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Effect of organic and inorganic sources of nutrients on productivity, specific gravity and processing quality of potato (*Solanum tuberosum*)

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ABSTRACT

Field experiment was conducted with potato (*Solanum tuberosum*) during winter (*rabi*) seasons of 2005–06 and 2006–07 to study the effect of different organic and inorganic sources of nutrients on productivity, specific gravity and processing quality of potato cultivars. The experiment comprised three varieties, viz Kufri Chipsona 1 (V_1), Kufri Chipsona 2 (V_2), Kufri Jyoti (V_3) and four nutrient sources viz. FYM @ 35 tonnes/ha (N_1), FYM @ 30 tonnes/ha + bio-fertilizers (N_2), FYM @ 25 tonnes/ha + mustard cake @ 1.0 tonne (N_3), recommended dose of NPK (180:150:150 kg/ha N, P_2O_5, K_2O respectively) (N_4). Kufri Chipsona 1 recorded maximum dry weight of tuber, total number of tubers/ha, total tuber yield (28.18 and 28.39 tonnes/ha) and NPK uptake. Kufri Chipsona 2 attained maximum plant height, number of small tubers (‹25g). Kufri Chipsona 1 produced about 19.10, 18.44% more yield than Kufri Chipsona 2 and 6.22, 6.21% more yield than Kufri Jyoti in the successive two years. *Chipsona* varieties produced high dry matter, starch, specific gravity, acceptable chip colour content and low reducing sugar. Kufri Jyoti produced maximum germination percentage, vitamin C and reducing sugar content. Recommended dose of NPK (N_4) showed the best performance in terms of growth and yield parameters as compared to organic sources of nutrients. FYM @ 30 tonnes/ha along with biofertilizers (N_2) recorded maximum soil fertility build-up after harvest of the crop and also helped to achieve required processing qualities of potato tuber. It was concluded that Chipsona varieties were suitable processing cultivars as they met all the necessary requirements and as well as integrated nutrient management using both manures and fertilizers gave high level of guarantee with improved quality potato production.

Key words: Biofertilizer, Fertilizer, Growth, Manure, NPK Uptake, Potato, Processing Quality, Yield

Potato (*Solanum tuberosum*) allows the farmer to harvest up to 80% of dry matter as edible nutritious food, as compared to only 50% of the cereals as grain (Pandey and Sarkar 2005). Besides being nutritionally superior and highly productive than most food crops, it has a relatively short duration and therefore amenable for inclusion in the intensive cropping system. Continuous use of inorganic fertilizers cause detrimental effects on soil physical health and thus reduces crop yields drastically (Guar 2002). A promising method to counteract these emerging threats is to switch on to organic farming practices which involves use of organic manures like FYM, vermicompost, neem cake, etc. and biofertilizers like *Azotobacter* and Phosphobacteria. In the world, India with 25 million tonnees produce comes in the third position in potato production, next to China (75 million tonnes) and Russia (37 million tonnes) (Chaturvedi 2007). Potato production in the country has reached to record levels in the last two decades and as a result during 2003–04, the total production reached to 23.12 million tonnes (Singh *et al.* 2007).

Over the last decade, there has been a sustained change in the potato consumption pattern in most of the developing countries. Processed products not only have a longer shelf-life, but also help in reducing the transportation cost and offer a means to utilize poor quality potatoes. Where developed nations consumed processed potatoes of about 30–76% of the total potato produce in Europe and North America, it is below 1% in India (Marwah *et al.* 2007). India is one of those developing countries where the demand for processed potato products is growing day by day, and the potato processing industry is set for further growth. Potatoes meant for processing should meet certain desired features to produce products of acceptable quality. Potato varieties with round or oval tubers with fleet eyes, dry matter content around 20% and reducing sugar content of less than 0.25%

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are desirable for processing into chips (Verma 1991).

The major challenge in the developing countries has been the lack of potato varieties suitable for processing. Kufri Chipsona 1 and Kufri Chipsona 2 released from CPRI, Shimla in 1988, have been contributing significantly to sustain the processing sector in the country. Numerous works have been done on the integrated use of nutrients on potato, however, information regarding use of strictly organic manure alone and its effect on productivity and quality of potato is still lacking. Hence, a field experiment was conducted to study the effect of different organic and inorganic sources of nutrients on potato.

MATERIALS AND METHODS

Field experiment was conducted during winter (*rabi*) seasons of 2005–06 and 2006–07 at Block Seed Farm, Adisaptagram, Hooghly, West Bengal (latitude 22°57´N, longitude 88°22´ E and altitude 9.75 m above mean sea level). The soil of the experimental site is typical Gangetic alluvium and sandy loam in texture with *p*H 6.4 and organic carbon 0.84%. The physico-chemical analysis of the soil was done by collecting soil samples from a depth of 0–30 cm. The soil contained 305, 15 and 221 kg/ha available N, P_2O_5 and K_2O, respectively. The experiment was conducted in split-plot design, replicated thrice, with three varieties, viz. Kufri Chipsona 1 (V_1), Kufri Chipsona 2 (V_2), Kufri Jyoti (V_3) in the main plots and four different sources of nutrients, viz FYM @ 35 tonnes/ha (N_1), FYN 30 tonnes/ha + biofertilizera (*Azotobacter* + phosphobacteria) (N_2), FYM @ 25 tonnes/ha + mustard cake @ 1.0 tonne (N_3) and recommended dose of NPK, ie 180:150:150 kg/ha N, P_2O_5, K_2O (N_4). Each year a basal dose of half of N, full P_2O_5 and K_2O were applied through urea, single super phosphate and muriate of potash respectively and rest half of N was top dressed at 30 days after planting. Farmyard manure, mustard cake as per the treatments were applied as basal in both years. *Azotobacter* and phosphobacteria were applied at the rate of 1.5 kg/ha as seed inoculation. 3 m × 3 m sized plots were demarcated and treatments were allotted randomly. These plots received the same treatment each year. Tubers weighing 30–40 g each were placed in upright position in furrows 60 cm apart at a distance of 20 cm and depth of 3–4 cm. The crop was planted on 27 November in 2005 and 21 November in 2006. Two hand weedings were done at 20 and 45 days after planting and earthing-up was done at 30 days after planting in both the years. In order to protect from pathological diseases two sprayings with Dithane M 45 (Mancozeb) @ 2.5 kg/ha were done at 40 and 60 days after planting and for protecting against aphids and other insects. Metasystox (oxydemeton-methyl) 25 EC (1.0%) was also sprayed at 45 and 65 days after planting in both years. The rainfall received during the crop growth period was 19 mm and 13 mm in first and second year, respectively. However, two light irrigations were given at five days interval within 12 days after planting. Then five irrigations were given at an interval of 7–8 days and the last two irrigations were given at 12 days interval in both years. Water level in each irrigation was maintained below two-third height of the ridges. Dehaulming was done after 80 days of planting when haulms start yellowing and falling on the ground. Harvesting was done 10–12 days after dehaulming. At harvest samples were collected from all the treatments in each year to collect data and to carry analysis of various quality parameters. However, germination percentage was counted at 35 days after planting. Representative soil samples (0–15 cm) were taken from each 12 plots after harvesting of the crop. Chemical analyses of soil and plant samples were done for N, P, K contents and total NPK uptake. Starch content of tubers was estimated following a rapid titrimetric method as mentioned by Moorthy and Padomaja (2000). Reducing sugar and ascorbic acid (Vitamin C) content were estimated by Shaffer Samogyi's micro-titration method and 2,6-dichlorophenol indophenol dye titration method (AOAC 1984) respectively. The observations on chip colour were taken visually using 7 point Hedonic Scale giving 1= Creamish white (excellent), 2= golden yellow (very good), 3= dull yellow (good), 4= deep yellow (satisfactory), 5= light brown (fair), 6= dark brown (not acceptable) and 7= very dark brown (not acceptable) (Ranganna 1977).

On calculating cost of produce and cost of inputs applied, benefit : cost ratio (B:C ratio) was determined for each treatment. The data relating to growth, yield parameters and processing qualities were statistically analyzed following analysis of variance (ANOVA) as described by Panse and Sukhatme (1984).

RESULTS AND DISCUSSION

Growth attributes

Growth attributes such as germination percentage, plant height and dry weight of tubers differed significantly due to different varieties and nutrient treatments in both the years (Table 1). Variety Kufri Jyoti (V_3) showed the highest germination percentage of tubers. The minimum germination percentage was recorded in varieties Kufri Chipsona 2 (V_2) and Kufri Chipsona 1 (V_1) both in the first and second year. Kufri Chipsona 2 (V_2) showed significantly taller plant (70.72 cm and 79.30 cm in successive years) than the other two varieties (Kufri Chipsona 1 and Kufri Jyoti), which may be attributed to its growth habit governed by genetic traits. Similar finding was reported by Kumar *et al.* (2004). The dry weight of tuber was maximum in variety Kufri Chipsonal-1 and minimum in Kufri Jyoti. Among the nutrient treatments recommended dose of NPK (N_4) recorded better performance with maximum germination percentage, plant height, dry weight of tubers in successive years than other treatments involving organic source of nutrients only. These results were in conformity with the finding of Lal and Khurana (2007).

Table 1 Effect of varieties and nutrients on growth and yield parameters of potato

Treatment	Germination (%)		Plant height (cm)		Dry weight of tubers (g/m²)		Number of different grades No tubers (thousand/ha)								Total no. of tubers (thousand/ha)	
							‹25g		26–50g		51–75g		› 75g			
	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07
Variety																
Kufri Chipsona 1 (V_1)	99.47	98.72	68.90	66.07	701.30	707.34	172.36	166.92	246.52	250.73	154.72	143.00	109.14	115.04	671.86	678.18
Kufri Chipsona 2 (V_2)	99.14	99.64	70.72	79.30	583.20	593.61	191.28	191.37	236.15	236.98	95.09	98.68	58.47	58.78	580.82	585.72
Kufri Jyoti (V_3)	99.56	99.83	70.51	66.96	568.91	579.58	169.83	172.61	204.10	203.15	97.77	99.05	50.07	52.20	521.82	527.00
SEm(±)	0.03	0.15	0.36	0.16	0.52	0.45	0.44	0.73	0.20	0.50	0.32	0.35	0.19	0.46	0.35	0.29
CD(*P*=0.05)	0.13	0.58	1.41	0.65	2.05	1.77	1.72	2.86	0.79	1.97	1.24	1.37	0.78	1.79	1.36	1.12
Nutrient																
FYM @ 35 t/ha(N_1)	99.18	99.33	68.99	67.96	614.01	623.70	178.54	178.28	229.39	232.01	110.86	109.46	70.21	72.81	589.07	562.45
FYM @ 25 t/ha+ Mustardcake @ 1.0 tonne ha(N_3)	98.81	98.96	66.46	66.14	603.34	615.61	183.47	183.72	238.28	240.87	99.05	97.93	65.64	65.40	586.40	587.92
Recommended dose (N_4)	99.89	99.85	75.57	77.94	632.16	637.69	167.69	166.55	220.22	220.65	129.90	133.11	84.42	86.74	599.39	610.38
SEm(±)	0.20	0.30	0.43	0.44	0.44	0.46	0.48	0.57	0.43	0.47	0.35	0.42	0.35	0.36	0.41	0.54
CD (*P* = 0.05)	0.59	0.91	1.28	1.31	1.30	1.38	1.42	1.68	1.27	1.39	1.04	1.25	1.04	1.06	1.22	1.61

Yield attributes

Varieties and nutrients applied showed significant effect on the number of small, medium, large and very large sized (<25g, 26-50g, 51-75g, >75g, respectively) tubers/ha and total number of tubers during the consecutive years of study (Table 1). When individual tuber grades were considered kufri chipsona-1 (V_1) was superior to other two varieties except in small sized tubers. Kufri Chipsona 2 (V_2) gave the maximum number of small tubers. Maximum total number of tubers was recorded from Kufri Chipsona 1(V_1) and the minimum from Kufri Jyoti. Results are in agreement with the findings of Kumar *et al.* (2005). Organic nutrient performed better in giving greater number of small and medium sized tubers while inorganic source of nutrient was in favour of producing large and very large sized tubers irrespective of variety. But recommended dose of inorganic sources of nutrient (N_4) recorded the maximum number of tubers and N_3 (FYM@25 tonnes/ha) along with mustard cake @ 1.0 tonne recorded the least value.

Yield

Variety Kufri Jyoti (V_3) recorded maximum yield of both small and medium sized tubers (Table 2). But highest yield of large and very large seeded tubers were achieved from Kufri Chipsona 1 (V_1). Kufri Chipsona 1 also recorded maximum total tuber yield (28.18 and 28.39 tonnes/ha in 2005–06 and 2006–07 respectively) and was significantly superior to other two varieties. Minimum yield was observed in Kufri Chipsona 2 (V_2). The results are in agreement with the findings of Marwaha *et al.* (2007). During both the years it was observed that the yield of large and very large sized tubers were highest in plants receiving recommended dose of NPK indicating that increase in yield was due to increase in size of tubers. Plants that received only organic source of nutrients gave higher number and yield of small and medium sized tubers which indicates the importance or organic farming in producing seed tubers. Highest total tuber yield was also recorded from the treatment with recommended dose of NPK (N_4). This result was in conformity with the findings of Upadhyay and Singh (2003).

Specific gravity and quality character of tubers

Physical character as specific gravity and quality characters as dry matter, starch, reducing sugar, vitamin C content and chip colour score of tubers differed significantly among the varieties during both the years of investigation (Table 4). Variety Kufri Chipsona 2 (V_2) recorded maximum specific gravity (1.085 in both years), dry matter, starch content and minimum vitamin C content. While Kufri Jyoti (V_3) recorded lowest specific gravity, dry matter, starch content and highest reducing sugar, vitamin C content. However Kufri Chipsona 2 (V_2) produced the most acceptable light colour chips of grade. Among the different nutrient sources, FYM@ 30 tonnes/ha + biofertilizers (N_2) gave the

Table 2 Effect of varieties and nutrients on yield of different grades and total yield of potato tubers

Treatment	Yield of different grades of tubers (tonne/ha)								Total yield of tubers (tonnes/ha)	
	‹25g		26–50g		51–75g		› 75g			
	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07
Variety										
Kufri Chipsona 1 (V_1)	5.73	5.77	6.61	6.72	8.62	8.69	7.20	7.21	28.18	28.39
Kufri Chipsona 2 (V_2)	6.78	6.78	5.81	5.94	5.85	5.81	5.18	5.20	23.66	23.97
Kufri Jyoti (V_3)	6.82	6.88	7.04	7.03	6.82	6.87	5.86	5.95	26.53	26.73
SEm(±)	0.33	0.21	0.39	0.36	0.37	0.41	1.03	0.29	0.25	0.28
CD (*P*=0.05)	1.31	0.81	1.52	1.39	1.44	1.60	4.05	1.18	0.98	1.09
Nutrient										
FYM @ 35 t/ha(N_1)	6.41	6.35	6.27	6.39	7.01	7.13	6.05	6.01	25.73	25.88
FYM @ 30 t/ha+ bio fertilizer(N_2)	6.40	6.51	6.46	6.55	7.19	7.15	6.12	6.22	26.17	26.42
FYM @ 25 t/ha+ Mustardcake @ 1.0 tonne/ha (N_3)	6.12	6.13	6.22	6.27	6.95	6.97	5.91	5.97	25.20	25.35
Recommended dose (N_4)	6.88	6.92	7.00	7.04	7.23	7.24	6.24	6.27	27.39	27.80
SEm(±)	0.50	0.49	0.27	0.52	0.29	0.47	1.22	0.43	0.40	0.48
CD (*P*=0.05)	1.49	1.44	0.81	1.55	0.86	1.40	NS	1.28	1.19	1.43

Table 3 Effect of varieties and nutrients on NPK uptake and available NPK in post harvest soil

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)		Avalable N (kg/ha)		Avalable P (kg/ha)		Avalable K (kg/ha)	
	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07
Variety												
Kufri Chipsona 1 (V_1)	127.91	130.50	21.09	23.69	136.32	146.76	342.51	358.00	17.51	25.39	237.16	242.56
Kufri Chipsona 2 (V_2)	121.28	127.67	17.93	20.68	130.35	139.69	342.75	356.96	17.46	25.08	235.42	243.00
Kufri Jyoti (V_3)	126.79	129.93	19.85	23.07	134.56	142.38	343.47	356.66	17.34	25.66	237.02	242.29
SEm(±)	0.58	0.43	0.08	0.25	0.25	0.33	0.52	0.36	0.09	0.33	0.49	0.36
CD(*P*=0.05)	2.28	1.69	0.33	0.97	0.98	1.30	N S	N S	N S	N S	N S	N S
Nutrient												
FYM @ 35 t/ha(N_1)	122.99	126.54	17.74	20.56	129.66	139.83	339.05	352.16	16.22	23.85	234.95	239.18
FYM @ 30 t/ha+ biofertilizer(N_2)	125.71	128.98	19.86	22.83	134.24	144.85	358.13	369.14	19.76	29.15	243.26	249.80
FYM @ 25 t/ha+ mustardcake @ 1.0 tonnes/ha (N_3)	117.18	124.28	15.73	18.60	126.77	133.63	327.81	346.67	15.93	22.87	230.60	234.91
Recommended dose (N_4)	135.42	137.66	25.15	27.92	144.29	153.45	346.65	360.85	17.83	25.63	237.31	242.87
SEm(±)	0.51	0.42	0.39	0.54	0.44	0.52	0.58	0.62	0.57	0.41	0.45	0.52
CD (*P*=0.05)	1.50	1.25	1.15	1.62	1.29	1.56	1.71	1.83	1.68	1.21	1.34	1.53

best performance with a highest specific gravity, dry matter, starch content in both first and second year. N_3 (FYM @ 25tonnes/ha + mustard cake @1.0 tonne recorded maximum reducing sugar content. FYM @ 25tonnes/ha + mustard cake @1.0 tonne recorded 4.75, 9.77% more reducing sugar content than recommended dose of NPK and 8.49, 13.77% more than FYM@ 30 tonnes/ha + biofertilizers in the two successive years. In case of starch content, Kufri Chipsona 2 recorded 9.04, 10.36% more than Kufri Chipsona 1 and 38.99, 40.35% more than Kufri Jyoti in both years. However, maximum vitamin C content was reported in N_1 (FYM @35 tonnes/ha) and N_2 (FYM @30 tonnes/ha + biofertilizers).

Table 4 Effect of varieties and nutrients on specific gravity and quality characters of potato tubers

Treatment	Specific gravity		Dry matter Content (%)		Starch content (mg/100g fresh weight)		Reducing sugar content (mg/ 100g fresh weight)		Vitamin c content (mg/100g fresh weight)		*Chip colour score	
	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07	2005–06	2006–07
Variety												
Kufri Chipsona 1 (V_1)	1.076	1.075	21.94	22.04	12.39	12.26	78.98	80.62	11.05	13.73	2.25	2.33
Kufri Chipsona 2 (V_2)	1.085	1.085	23.50	23.58	13.51	13.53	106.86	109.26	10.77	13.52	1.50	2.25
Kufri Jyoti (V_3)	1.071	1.071	18.47	18.59	9.72	9.64	184.29	186.47	12.51	14.66	5.25	5.50
SEm(±)	0.0007	0.0013	0.08	0.14	0.08	0.12	0.33	0.27	0.08	0.22	0.34	0.28
CD(*P*=0.05)	0.0024	0.0039	0.33	0.54	0.34	0.47	1.28	1.05	0.33	0.85	1.33	1.10
Nutrient												
FYM @ 35 tonnes/ ha(N_1)	1.077	1.076	21.07	21.16	11.71	11.64	124.60	125.67	11.39	14.59	2.67	3.00
FYM @ 30 tonnes/ ha+biofertilizer(N_2)	1.079	1.078	21.78	21.98	12.26	12.16	118.21	118.50	11.65	14.04	2.67	3.00
FYM @ 25 tonnes/ ha+mustardcake @ 1.0 tonnes/ha(N_3)	1.075	1.075	20.88	20.94	11.55	11.50	128.25	134.82	11.24	13.20	3.00	3.11
Recommended dose (N_4)	1.078	1.077	21.50	21.54	11.98	11.93	122.44	122.82	11.48	14.05	3.67	4.33
SEm(±)	0.0007	0.0007	0.10	0.11	0.09	0.06	0.47	0.56	0.14	0.25	0.28	0.31
CD (*P*=0.05)	0.0021	0.0021	0.29	0.30	0.27	0.18	1.40	1.68	NS	0.74	NS	0.93

•7 point Hedonic Scale for chip colour: 1, Excellent; 2, very good; 3, good, 4, satisfactory; 5, fair; 6, not acceptable; 7, not acceptable

Organic sources of nutrients (N_1, N_2 and N_3) produced lighter colour chips than those receiving purely inorganic sources of nutrient (N_4).

NPK Uptake and available N, P, K in post-harvest soil

Kufri Chipsona-1 (V_1) significantly showed maximum N, P, K uptake (127.91, 130.50 kg/ha N, 21.09, 23.69 kg/ha P and 136.32, 146.76 kg/ha K during 2005–06, 2006–07, respectively). But no significant effect was observed in the available soil N, P, K after harvest of crop due to the variety used (Table 3). Recommended dose of NPK (N_4) recorded maximum N, P, K uptake of 135.42, 137.66 kg/ha N; 25.15, 27.92 kg/ha P; 144.29, 153.45 kg/ha K respectively in successive years, may be due to increase in plant growth parameters and tuber yield. This is in agreement with the finding of Sood (2007). Whereas, treatment N_2 (30 tonnes/ha FYM + biofertilizers) recorded maximum soil available NPK after the harvest of crop (Table 3).

Economics

The highest benefit:cost ratio was achieved when Kufri Chipsona 1 (V_1) was cultivated along with recommended

Table 5 Economics of nutrients application on different potato cultivars

Treatment	Total cost of cultivation (₹/ha)			Benefit : cost ratio		
	2005–06	2006–07	Mean	2005–06	2006–07	Mean
Variety						
Kufri Chipsona 1 (V_1)	43 397.50	44 897.50	44 147.50	1.28	1.22	1.25
Kufri Chipsona 2 (V_2)	43 397.50	44 897.50	44 147.50	0.92	0.88	0.90
Kufri Jyoti (V_3)	43 397.50	44 897.50	44 147.50	1.15	1.09	1.12
Nutrient						
FYM @ 35 tonnes/ha(N_1)	43 750.00	45 250.00	44 500.00	1.06	1.00	1.03
FYM @ 30 tonnes/ha + biofertilizer(N_2)	42 650.00	44 150.00	43 400.00	1.15	1.09	1.12
FYM @ 25 tonnes/ha + mustardcake @ 1.0 tonne (N_3)	46 250.00	47 750.00	47 000.00	0.91	0.86	0.89
Recommended dose (N_4)	40 940.00	42 440.00	41 690.00	1.34	1.29	1.32

dose of NPK (N_4) (Table 5). The increase in B:C ratio from the use of inorganic sources of nutrients may be attributed to tuber number and yield as compared to organic manures (Kumar *et al.* 2005). Amongst nutrient sources plots treated with recommended dose of NPK, recorded maximum net profit and B:C ratio. It was followed by the treatment comprising application of FYM @ 30 tonnes/ha + biofertilizers in both the years. The minimum response in both net profit and B:C ratio were recorded in plots treated with FYM @ 25 tonnes/ha along with mustard cake @ 1.0 tonne/ha. Amongst the organic sources of nutrients, N_2 (FYM @ 30tonnes/ha + biofertilizers) recorded the highest B:C ratio which justifies the importance of bioferlizers in fertilizer economy. The results are in agreement with the findings of Sood (2007).

The results of the field experimentation on effect of different organic and inorganic sources of nutrients on potato cultivars revealed that Chipsona varieties are suitable processing cultivars as they met all the necessary requirements, while Kufri Jyoti may be considered preferably for table purpose and canning. High levels of productivity in potato cannot be sustained through organic farming alone and only integrated soil fertility management using manures and fertilizers can guarantee not only high levels of potato production but also improve the quality of produce.

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