



## Expression of Quantitative and Qualitative Traits in Potato (*Solanum tuberosum* L.) Grown through Organic Production Intervention in Eastern Indian Plateau

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### Abstract

The investigation was conducted during two consecutive *rabi* seasons of 2019-20 and 2020-21 at the Organic Experimental Farm of Ranchi campus of the university by employing eight traditionally grown potato varieties of the region viz., V<sub>1</sub> (Kufri Jyoti), V<sub>2</sub> (Siwan), V<sub>3</sub> (C-40), V<sub>4</sub> (2236), V<sub>5</sub> (Ultimatum), V<sub>6</sub> (Sathi), V<sub>7</sub> (Lal Gulab) and V<sub>8</sub> (Nainital). They were grown independently through four organic growing conditions namely, C<sub>1</sub> (Conventional Farming) where only Farm Yard Manure (FYM) @ 10 t.ha<sup>-1</sup> was applied, C<sub>2</sub> (Bulky Organic Manure) where along with the FYM @ 10 t.ha<sup>-1</sup>, vermicompost @ 20 t.ha<sup>-1</sup> was applied, C<sub>3</sub> (Vivek Krishi) where along with the FYM @ 10 t.ha<sup>-1</sup>, enriched Sanjeevani (10%) was applied, and C<sub>4</sub> (Absolute Control) where no organic input was used. Four separate field experiments based upon the predesigned growing conditions were intended by adopting Completely Randomized Block Design (CRBD) experimental design by assigning thrice replication of each of the eight varieties of the crop. Different growth and yield attributes along with the quality contributing traits were studied and found to be highly influenced by different organic growing conditions. Most of the studied growth and yield attributing traits of potato were highly influenced by the growing condition (C<sub>2</sub>) where along with the FYM @ 10 t.ha<sup>-1</sup>, Vermicompost @ 20 t.ha<sup>-1</sup> was applied resulting higher yield (34.13 t.ha<sup>-1</sup>) as estimated in V<sub>4</sub> (2236). However, almost all quality attributing traits were highly influenced by the growing condition (C<sub>3</sub>) ensuing higher starch content (31.86% in V<sub>6</sub>) where along with the FYM @ 10 t.ha<sup>-1</sup> a liquid organic formulation Enriched Sanjeevani (10%) was applied. The study revealed that



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potato is highly responsive to different organic growing conditions especially bulky organic manure (vermicompost) for higher yield and Vivek Krishi for proximate quality traits expression under the organic growing condition of the south Chhota Nagpur region of the eastern Indian plateau.

### Introduction

Potato (*Solanum tuberosum* L.) is one of the most important non-grain food crops in the world. It is usually described as the king of vegetables of the family Solanaceae and extensively grown all over the world.<sup>1</sup> Potato is believed to have its roots in the Andean regions of South America, where it has been recognized as the main staple food for at least 8,000 years.<sup>2</sup> Vegetable farming, particularly potato growing is regarded as one of the most important sources of food security and revenue generation among rural communities of eastern Indian plateau and its production in our country exceeded 53 million metric ton in 2022. Though conventional chemical farming produces a greater and more consistent yield of potatoes, but it is also an expensive practice, thus small, and marginal farmers find it difficult to afford for growing the crop in this manner, whereas the inputs generally used for organic farming practices are quite cheaper or may easily be produced even by the resource poor farmers. Potato is a chemically intensive crop that harms soil fertility and the tuber quality, therefore, supplementing the nutrient through organic sources has become essential to sustain production over time and to maintain soil health. The application of bulky organic manures, specially vermicompost, plays an important role in potato cultivation.<sup>3</sup> It significantly influences different yield attributes of potatoes like plant height, number of stems per hill, average tuber weight, bulking ratio, total yield and so on. Vermicompost also has a significant influence on different quality attributes of potatoes namely specific gravity, tuber dry weight, ascorbic acid content, etc. The organically produced liquid manures (like Sanjeevani) can increase the productivity and profitability of potatoes.<sup>4-5</sup> Such an organic formulation explicitly Enriched Sanjeevani, a liquid organic formulation that makes the soil lifetime fertile. A relevant research work in this particular context demonstrated that Enriched Sanjeevani prepared by mixing cow dung: cow urine: water at 1:1:10 proportions along with one handful of garden soil and 50 g of molasses for each kilogram of cow dung has great potential to enhance yield

and proximate quality trait expressions in brinjal.<sup>6</sup> Considering all the above-mentioned valuable aspects, the present investigation was conducted to evaluate yield and quality contributing attributes of potato under non-chemical growing conditions in eastern Indian plateau.

### Materials and Methods

The details of materials and methodology followed in the present investigation have been accentuated through the following sub-sections:

#### Experimental Site and Design

The experiment was conducted in an organic experimental plot of Ramakrishna Mission Vivekananda Educational and Research Institute, Morabadi, Ranchi during the two consecutive rabi seasons of 2019-20 (Year-I) and 2020-21 (Year-II). Completely Randomized Block Design (CRBD) was adopted in conducting field experiments separately under four (4) organic growing conditions employing eight (8) varieties with their thrice replication. Finally, ninety-six (24 plots for each of the four growing conditions) experimental plots each of with 2.7 m x 2.0 m sizes (5.40 m<sup>2</sup>) were used for performing the experiment.

#### Details of Varieties and Experimental Condition

Eight commonly grown potato varieties, namely V<sub>1</sub>: Kufri Jyoti; V<sub>2</sub>: Siwan; V<sub>3</sub>: C-40; V<sub>4</sub>: 2236; V<sub>5</sub>: Ultimum; V<sub>6</sub>: Sathi; V<sub>7</sub>: Lal Gulab; and V<sub>8</sub>: Nainital were subjected to grow independently under four organic growing conditions, viz. C<sub>1</sub>: Conventional Farming [where only FYM @ 10 t.ha<sup>-1</sup> was applied as basal dose 7 days before planting]; C<sub>2</sub>: Bulky Organic Manure [where along with FYM @ 10 t.ha<sup>-1</sup>, vermicompost @ 20 t.ha<sup>-1</sup> was applied twice, one with ½ quantity of vermicompost along with FYM as basal application before 7 days of planting and remaining ½ as a split application at 45 days after planting (DAP)]; C<sub>3</sub>: Vivek Krishi [where along with FYM @ 10 t.ha<sup>-1</sup> as basal application 7 days before planting, enriched Sanjeevani @ 10% was applied twice as soil drenching split application

one at 15 DAP and another at 45 DAP]; and C<sub>4</sub>: Absolute Control [where no input was applied and thereby considered organic by default].

### Seed Treatment and Spacing

Seed tubers were treated with *Trichoderma viride* @5g.kg<sup>-1</sup> before sowing them at 45 cm inter row and 20 cm intra row spacing in the experimental plots.

### Organic Plant Protection Measures

Whey water mixed with turmeric powder @10g.litre<sup>-1</sup> was applied four times starting from 15 DAP at 15 days interval as prophylactic measures against pathogenic infections and Dashparni (a botanical preparation of ten herbs/shrubs those are not generally preferred by cattle or even wild animals) @10% and neem oil @ 0.3% alternately applied four times at fortnightly interval starting from 21 DAP as a precautionary measure against different sucking and chewing pests.

### Observations Recorded and Data Analyses

Different growth and yield attributes of potato viz. plant height (at harvest) (cm), number of tubers per plant, average tuber weight (g), bulking ratio and total yield (t. ha<sup>-1</sup>) were taken time to time. Similarly,

several quality attributes like Total Soluble Solids (TSS in %), dry weight of the tuber (%), total sugar content (%) by the Anthrone method, the ascorbic acid (mg.100g<sup>-1</sup>) content of tuber as determined by the dye titration method<sup>7</sup> and starch content (%) of tuber as assessed by using Anthrone method<sup>8</sup> were estimated for evaluation of the crop varieties under different organic growing conditions. Data thus obtained were subjected to statistical analysis by the Analysis of Variance (ANOVA) method<sup>9</sup> and the significance of different sources of variations was tested by Error Mean Square by Fisher and Snedecor's 'F' test at 0.05 probability level. For determination of critical differences at the 5% level of significance, Fisher and Yates' table was consulted. The comparison among different varieties was addressed by using the Duncan's Multiple Range Test (DMRT)<sup>10</sup> alongside CD<sub>0.05</sub>. All cases the interpretation was based upon the pooled mean values of the both years' data.

### Results

The findings of the experiment regarding yield as well as quality contributing traits have been categorically represented as per the following:

**Table 1: Per se performance on plant height (cm) of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	57.67	55.77	56.72b	60.60	58.58	59.59d	57.40	61.30	59.35d	35.70	31.56	33.63d
V <sub>2</sub>	62.45	58.49	60.47ab	57.90	55.88	56.89e	61.23	57.19	59.21d	34.90	32.82	33.86cd
V <sub>3</sub>	59.85	62.81	61.33a	64.50	62.38	63.44ab	65.30	63.28	64.29a	35.20	33.16	34.18c
V <sub>4</sub>	61.10	65.04	63.07a	59.00	62.90	60.95c	56.60	59.40	58.00f	36.20	34.18	35.19a
V <sub>5</sub>	58.66	62.60	60.63a	65.90	62.24	64.07a	59.80	57.64	58.72e	35.00	33.70	34.35bc
V <sub>6</sub>	63.10	65.06	64.08a	58.88	62.72	60.80c	64.95	62.73	63.84b	36.27	33.17	34.72b
V <sub>7</sub>	64.60	62.58	63.59a	63.50	61.42	62.46b	64.8	62.76	63.78b	34.60	32.58	33.59d
V <sub>8</sub>	59.74	63.76	61.75a	63.97	61.57	62.77b	59.87	63.63	61.75c	35.25	32.43	33.84cd
SEm (±)	1.76	0.88	1.80	1.90	1.28	0.50	1.63	1.43	0.19	1.06	1.10	0.18
CD <sub>(P&lt;0.05)</sub>	3.77	1.89	3.86	4.07	2.74	1.08	3.49	3.06	0.41	NS	NS	0.38
CV (%)	13.09	7.06	9.07	14.78	9.13	8.00	12.00	10.09	9.17	12.78	14.79	4.19

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

**Growth and Yield Attributes**

The results illustrated that almost all the yield attributes were greatly influenced by the intervention of different organically designed treatments with statistically significant ( $P \leq 0.05$ ) difference among different varieties. In this context, highest plant height

at harvest (64.08 cm) was recorded in  $V_6$  (Sathi) under  $C_1$  (conventional farming) growing condition, whereas the lowest plant height (33.59 cm) was recorded in  $V_7$  (Lal Gulab) under  $C_4$  (absolute control) growing condition where no organic input was applied (Table 1).

**Table 2: Per se performance on number of tubers. plant<sup>-1</sup> of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	$C_1$			$C_2$			$C_3$			$C_4$		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
$V_1$	3.55	5.51	4.53	5.50	3.44	4.47b	3.56	5.5	4.53d	4.35	2.19	3.27
$V_2$	5.20	3.34	4.27	3.32	5.22	4.27c	6.00	4.40	5.20ab	4.50	1.76	3.13
$V_3$	5.10	3.04	4.07	5.90	3.84	4.87a	5.50	5.16	5.33a	2.21	4.19	3.20
$V_4$	6.50	2.44	4.47	3.45	5.21	4.33bc	4.90	5.36	5.13b	2.75	3.91	3.33
$V_5$	5.25	3.55	4.40	5.90	3.84	4.87a	3.76	5.44	4.60cd	3.33	3.73	3.53
$V_6$	5.30	3.10	4.20	3.87	5.59	4.73a	3.27	6.19	4.73c	4.46	2.48	3.47
$V_7$	5.50	3.44	4.47	5.20	3.06	4.13c	5.52	5.14	5.33a	4.14	2.66	3.40
$V_8$	5.05	4.15	4.60	5.80	3.66	4.73a	5.24	5.16	5.20ab	3.42	2.84	3.13
SEm ( $\pm$ )	0.54	0.70	0.27	0.50	0.81	0.09	0.37	0.35	0.08	0.50	0.51	0.23
CD ( $P \leq 0.05$ )	1.15	1.51	NS	1.08	1.73	0.20	0.78	0.75	0.16	1.08	1.10	NS
CV (%)	15.33	30.02	24.04	15.67	29.00	27.33	11.67	10.04	18.33	20.03	26.33	32.11

Note: NS: Non-significant,  $C_1$ : Conventional Farming,  $C_2$ : Bulky Organic Manure,  $C_3$ : Vivek Krishi,  $C_4$ : Absolute Control (Inherent Fertility Status of Experimental Soil);  $V_1$ : Kufri Jyoti,  $V_2$ : Siwan,  $V_3$ : C-40,  $V_4$ : 2236,  $V_5$ : Ultimatium,  $V_6$ : Sathi,  $V_7$ : Lal Gulab, and  $V_8$ : Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at  $P = 0.05$  by Duncan's Multiple Range Test.

In case of number of tubers per plant under  $C_1$  and  $C_4$  growing conditions no statistical difference observed among the varieties but in remaining two growing conditions statistically significant ( $P \leq 0.05$ ) difference among varieties was recorded and consequently maximum number of tubers per plant (5.33) was observed in  $V_3$  [C-40] and  $V_7$  [2236] under  $C_3$  (Vivek Krishi) experimental condition, whereas, the minimum number of tubers per plant was observed in  $V_2$  (Siwan) and  $V_8$  (Nainital) varieties under  $C_4$  (absolute control) growing condition, where no organic intervention was given for the cultivation of potato (Table 2).

For average tuber weight, the highest average tuber weight (159.53g) was documented in  $V_3$  [C-40] under  $C_2$  (bulky organic manure) growing conditions, while

the lowest average tuber weight was documented in  $V_1$  [Kufri Jyoti] under  $C_4$  (absolute condition) experimental condition (Table 3).

In case of bulking ratio, it was documented that  $V_8$  (Nainital) recorded highest bulking ratio (19.33) under  $C_2$  (bulky organic manure) growing conditions, whereas  $V_2$  (Siwan) recorded lowest bulking ratio (1.37) under  $C_4$  (absolute control) growing condition (Table 4).

Highest yield (34.13 t. ha<sup>-1</sup>) was observed in  $V_4$  [2236] under  $C_2$  (bulky organic manure) experimental condition, whereas the low yield (2.30 t. ha<sup>-1</sup>) was found in  $V_1$  [Kufri Jyoti] under  $C_4$  (absolute control) growing conditions (Table 5).

**Table 3: Per se performance on average tuber weight (g) of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	87.52	86.22	86.87f	149.53	145.93	147.73d	123.21	119.99	121.60e	83.27	76.91	80.09d
V <sub>2</sub>	94.43	91.97	93.20e	155.42	148.72	152.07b	126.35	125.25	125.80d	85.43	77.53	81.48c
V <sub>3</sub>	103.21	105.45	104.33d	161.27	157.79	159.53a	122.35	126.19	124.27d	87.56	84.44	86.00bc
V <sub>4</sub>	120.24	110.02	115.13c	148.46	151.54	150.00bc	135.21	130.79	133.00b	85.29	88.45	86.87ab
V <sub>5</sub>	129.30	125.50	127.40b	145.32	139.62	142.47e	130.47	129.39	129.93c	88.47	84.39	86.43abc
V <sub>6</sub>	127.32	124.94	126.13b	150.01	148.13	149.07cd	135.86	133.60	134.73ab	86.26	84.18	85.22bc
V <sub>7</sub>	124.55	131.05	127.80b	151.06	147.34	149.20cd	136.24	133.76	135.00a	89.37	85.53	87.45a
V <sub>8</sub>	134.91	130.69	132.80a	148.35	151.91	150.13bc	127.32	123.88	125.60d	88.57	84.09	86.33abc
SEm (±)	0.61	0.87	1.20	1.30	0.93	1.18	0.76	0.55	0.82	1.06	0.66	0.57
CD <sub>(P≤0.05)</sub>	1.30	1.87	2.57	2.79	1.99	2.54	1.64	1.17	1.75	2.28	1.42	1.23
CV (%)	2.17	3.08	7.01	3.23	2.97	4.08	2.69	1.87	3.23	5.38	3.09	7.03

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

**Table 4: Per se performance on bulking ratio of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	5.00	3.60	4.30e	11.04	9.16	10.10f	12.23	9.43	10.83c	1.32	1.54	1.43e
V <sub>2</sub>	7.04	5.18	6.11d	10.50	6.34	8.42g	10.67	5.49	8.08e	1.96	0.78	1.37e
V <sub>3</sub>	4.30	4.50	4.40e	14.85	12.73	13.79d	11.02	8.62	9.82d	2.77	0.51	1.64e
V <sub>4</sub>	7.01	6.57	6.79cd	17.05	16.83	16.94c	13.33	12.13	12.73a	3.03	1.49	2.26d
V <sub>5</sub>	11.21	7.97	9.59a	17.17	16.69	16.93c	14.23	11.69	12.96a	4.30	3.22	3.76b
V <sub>6</sub>	10.07	8.29	9.18ab	16.48	21.04	18.76b	14.24	10.46	12.35b	5.15	4.79	4.97a
V <sub>7</sub>	7.98	8.08	8.03bc	13.29	11.09	12.19e	11.29	12.85	12.07b	3.00	1.44	2.22d
V <sub>8</sub>	8.15	7.43	7.79bc	21.58	17.08	19.33a	9.06	11.06	10.06d	4.04	2.22	3.13c
SEm (±)	0.54	0.49	0.65	0.61	0.74	0.17	0.51	0.55	0.14	0.34	0.26	0.13
CD <sub>(P≤0.05)</sub>	1.17	1.04	1.39	1.32	1.58	0.36	1.08	1.17	0.30	0.74	0.57	0.29
CV (%)	34.20	34.01	29.80	18.07	24.04	36.11	19.31	24.08	40.60	48.40	57.10	53.70

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

**Table 5: Per se performance on yield (t.ha<sup>-1</sup>) of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	5.57	7.65	6.61f	15.26	17.22	16.24g	16.25	18.57	17.41d	1.90	2.70	2.30e
V <sub>2</sub>	12.87	13.21	13.04ab	20.96	15.32	18.14f	15.97	18.87	17.42d	1.50	4.42	2.96d
V <sub>3</sub>	12.87	8.19	10.53d	35.54	32.54	34.04a	23.58	24.92	24.25c	3.30	4.80	4.05c
V <sub>4</sub>	11.08	16.72	13.90a	32.91	35.35	34.13a	23.37	27.93	25.65b	5.15	3.93	4.54b
V <sub>5</sub>	10.27	13.47	11.87c	24.37	21.37	22.87e	16.27	18.75	17.51d	4.92	5.22	5.07b
V <sub>6</sub>	13.28	9.56	11.42c	22.76	25.02	23.89d	14.72	16.74	15.73f	5.75	6.91	6.33a
V <sub>7</sub>	11.00	7.28	9.14e	26.46	27.70	27.08c	25.38	28.28	26.83a	4.30	5.58	4.94b
V <sub>8</sub>	13.02	12.38	12.70b	30.75	32.31	31.53b	15.22	17.58	16.40e	4.86	5.34	5.10b
SEm (±)	0.35	0.62	0.23	0.71	0.57	0.27	0.71	0.22	0.27	0.49	0.34	0.22
CD <sub>(P≤0.05)</sub>	0.75	1.33	0.49	1.52	1.22	0.57	1.52	0.48	0.58	1.05	0.72	0.46
CV (%)	14.11	25.05	51.30	12.09	10.00	22.08	17.28	4.73	8.28	44.90	31.07	42.30

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

**Table 6: Per se performance on TSS (%) content in tubers of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	6.09	5.89	5.99	4.53	6.13	5.33bcdf	4.93	6.51	5.72abc	7.95	5.23	6.59
V <sub>2</sub>	7.03	5.27	6.15	4.87	6.83	5.85bcd	5.92	6.10	6.01ab	6.48	5.56	6.02
V <sub>3</sub>	5.38	7.00	6.19	6.38	5.64	6.01bc	6.17	6.09	6.13ab	7.02	6.96	6.99
V <sub>4</sub>	4.32	6.86	5.59	5.50	5.08	5.29df	6.02	4.94	5.48c	6.48	7.28	6.88
V <sub>5</sub>	6.85	6.05	6.45	5.29	5.09	5.19df	5.93	5.07	5.50c	5.50	5.84	5.67
V <sub>6</sub>	6.25	5.89	6.07	6.04	4.62	5.33bcdf	5.27	6.27	5.77abc	7.12	6.30	6.71
V <sub>7</sub>	4.43	6.65	5.54	5.12	5.16	5.14f	5.73	5.13	5.43c	6.06	5.92	5.99
V <sub>8</sub>	9.40	7.70	8.55	5.97	7.73	6.85a	6.50	5.86	6.18ab	6.96	5.88	6.42
SEm (±)	0.75	0.66	4.85	0.27	0.46	0.32	0.64	0.61	0.23	0.37	0.28	4.03
CD <sub>(P≤0.05)</sub>	1.61	1.42	NS	0.59	0.99	0.69	NS	NS	0.49	0.79	0.60	NS
CV (%)	28.25	26.55	28.25	12.99	20.34	23.73	28.25	27.12	16.95	14.12	11.30	17.51

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

**Table 7: Per se performance on dry matter content (%) in tubers of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	18.65	16.89	17.77	24.97	26.43	25.70a	21.97	22.03	22.00b	20.68	25.06	22.87
V <sub>2</sub>	20.98	22.88	21.93	20.08	19.12	19.60e	23.43	20.57	22.00b	24.65	21.61	23.13
V <sub>3</sub>	21.86	22.74	22.30	24.36	22.38	23.37bc	24.97	21.63	23.30a	22.96	19.30	21.13
V <sub>4</sub>	19.27	22.27	20.77	24.44	22.82	23.63bc	21.97	23.97	22.97a	20.68	19.12	19.90
V <sub>5</sub>	20.02	19.78	19.90	21.97	19.49	20.73d	20.68	18.92	19.80d	25.86	22.48	24.17
V <sub>6</sub>	23.47	21.27	22.37	21.96	23.64	22.80bc	19.68	18.26	18.97e	22.96	20.04	21.50
V <sub>7</sub>	25.35	20.65	23.00	20.57	16.97	18.77e	22.68	19.98	21.33bc	23.86	20.40	22.13
V <sub>8</sub>	20.97	22.17	21.57	23.97	22.03	23.00bc	19.63	21.91	20.77c	20.85	17.55	19.20
SEm (±)	0.71	0.78	1.95	0.62	0.93	0.39	0.67	1.32	0.34	0.81	0.84	1.44
CD <sub>(P≤0.05)</sub>	1.52	1.67	NS	1.33	2.00	0.83	1.44	2.83	0.73	1.73	1.79	NS
CV (%)	14.56	15.53	21.36	11.65	18.45	14.56	13.59	27.18	18.45	15.53	17.48	22.33

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

### Proximate Quality Attributes

Different quality contributing traits of potato showed statistically significant (P≤0.05) differences among different varieties. The results revealed that all cases, both C<sub>2</sub> (bulky organic manure) and C<sub>3</sub> (Vivek Krishi) experimental conditions performed extraordinarily well over remaining two growing conditions. In this context, highest TSS (6.99%) was recorded in V<sub>3</sub> [C-40] under C<sub>4</sub> (Absolute Control) growing conditions, whereas the lowest TSS (5.14%) was recorded in V<sub>7</sub> [Lal Gulab] under C<sub>2</sub> (Bulky Organic Manure) growing conditions (Table 6). No significant differences among varieties were observed in terms of expression of this quality attributing trait in the case of Conventional (C<sub>1</sub>) and Absolute Control (C<sub>4</sub>) growing conditions.

In case of dry matter content of tuber, non-significant differences were once again recorded under C<sub>1</sub> (Conventional farming) and C<sub>4</sub> (Absolute control) but in remaining two growing conditions statistically significant difference among varieties were recorded (Table 7). The highest dry weight (25.70%) was recorded in V<sub>1</sub> [Kufri Jyoti] under C<sub>2</sub> (bulky organic

manure) growing condition, while the lowest value (17.77%) was recorded in V<sub>1</sub> [Kufri Jyoti] under C<sub>1</sub> (Conventional farming condition).

Similar trends of non-significant differences were also observed in case of total sugar in C<sub>1</sub> and C<sub>4</sub> growing conditions. However, the highest reducing sugar content (13.65%) was documented in V<sub>1</sub> [Kufri Jyoti] under C<sub>3</sub> (Vivek Krishi) growing condition, whereas the lowest (5.26%) was documented in V<sub>1</sub> [Kufri Jyoti] under C<sub>2</sub> (Bulky organic manure) growing condition (Table-8).

In case of the ascorbic acid content, although non-significant differences were found under C<sub>4</sub> (Absolute control) growing condition in contrast to the statistically significant (P≤0.05) difference among varieties for the remaining growing conditions and consequently the maximum ascorbic acid (19.26 mg.100g<sup>-1</sup>) was observed in V<sub>1</sub> [Kufri Jyoti] under C<sub>1</sub> (Conventional Farming) growing condition, while the minimum value (6.42 mg.100g<sup>-1</sup>) was found in V<sub>5</sub> [Ultimatum] under C<sub>3</sub> (Vivek Krishi) growing condition (Table 9).

**Table 8: Per se performance on total sugar content (%) in tubers of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	10.07	7.71	8.89	6.27	4.25	5.26f	12.84	14.46	13.65a	8.50	7.94	8.22
V <sub>2</sub>	10.45	8.21	9.33	7.94	4.84	6.39cd	12.96	13.70	13.33a	8.51	7.29	7.90
V <sub>3</sub>	8.52	7.36	7.94	7.93	5.87	6.90b	10.37	8.99	9.68c	9.27	7.55	8.41
V <sub>4</sub>	8.38	8.06	8.22	5.37	7.67	6.52cd	11.69	9.05	10.37b	8.31	6.65	7.48
V <sub>5</sub>	12.21	10.01	11.11	6.83	4.71	5.77e	7.92	5.72	6.82e	7.26	5.16	6.21
V <sub>6</sub>	7.37	5.49	6.43	7.47	5.87	6.67bcd	11.21	8.79	10.00bc	7.43	5.67	6.55
V <sub>7</sub>	9.74	8.24	8.99	7.52	6.44	6.98b	8.29	7.29	7.79d	7.12	5.16	6.14
V <sub>8</sub>	10.97	8.71	9.84	8.37	6.67	7.52a	7.41	6.09	6.75e	7.28	5.12	6.20
SEm (±)	0.56	0.27	1.95	0.72	0.58	0.14	0.85	0.77	0.28	0.18	0.71	1.01
CD <sub>(P≤0.05)</sub>	1.19	0.57	NS	1.55	1.24	0.30	1.83	1.64	0.60	0.39	1.51	NS
CV (%)	25.49	14.71	14.71	44.12	44.12	45.10	36.27	36.27	28.43	9.80	50.00	12.75

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

**Table 9: Per se performance on ascorbic acid content (mg.100g<sup>-1</sup>) in tubers of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	20.21	18.31	19.26a	12.22	14.44	13.33a	11.26	10.46	10.86ab	9.90	6.90	8.40
V <sub>2</sub>	10.67	9.09	9.88de	12.97	13.69	13.33a	10.64	9.12	9.88b	10.73	8.03	9.38
V <sub>3</sub>	12.21	14.45	13.33c	8.46	6.36	7.41d	7.36	6.46	6.91c	9.27	8.51	8.89
V <sub>4</sub>	17.35	15.25	16.30b	8.26	6.56	7.41d	10.62	9.14	9.88b	7.84	8.96	8.40
V <sub>5</sub>	8.51	7.29	7.90de	9.76	8.02	8.89c	7.26	5.58	6.42c	9.51	8.27	8.89
V <sub>6</sub>	10.62	9.14	9.88de	14.21	12.45	13.33a	12.74	9.98	11.36a	11.56	9.18	10.37
V <sub>7</sub>	8.37	6.45	7.41e	7.36	10.42	8.89c	11.36	10.36	10.86ab	11.81	9.91	10.86
V <sub>8</sub>	9.27	11.47	10.37d	12.61	11.09	11.85b	10.62	9.14	9.88b	9.26	8.52	8.89
SEm (±)	0.77	0.63	1.20	0.67	0.95	0.62	0.98	0.63	0.58	0.34	0.61	2.30
CD <sub>(P≤0.05)</sub>	1.65	1.34	2.56	1.44	2.04	1.33	2.10	1.36	1.25	0.73	1.31	NS
CV (%)	28.71	24.75	28.71	27.72	40.59	35.64	42.57	32.67	11.88	14.85	31.68	26.73

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.



While in case of starch content, the highest value (31.86%) was recorded in V<sub>6</sub> [Sathi] under C<sub>3</sub> (Vivek Krishi) growing condition, while the lowest (12.03%) being recorded in V<sub>3</sub> [C-40] under C<sub>1</sub> (Conventional Farming) growing condition (Table 10).

**Table 10: Per se performance on starch content (%) in tubers of different potato varieties as influenced by different organically designed treatments**

Variety	Growing Condition											
	C <sub>1</sub>			C <sub>2</sub>			C <sub>3</sub>			C <sub>4</sub>		
	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean	Year -I	Year -II	Pooled Mean
V <sub>1</sub>	22.61	20.25	21.43c	23.51	20.99	22.25b	18.25	16.25	17.25g	15.62	14.02	14.82e
V <sub>2</sub>	16.27	14.55	15.41d	21.56	18.78	20.17c	27.51	25.25	26.38d	16.26	15.52	15.89d
V <sub>3</sub>	13.21	10.85	12.03e	22.45	21.31	21.88b	28.05	26.75	27.40c	17.26	14.46	15.86d
V <sub>4</sub>	13.72	11.80	12.76e	28.76	26.78	27.77a	29.62	26.60	28.11b	14.51	12.03	13.27f
V <sub>5</sub>	16.26	14.56	15.41d	23.51	21.35	22.43b	21.36	20.18	20.77e	14.27	11.85	13.06f
V <sub>6</sub>	22.71	19.41	21.06c	19.65	17.63	18.64d	32.16	31.56	31.86a	18.26	16.58	17.42c
V <sub>7</sub>	24.45	21.83	23.14b	17.52	14.82	16.17e	20.61	19.31	19.96f	23.71	21.53	22.62b
V <sub>8</sub>	27.51	24.73	26.12a	19.54	17.60	18.57d	25.41	27.03	26.22d	26.47	24.39	25.43a
SEm (±)	0.84	0.92	0.35	0.66	1.00	0.18	0.80	0.64	0.32	1.28	0.39	0.40
CD <sub>(P≤0.05)</sub>	1.80	1.97	0.76	1.41	2.15	0.38	1.71	1.37	0.69	2.75	0.83	0.85
CV (%)	18.63	23.53	4.90	12.75	22.55	3.92	13.73	11.76	9.80	31.37	9.80	6.86

Note: NS: Non-significant, C<sub>1</sub>: Conventional Farming, C<sub>2</sub>: Bulky Organic Manure, C<sub>3</sub>: Vivek Krishi, C<sub>4</sub>: Absolute Control (Inherent Fertility Status of Experimental Soil); V<sub>1</sub>: Kufri Jyoti, V<sub>2</sub>: Siwan, V<sub>3</sub>: C-40, V<sub>4</sub>: 2236, V<sub>5</sub>: Ultimatum, V<sub>6</sub>: Sathi, V<sub>7</sub>: Lal Gulab, and V<sub>8</sub>: Nainital. In each column with letters next to a pooled mean, entries with different letters indicate significant differences as regards to different potato varieties at P = 0.05 by Duncan's Multiple Range Test.

## Discussion

The variation of different quantitative and qualitative traits expression in different varieties of potato may not only be due to disparity in genetic makeup of the studied varieties but also because of the diverse conditions in which they are grown.

## Growth and Yield Attributes

Difference in plant height being the genetic factor, though influenced by inputs applied for the purpose showed that the higher amount of diversified organic inputs applied through other organic growing conditions may have no positive influence over the expression of plant height in different varieties of potato. This type of observation may probably be due to conducting the experiment in already organically converted experimental conditions. The findings on number of tubers per plant clearly showed the potential of organic liquid manure 'Sanjeevani' for supplementation of plant nutrients under the influence of its huge beneficial microbial loads. More number of tubers per plant may be due to better plant

growth under more available nitrogenous source of the organic liquid manure as applied through Vivek Krishi growing condition and consequently the better photosynthetic ability that leads to more tubers per plant due to accumulation of photosynthates. The findings on more tubers per plant under nutrient available growing condition corroborated well with some of the earlier investigation.<sup>11</sup> Recent findings also revealed that the weight of tuber in potato significantly increased due to the application of different manures and micro-nutrients could be due to more luxuriant growth, more foliage and higher supply of photosynthesis, which helped in producing bigger tuber, resulting higher yield.<sup>12</sup> The more tuber yield under C<sub>2</sub> (bulky organic manure) growing condition is close conformity with the earlier observation where the application of vermicompost found to be increased significantly the total and marketable yield of potatoes.<sup>13</sup> Application of organic manures has led in enhanced organic carbon content, the availability of macro and micronutrients, beneficial microorganism activity and release of

nutrients during the entire crop growth period and consequently ensured more yield.<sup>14</sup>

### Proximate Quality Attributes

Total soluble solids are sometimes inversely related to the weight of the produce and this is especially true for the crops like potato where underground tuber is edible part. The higher the tuber weight the lower the TSS content as estimated in the present investigation confirmed by the earlier findings.<sup>15</sup> Dry matter content of tuber being the genetic factor<sup>16</sup> but greatly influenced by the cultural practices, climate and soil may largely affect final dry matter content.<sup>17</sup> The reduced and gradually released nitrogen from organic sources of plant nutrients used in the present study greatly influenced the dry weight of tuber. Therefore, the higher level of dry matter content was found in tubers grown through the conventional or even the absolute control (organic by default) growing conditions. The reducing sugars of potato tubers are regulated by variety, cultural, and environmental factors.<sup>18</sup> Hence, different varieties expressed independently during articulation of this quality trait under diverse growing conditions. Higher level of ascorbic acid in potato tubers grown through conventional farming is associated with the stress growing condition.<sup>19</sup> The bio-synthesis of ascorbic acid in plant system is triggered by adverse growing condition and consequently more ascorbic acid was synthesized in C<sub>1</sub> (Conventional Farming) and C<sub>4</sub> (Absolute Control) growing conditions than their respective two organic growing counterparts. The starch contents of tubers as estimated here are in accordance with the earlier findings.<sup>20-21</sup> Although the starch content varied with genotype<sup>22</sup> but positively correlated with specific gravity and dry matter content.<sup>23</sup> The variation of starch content in different studied varieties may also be due to variation in maturity of tuber under different growing conditions<sup>24</sup> and cultural practices.<sup>25</sup> The later the maturity the more may be the starch content probably due to the possibilities of accumulation of more plant nutrients over longer duration to mature tubers.<sup>26</sup>

### Conclusion

From the study, it may be concluded that potato is highly responsive to organic growing conditions. In this perspective, Bulky organic manure (C<sub>2</sub>) and Vivek Krishi (C<sub>3</sub>) growing conditions emerged as suitable alternative approaches of non-chemical production intervention concerning the expression of growth, yield and quality traits of potato varieties conventionally grown in the eastern Indian plateau especially in the south Chota Nagpur region. Farmers of this region especially the progressive farmers can adopt these alternatives but new technologies to grow potato cultivation and for them Vivek Krishi and bulky organic manure both have suitable option where the quality of produce is better than other alternative organic growing conditions. Bulky organic manure applied condition (where FYM and vermicompost were used to grow the crop varieties) is suitable for higher yield in potato under the south Chota Nagpur region of eastern Indian plateau but Vivek Krishi growing condition (where along with the FYM, enriched Sanjeevani was applied for growing the crop varieties) emerged with comparatively better-quality tuber production than its respective three other organic growing counterparts.

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### Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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