adopted only IPVs in 95.3 percentof potato area,as compared to Bulandshahar (60.4 % farmers, 44.6 % area). In case of certified seeds, there was low adoption, especially in Bulandshahar district. Overall, only 22.2 percent farmers planted certified seeds inabout 29.9percentpotato area.

Pre-sprouting treatment, seed rate, seed retention period and planting space: In general, well sprouted potato seed tubers are recommended at the rate of 25-35 q/ha, depending on their size and purposes of production (seed, ware and processing).The results revealed that on an average, about 54.1 percent of the farmers followed optimum seed rate in about 46 percent potato area. The average seed rate in the study was found tobe 34.13 q/ha (Bulandshahar- 33.13 q/ha and Meerut 35.15 q/ha), which is optimum. However, considerable number of farmers (42.4 %) stillused excess seed rate.

The adoption of pre sprouting of seed tubers was very high and was followed by majority (76.5 %) of the farmers, covering about 72 percent potato area. Similarly, the recommended seed retention period was followed by majority (89.4%)of the respondents. For potato production in the plains, theintra-row spacing of 15-30 cm and inter-row spacing of 40-60 cm are recommended, depending on size of the seeds, purposes of production and methods of planting (manual vs. machinery).The adoption of planting space was very high as majority (70.6 %) of the respondents followed it, with an averageinter-row spacing of 58.6 cm and intra-row spacing of 19.4 cm.

Balanced dose of fertilizers: For majority of potato grown in Indo-Gangetic plains, the economic response of potato to NPK fertilizers has been noticed up to 150-180 kg N/ha, 60-100 kg P_2O_5/ha and 100-150 kg K_2O/ha.In the study areas, it was found that on an average, the NPK dose was 197.2:134.2:134.0 kg/ha (Bulandshahar = 187.8:129.8:113.6 Kg/ha, Meerut=206.9:138.6: 154.9Kg/ha), indicating that considerable farmers applied excess N and P fertilizers. Overall, only 30.6 percent of the respondents followed the recommended first dose of N fertilizer, which covered about 24.4 percent of potato area and the seconddose of N fertilizers was followed by only 31.7 percent farmers.

Avery large adoption gap was observed in case of adoption of optimum phosphatic fertilizer dose in which only 22.3 percent farmers adopted in 19.1 percent area. Majority of them (67 %) applied excess dose which covered 70percent of potato area. In case of potash fertilizer, the extent of adoption was better with about 38.3 percent farmers followed the recommended dose covering 41.0 percent of potato area. Singh *et al.* (2010) and Peer *et al.* (2014) also reported similar results in their potato adoption studies.

Table 1: Extent of adoption of improved potato production technologies in UP (in %)

Improved production technologies	Bulandshahar (n=43)		Meerut (n=42)		Overall (N=85)	
	Farmers	Area	Farmers	Area	Farmers	Area
1. Improved varieties						
• Improved varieties	60.4	44.6	97.6	95.3	78.8	79.3
• Both	34.9	51.5	2.4	4.7	18.8	19.5
• Local varieties	4.7	3.9	0.0	0.0	2.4	1.2
2. Certified quality potato seeds	6.7	12.0	37.8	30.3	22.2	29.9
3. Optimum seed rate						
• >25 q/ha	4.7	5.3	2.4	2.4	3.5	3.3
• 25-35 q/ha (optimum seed rate)	58.1	49.2	50.0	44.6	54.1	46.0
• >35 q/ha	37.2	45.5	47.6	53.0	42.4	50.6
4. Pre -sprouting of seed tubers	79.1	79.5	73.8	68.6	76.5	72.0
5. Seed retention period (≤ 4 years)	90.7	96.0	88.1	91.6	89.4	93.0
6.Maintenance of spacing	79.1	74.5	61.9	61.6	70.6	65.6
7. First dose of Nitrogen fertilizer						
• <75 kg N/ha	25.6	40.2	35.7	35.8	25.8	37.2
• 75-90 kg N/ha (optimum dose)	32.6	26.0	23.8	23.6	30.6	24.4
• >90 kg N/ha	39.5	29.6	40.5	40.5	41.2	37.1
• No application	2.3	4.2	0.0	0.0	2.4	1.3
8. Second dose of Nitrogen fertilizer						
• <75 kg N/ha	16.3	39.2	16.6	10.7	16.5	19.7
• 75-90 kg N/ha (optimum dose)	37.2	30.5	26.2	14.4	31.7	19.5
• >90 kg N/ha	41.8	25.3	52.4	71.5	47.1	56.9
• No application	4.7	4.9	4.8	3.4	4.7	3.9
9. Phosphatic fertilizer dose						
• <60 kg P_2O_5/ha	7.0	3.6	7.1	3.6	7.1	3.6
• 60-100 kg P_2O_5/ha (optimum dose)	18.6	21.9	26.2	17.9	22.3	19.1
• >100 kg P_2O_5/ha	69.7	66.2	64.3	76.1	67.1	73.0
• No application	4.7	8.3	2.4	2.4	3.5	4.3
10. Potash fertilizer dose						
• <100 kg K_2O/ha	44.2	53.9	21.4	20.1	32.9	30.8
• 100-150 kg K_2O/ha (optimum dose)	46.5	37.5	31.0	42.7	38.8	41.0
• > 150 kg K_2O/ha	7.0	4.5	40.5	35.2	23.6	25.5
• No application	2.3	4.2	7.1	2.0	4.7	2.7
11. Irrigation scheduling						
• < 8 days interval	4.7	3.4	0.0	0.0	2.4	1.1
• 8-15 days interval (optimum)	55.8	66.1	81.0	77.6	68.2	74.0
• > 15 days interval	39.5	30.5	19.0	22.4	29.4	25.0
12. Pre -irrigation	95.3	94.4	92.9	88.4	94.1	90.3
13. Management of late blight	67.4	79.6	81.0	78.8	74.1	79.0

Irrigation scheduling:Generally,time interval approach for irrigation scheduling is adopted in the plains. In this method, irrigation is scheduled at an interval of 8-15 days, depending on decrease/increase of temperature and types of soil. First irrigation before planting is equally importantfor uniform germination. The adoption of proper irrigation scheduling wasvery high in the study locations in which about 68.2 percent of the farmers followed it in 75.0 percent potato area. It is inferred from the Table1 that majority of farmers(94.1 %) alsofollowed pre irrigation which covered 90.3 percent of the potato area.

Chemical management of late blight: Late blight was the major disease experienced by the farmers, which resulted in yield loss ranging from 5-40 percent. Normally, for chemical management of late blight, a spray schedule of minimum of four fungicides sprays (first spray of contact fungicides as soon as weather conditions become congenial for late blight, second spray with systemic or translaminar fungicidesas soon as the disease is noticed in the field, remaining third and fourth sprays at 8-10 days interval using systemic/translaminar fungicides) is recommended. The study revealed that overall, majority (74.1 % farmers, 79.0 % potato area) followed chemical management of late blightwith recommended dose of fungicides. Khalil *et al.* (2014) also observed similar result in his study.

Level of adoption of farmers

In order to have a clear understanding of the overall adoption of the selected IPPTs, we also assessed the number of technologies adopted by farmers out of 13 selected technologies (Fig. 1). We found thatnone of the respondent

farmers adopted all 13 technologies. The mean number of IPPTs adopted was 7.62 with a standard deviation of 1.63. Majority of farmers (32 %) adopted 8 technologies, 16.5 percent adopted 7 and 9 technologies, 11.8 percent adopted 6, 9.4 adopted 10, 7.1 percent adopted 5, 4.7 percent adopted 4 and only 2.4 percent adopted 11 improved technologies. With respect to the level of adoption of respondents (Table 2), we found that majority (60 %) of them have medium level of adoption, followed by high level (28 %) and only about 12 percent have low level of adoption. Multiple researchers (Patel *et al.*,2012;Uddin *et al.*, 2014;Mishra *et al.*, 2017;Uikey *et al.*, 2018) found similar results in their studies on adoption level of potato growers.

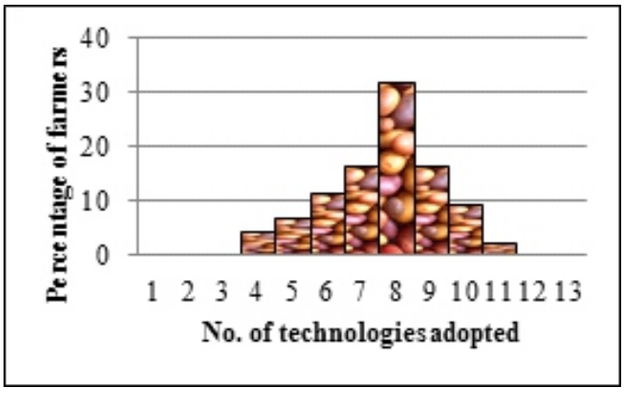

Fig. 1: Distribution of IPPTs adopted by farmer

Table 2: Distribution of farmers according to their level of adoption (N=85)

Adoption level	AI Score	f	%
Low	<41.1	10	11.8
Medium	41.1 - 66.2	51	60.0
High	>66.2	24	28.2

Patterns of adoption of improved potato varieties

The availability of quality seed of improved varieties is crucial for realizing productivity and sustainability of potato production.The results revealed that there was very high incidence (% farmers) and intensity (% area) of adoption of IPVs in both districts (Table 3), with the overall incidence and intensity of adoption of 97.6 percentand of 89.4percent, respectively. The proportion of farmers growing IPVs is higher than the proportion of area indicates that some adopter farmers also grow local varieties on some portion of their farms.The variety-wise incidence and intensity adoption of potato varieties was given in Fig. 2a and 2b, respectively. Figures revealed that ICAR-CPRI's varieties were the most popular verities among farmers, as all improved varieties in the study areas were developed by the institute. Kufri Bahar was the leading potato variety with the incidence and intensity of adoption of 27.8 percent and of 37.6 percent, respectively. The second popular variety adopted by farmers was Kufri Pukhraj (incidence = 21.7 %, intensity=21.4 %), which was followed by Kufri Khyati, Kufri Chipsona-3 and Kufri Chipsona-1. Some farmers also adopted local varieties like S-4, 302 and S-1. It could be inferred from the study that larger potato area was under old varieties [(for example, Kufri Bahar was released in 1980, Kufri Pukhraj (1998), Kufri Chipsona -1 (1998)]. These varieties needed to be replaced by other new improved varieties for higher productivity and market demands.

Table 3: The intensity and incidence of adoption of improved varieties

Location	Incidence (% farmers)	Intensity (% area)
Bulanshahar	95.3	69.1
Meerut	100	98.53
Overall	97.6	89.40

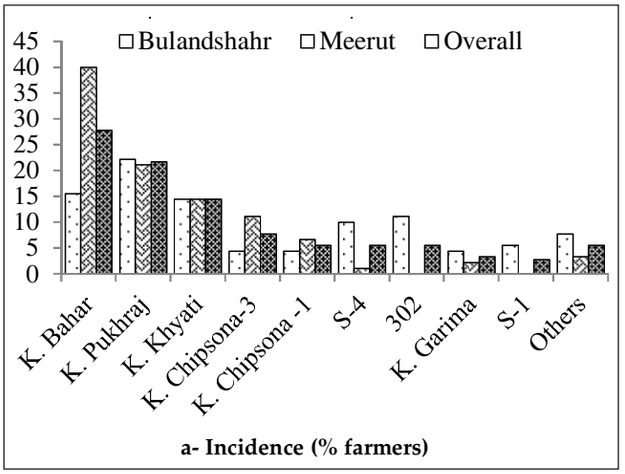

Fig. 2a: Variety-wise incidence of adoption

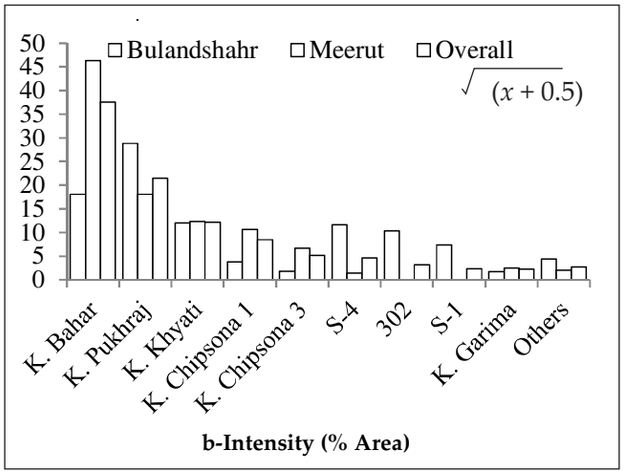

Fig. 2b: Variety wise intensity of adoption

Sources of potato seeds

From the study, it was identified that the most important seed source was farm saved seeds which was usedby about 38.9 percent of farmers and covered about 42.2 percent ofpotato area (Table 4). The second important source was fellow farmers (23.3 %of adopters, 15.6 % potato area). About 21 percent of farmers obtained seeds from theState Agriculture/Horticulture Departments and State Agricultural Universities for planting in about 26.8 percent ofpotato area. Besides these, some farmers also purchased seeds from other seed sources like local seed dealers, private companiesand

ICAR-CPRI. The results revealed that only few farmers used seeds from reliable sources. This may be due to unavailability or high price of quality seeds in the market. Therefore, government should take measures to ensure regular supply of quality seeds at prices affordable by all categories of farmers, and extension activities like trainings, Frontline Demonstrations, etc. should also be organized for farmers on scientific production of quality seeds.

Table 4: Sources of potato seeds in percentage (N=180)

Seed Sources	Farmers (%)	Area (%)
Farm saved seeds	38.9	42.2
Fellow farmers and relatives	23.3	15.6
State Agri./Hort. Dept. and SAUs	21.1	26.8
Local seed dealers and private companies	15.5	12.3
ICAR-CPRI	1.2	3.1

NB:N=180, since some farmers procured seeds from more than two sources

Constraints in adoption of improved potato production technologies

The constraints faced by potato growers in adoption of IPPTs in the study areas were analyzed, categorized and presented in Table 5.

***Socio-economic constraints*:** Under the category of socio-economic constraint, lack of credit and subsidy facilities with an overall weighted mean score (WMS) of 2.66 was ranked as the first major constraint in the study areas. Lal *et al*, (2011) also reported that lack of credit facilities was the most serious constraint in Bihar. Non availability and high cost of labor during peak period was the second major constraint (WMS=2.54). Farmers also experienced that due to high cost of quality seeds, which was ranked third(WMS=2.11), they have to either use their own seeds or purchased cheap and poor quality seeds from the local. This constraint was also reported by Deka *et al*.(2014).Besides, they also reported that other inputs, especially fertilizers and fungicides were costly, leading to high cost of cultivation(WMS=2.05). Other constraints faced by farmers in the study areas were small size of land holding, low profitability in potato cultivation and high irrigation cost.

Table 5: Constraints in adoption of potato production technologies

Constraints		Bulandshahar		Meerut		Overall	
		WMS	Rank	WMS	Rank	WMS	Rank
Socio-Economic	Lack of credit & subsidy facilities	2.77	I	2.55	I	2.66	I
	Non availability and high cost of labor	2.53	II	2.55	I	2.54	II
	Highcost of quality seeds	2.09	III	2.12	II	2.11	III
	High cost of cultivation	2.07	IV	2.02	III	2.05	IV
	Small size of land holding	2.07	IV	1.88	IV	1.98	V
	Low profitability in potato cultivation	2.09	III	1.83	V	1.96	VI
	High irrigation cost	1.14	V	1.12	VI	1.13	VII
Technological	Lack/unavailability of inputs at right time	2.53	I	2.31	I	2.42	I
	Lack of training on scientific potato production	2.35	II	2.26	II	2.31	II
	High cost/lack of storage and processing facilities	2.12	III	1.93	IV	2.02	III
	Lack of knowledge about scientific potato production	1.98	IV	1.98	III	1.98	IV
	Lack of guidance by extension functionaries	1.65	VI	1.93	IV	1.79	V
	Lack of good quality seeds	1.67	V	1.71	V	1.69	VI
	Lack of region specific potato variet ies	1.65	VI	1.67	VI	1.66	VII
Environmental	Heavy incidence of diseases/insects	2.33	I	2.29	I	2.31	I
	Highly fluctuating weather condition	2.14	II	2.14	II	2.14	II
	Excessive soil erosion	1.56	III	1.60	III	1.58	III
	Poor drainage	1.42	IV	1.48	IV	1.45	IV
	Low soil fertility status	1.05	VI	1.14	V	1.09	V
	Less availability of ground water	1.07	V	1.10	VI	1.08	VI
Marketing	Lower price of produce	2.56	I	2.67	I	2.61	I
	Price fluctuation every year	2.51	II	2.60	II	2.55	II
	Exploitation by middlemen	2.26	III	2.14	III	2.20	III
	High cost and inadequate capacity of cold stores	2.09	IV	1.98	IV	2.03	IV
	Lack of and high cost of transportation	2.05	V	1.95	V	2.00	V
	Delayed payment by the traders	1.98	VI	1.98	IV	1.98	VI
	Far marketplaces	1.65	VII	1.60	VI	1.62	VII

WMS=Weighted Mean Score

Technological constraint **:** In this category,lack/unavailability of inputs at right time was ranked as the first major constraint in both districts with the overall WMS of 2.42. This constraint was also reported by Peer *et al.* (2014). Lack of training on scientific potato production was ranked second (WMS= 2.31) which was followed by high cost/lack of storage and processing facilities (WMS=2.02, Rank III. Some farmers felt that they were lacking the knowledge about scientific potato production (WMS=1.98) because of lack of guidance by extension staffs (WMS=1.79) and training programme. However, the study revealed that lack of good quality seeds (WMS=1.69) and lack of region specific suitable potato varieties (WMS=1.66) were not the big problems in the study areas, but, high cost of quality seeds constrained farmers from purchasing them.

Environmental constraints**:** Heavy incidence of diseases and insects was considered as the first major environmental constraint with the overall WMS of 2.31). Deka *et al.* (2014)also reported that heavy pest and disease incidence was the major constraint in their studies. Farmers also experienced highly fluctuating weather condition (WMS= 2.14, Rank II) regularly. Other environmental constraints faced by farmers were excessive soil erosion (WMS=1.58), poor drainage (WMS=1.45),low soil fertility status (WMS=1.09) and less availability of ground water (WMS=1.08)

Marketing constraints**:** Under marketing constraints, low price of produce (WMS=2.61) and price fluctuation every year (WMS=2.55) were ranked as the first and second marketing constraints, respectively. Exploitation by middlemen (WMS=2.20) was ranked as the third constraint which was followed by high cost and inadequate capacity of cold stores, lack of and high cost of transportation, delayed payments by traders and far marketplaces. All these marketing constraints deter farmers to get good income at the right time, leading to low adoption of improved potato technologies. Other researchers (Lal *et al.*,2011; Patel *et al.*, 2012; Deka *et al.*, 2014) also identified similar potato marketing constraints in their studies.

CONCLUSION

The farm level adoption of improved potato technologies in UP has been identified. The study found that there was very poor adoption of some technologies and majority of farmers have medium level of adoption. Therefore, there is a need to enhance the knowledge and skills of potato growers for helping them to achieve higher yield and income. There was very high incidence and intensity of adoption of improved varieties; however, larger areas were under old varieties, which should be replaced by other newly released varieties. In order to speed up the dissemination and adoption of improved potato production technologies, the state governments, researchers and policy makers should put more emphasis on those serious adoption constraints faced by farmers.

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