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Assessment of Potato (*Solanum tuberosum* L.) Performance for Yield and Quality Production under Natural Farming System in Gird Region of Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Objective of the Study: To assess the potato (*Solanum tuberosum* L.) performance for yield and quality production under natural farming system in gird region of Madhya Pradesh.
Study Design: Randomized complete block design.
Place and Duration of Study: ICAR-Central Potato Research Institute- RS, research farm Gwalior during winter (*Rabi*) season of 2022-2023.

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Methodology: Selected 5 plants from each treatment and replicated 3 times. Then follows methods as per given in materials and methods section of paper. Treatments T_1: Control, T_2: Inorganic practices (standard technology), T_3: NADEP compost @ 25 t/ha + *Azotobacter* @ 1L/ha + PSB (Phosphorus solublizing bacteria) @ 1L/ha, T_4: T_3+ FYM @ 25 t/ha, T_5: T_3 + Vermicompost @ 7.5 t/ha, T_6: T_3+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 g/L, T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha.

Results: Results revealed that maximum number of tubers (135.03, 144.598 and 245.344) for grade 25-50 g, 50-75 g and >75 g respectively, highest number of tubers per ha (591286 at harvest), maximum yield of tubers (6.75, 10.844 and 18.40 t/ha) for grade 25-50 g, 50-75 g and >75 g respectively, highest yield of tubers (37.665 t/ha), highest true density of tubers (1.123 g/cc), highest tuber dry matter (17.173%) and highest starch content (14.313%) were recorded in treatment T_7. While, the maximum number of tubers (129.08) for grade (0-25 g) and, maximum yield of tubers (3.2098 t/ha) for grade (0-25 g) was found in control plot.

Conclusion: Among 7 treatments, T_7- Integrated practice (90% inorganic practices, 10% organic) found better for number of tubers in different grades, yield of tubers in different grades, total tuber yield (t/ha) and for quality parameters *e.i.*, True density (g/cc), Tuber dry matter (%) and Tuber starch content (%).

Keywords: Potato; quality; starch; tuber; yield.

1. INTRODUCTION

In recent years, the global agricultural landscape has witnessed a paradigm shift towards sustainable and eco-friendly farming practices, with a growing emphasis on natural farming systems [1]. As the demand for food continues to rise in tandem with population growth, there is an increasing need to explore alternative agricultural approaches that prioritize environmental stewardship and minimize the ecological footprint of food production. In this context, the cultivation of staple crops, such as potatoes (*Solanum tuberosum* L.), under natural farming systems has emerged as a subject of considerable interest and significance.

Potatoes are a vital component of the world's food supply, providing essential nutrients and calories to millions of people [2]. However, traditional farming methods often involve the use of synthetic fertilizers, pesticides, and other agrochemicals, which can have adverse effects on soil health, biodiversity, and overall ecosystem resilience. Recognizing these challenges, natural farming systems, characterized by a holistic and sustainable approach, offer a promising alternative for potato cultivation.

This study was contribute to the existing body of knowledge by shedding light on the practical implications of transitioning from conventional to natural farming systems in the context of potato production. As global agriculture faces the dual challenges of ensuring food security and mitigating environmental degradation, understanding the nuances of sustainable farming practices becomes paramount [3]. The findings of this research can inform policymakers, farmers, and researchers alike, guiding the development of strategies that promote a resilient and sustainable future for potato agriculture.

2. MATERIALS AND METHODS

The experiment was carried in the ICAR-Central Potato Research Institute-RS, research farm in Gwalior which is located at 26°13' North latitude, 78°14' East longitude and 206 meters above mean sea level in the North tract of M.P. Gwalior's climate is subtropical, with summer temperatures reaching up to 48°C and minimum temperature as low as 4.0°C during the winter season. The annual rainfall ranges between 750 and 800 mm, with the majority falling between the end of June and end of September, with only a few showers in the winter months. Mean monthly meteorological data (maximum and minimum temperature, relative humidity, evaporation and precipitation) were collected at the Meteorological Observatory-College of Agriculture, Gwalior during the crop growth season. According to the data the total rainfall received during the crop growth period was 17.4 mm during the crop growing period the average maximum and lowest temperature were 28°C and 10°C, respectively. The relative humidity ranged from 37.2% to73.4%.

2.1 Treatment Details

T_1: Control, T_2: Inorganic practices (standard technology), T_3: NADEP compost @ 25 t/ha + *Azotobacter* @ 1L/ha + PSB @ 1L/ha, T_4: T_3+ FYM @ 25 t/ha, T_5: T_3+Vermicompost @ 7.5 t/ha, T_6: T_3+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 g/L (for management of foliar diseases), T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha.

2.2 Data Collected

1. Yield of tubers (t/ha) in each grade (<25g, 25-50g, 50-75g and >75): The yield of tubers per plot was determine using an electronic weighing scale for each grade (25g, 25-50g, 50-75g, >75, and total potato).

2. Number of tubers (per plot and per ha) in each grade (<25g, 25-50g, 50-75g and >75): The number of tubers per plot was counted manually for each grade (**<**25g, 25-50g, 50-75g, >75,) and converted in per ha area.

3. Total tuber yield (t/ha): Total fresh tuber yield (kg/plot) was taken at harvest in individual (net plot) plots and was converted to t/ha.

4. True density of potato: The toluene displacement technique was used to measure the volume and actual density of fresh potato tubers. Toluene was chosen since it is less absorbed by the sample. The real density was determined using the volume of toluene displaced and the mass of the sample, as stated by Mohsenin [4].

$$\textit{True density}\ (g/cm^3) = \frac{\text{Weight of tuber in air}}{\text{Weight of tuber in air - weight of tuber in water}}$$

5. Tuber dry matter content (%): 100g of sample was obtained and pre-dried at 60°C for 15 hours before being dried for 3 hours at 105°C in a drying oven [5]. It was estimated as follows**:**

$$\text{Tuber dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \text{x100}$$

6. Starch content in tuber (%): A dry sample weighing 0.1 to 0.5 g was homogenized in hot 80% ethanol before centrifugation at 10,000 rpm for 20 minutes to assess the starch content. The residue was then treated with 5 ml of water and 6.5 ml of perchloric acid and chilled at 0 C for 20 minutes. The residue was centrifuged again, and the supernatant was kept for further investigation. The final volume was increased to 100 ml and diluted in a 1:5 ratio with distilled water. Each test tube received 4 cc of enthrone reagent and was cooked in a boiling water bath for roughly 8 minutes. The contents were quickly cooled, and the intensity of green to dark green was measured using a UV visible spectrophotometer.

$$\textbf{Starch}\ (\%) = \textbf{Glucose content} \times \mathbf{0.95}$$

2.3 Data Analysis

The recorded data were analyzed using OP STAT statistical software was used for one-way ANOVA at $p < 0.05$ (student t-test). Origin 2017 software was used for charting.

3. RESULTS AND DISCUSSION

1. Number of tubers (''000/ha) in different grades: In grade (0-25 g), the maximum number of tubers (129.08) was found in control plot. The greater number of decreased size tubers could be due to insufficient availability of proper nutrients. In grade (25-50 g), the maximum number of tubers (135.03) was found in T_7. This could due to proper supply of nutrients both by inorganic (at early stage) and by organic (later stage). In grade (50-75 g), the maximum number of tubers (144.598) was found in T_7. This is due to proper supply of nutrients both by inorganic (at early stage) and by organic (later stage). In grade (>75 g), the maximum number of tubers (245.344) was found in T_7. This is due to proper supply of nutrients both by inorganic (at early stage) and by organic (later stage). Total number of tubers per ha have been presented in the Table1. Highest number of tubers per ha (591286 at harvest) were recorded in treatment T_7. This might be due to use of organic sources along with inorganic fertilizers because organic sources of nutrients improved the soil aeration, root development and increased microbial and biological activities in the rhizosphere. Therefore, a greater number of tubers. Findings are supported by Sayed et al [6] and Yadav et al [7]. Barman et al. [8] reported that significant increased towards number and weight of B grade tubers (50-75 g) was recorded under treatment T_5 (Vermicompost @ 2.5 t/ha + half NPK through inorganic fertilizer). Singh et al. [9] found that highest number of tubers is recorded with the

Table 1. Effect of treatments on number of tubers in different grades

Treatments	Number of tubers per plot				Number of tubers per ha (0000^{-1})			
	0-25gm	**25-50gm**	**50-75gm**	**>75gm**	**0-25gm**	**25-50gm**	**50-75gm**	**>75gm**
T_1- Control	167.30	104.40	111.76	191.83	129.08	80.55	86.23	148.0195
T_2- RDF- Inorganic	127.80	161.54	157.30	317.46	98.611	124.64	121.37	244.9588
T_3- NADEP+PSB+Azotobacter	160.90	148.45	147.16	209.26	124.1512	114.544	113.55	161.4712
T_4- T_3 + FYM @ 25 t/ha	160.30	137.00	157.16	218.33	123.688	105.7099	121.27	168.4671
T_5- T_3 + vermi-compost @ 7.5 t/ha	166.40	154.75	114.30	237.50	128.39	119.40	88.19	183.2562
T_6- T_3+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 gm/l (for management of foliar diseases)	162.06	168.14	134.66	250.66	125.0463	129.73	103.900	193.4156
T_7- Integrated practice (90% inorganic practices, 10% organic)	85.68	175.00	187.40	317.96	66.311	135.03	144.598	245.3447
S.Em.	**14.68**	**11.81**	**6.53**	**9.93**	**11.32**	**9.11**	**5.04**	**7.667**
CD at 5%	**43.95**	**35.38**	**19.56**	**29.75**	**33.80**	**27.21**	**7.12**	**22.88**

Table 2. Effect of treatments on yield of tubers in different grades

Treatments	Yield of tubers per plot (kg)				Yield of tubers per ha (t)			
	0-25gm	**25-50gm**	**50-75gm**	**>75gm**	**0-25gm**	**25-50gm**	**50-75gm**	**>75gm**
T_1- Control	4.18	5.22	8.38	14.33	3.22	4.02	6.46	11.10
T_2- RDF- Inorganic	3.19	8.07	11.79	23.81	2.46	6.23	9.10	18.37
T_3- NADEP+PSB+Azotobacter	4.02	7.42	11.03	15.69	3.10	5.72	8.51	12.11
T_4- T_3 + FYM @ 25 t/ha	4.00	6.85	11.78	16.37	3.09	5.28	9.09	12.63
T_5- T_3 + vermi-compost @ 7.5 t/ha	4.16	7.73	8.57	17.81	3.20	5.97	6.61	13.74
T_6- T_3+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 gm/l (for management of foliar diseases)	4.05	8.40	10.10	18.80	3.12	6.48	7.79	14.50
T_7- Integrated practice (90% inorganic practices, 10% organic)	2.14	8.75	14.05	23.84	1.56	6.75	10.844	18.40
S.Em.	**0.36**	**0.59**	**0.49**	**0.74**	**0.28**	**0.45**	**0.37**	**0.57**
CD at 5%	**1.009**	**1.76**	**1.46**	**2.23**	**0.84**	**1.36**	**1.12**	**1.71**

application of 75% RDF + 2 tonnes ha^{-1} FYM + 20 kg ha^{-1} sulphur + 20 kg ha^{-1} zinc sulphate + 1 tonnes ha^{-1} vermicompost + Azotobacter (seed treatment).

2. Grade wise yield (t/ha) of tubers: In grade (0-25 g), the maximum yield of tubers (3.2098 t/ha) was found in control plot. The greater number of decreased size tubers is due to insufficient availability of proper nutrients. In grade (25-50 g), the maximum yield of tubers (6.75 t/ha) was found in T_7. This is due to proper supply of nutrients both by inorganic (at early stage) and by organic (later stage). In grade (50-75 g), the maximum yield of tubers (10.844 t/ha) was found in T_7. This is due to proper supply of nutrients both by inorganic (at early stage) and by organic (later stage). In grade (>75 g), the maximum yield of tubers (18.40 t/ha) was found in T_7. This might be due to combined use of organic and inorganic fertilizers, which provide balance nutrition to plant. Hensh et al. [10] found that higher yield of larger size tubers i.e. grade A (>100 g) and B (50-99 g) tubers was recorded with treatment T_{10}- 80% RDN through chemical fertilizer + 20% through vermicompost + biofertilizer, while yield of grade C (<50 g) found higher with treatment T_2- 80% RDN through chemical fertilizer + 20% through Farm Yard Manure. Dev et al. [11] reported maximum tuber yield grade wise with treatment T_5 (RDF 75% + 25% FYM-N + ZnSO4@ 40 kg ha^{-1}). Islam [12] revealed that maximum no. of tubers found in treatment T_7 (Poultry Manure @ 3 t ha^{-1} + rest nutrients from RDF). Narayan [13] found that 'A', 'B' and 'C' grade tubers were significantly higher with application of 75% recommended dose of fertilizer with 8 tons ha^{-1} vermicompost + Azotobacter and PSB (N_6) treatment.

3. Total tuber yield (t/ha): Total yield of tubers per ha have been presented in the Table 2. Highest yield of tubers per ha (37.665 t/ha at harvest) was recorded in treatment T_7. This might be due to application of fertilizers in combination with organic manure which increased the nutrient-use efficiency through modification of soil physical condition, and resulted in higher total uptake of nutrients because of better root penetration leading to better absorption of nutrients and moisture. Findings are supported by Mohammed et al [14]. Hensh et al. [10] found that Maximum total tuber yield (31.39, 32.70 and 32.05 t ha-1 , in both the years and in pooled data respectively) of potato was also recorded with treatment T_{10}-80% RDN through chemical fertilizer + 20% through vermicompost + biofertilizer) which was statistically at par with treatments T_{11} (80% RDN through chemical fertilizer + 20% through mustard oil cake + biofertilizer), T_9 (80% RDN through chemical fertilizer + 20% through FYM + biofertilizer) and T_3 (80% RDN through chemical fertilizer + 20% through vermicompost). Dev et al. [11] reported maximum total tuber yield found with treatment T_5 (RDF 75% + 25% FYM-N + ZnSO4@ 40 kg ha^{-1}). Singh et al. (2018) revealed that the highest tuber yield was recorded with the application 75% RDF + 2 tonnes ha^{-1} FYM + 20 kg ha^{-1} sulphur + 20 kg ha^{-1} zinc sulphate + 1 tonnes ha^{-1} vermicompost + Azotobacter (seed treatment). Islam [12] revealed that maximum yield tubers found in treatment T_7 (Poultry Manure @ 3 t ha^{-1} + rest nutrients from RDF).

4. True density (g/cc): True density has been presented in the Table 3. Highest true density of tubers (1.123 g/cc) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Therefore, greater photosynthates developed in tubers hence grater the density. Findings are supported by Ram et al. [15].

5. Tuber dry matter (%): Tuber dry matter has been presented in the Table 3. Highest tuber dry matter (17.173%) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Therefore, greater photosynthates developed in tubers hence grater the density. Findings are supported by Ram et al. [15]. Chaudhary and Rawat [16] revealed that maximum tuber dry matter found in treatment T_4- 75% RDF of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha. Mohammed et al. [17] found that the maximum tuber dry matter in treatment - 10 t FYM ha^{-1} + 111 kg N ha^{-1} + 92 kg P_2O_5 ha^{-1}. Islam [12] revealed that maximum no. of tubers found in treatment T_7 (Poultry Manure @ 3 t ha^{-1} + rest nutrients from RDF).

6. Starch content (%): Tuber starch has been presented in the Table 3. Highest starch content (14.313%) is recorded in treatment T_7. This is due to more and continuous availability of nutrients. Therefore, greater photosynthates developed in tubers hence grater the density. Findings are supported by Ram et al. [15]. Chaudhary and Rawat [16] revealed that maximum starch content found in treatment T_4- 75% RDF of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha.

Table 3. Effect of treatments on total tuber yield (t/ha), True density (g/cc), Tuber dry matter (%) and Tuber starch content (%)

Treatments	Total tuber yield (t/ha)	True density (g/cc)	Tuber dry matter (%)	Tuber starch content (%)
T_1	24.80	1.030	14.085	13.068
T_2	36.17	1.113	16.263	13.545
T_3	29.45	1.070	14.383	13.485
T_4	30.10	1.033	14.568	13.310
T_5	29.55	1.063	14.120	14.150
T_6	31.91	1.073	15.335	13.695
T_7	37.65	1.123	17.173	14.313
S.Em.	**0.83**	**0.015**	**0.236**	**0.155**
CD at 5%	**2.49**	**0.045**	**0.707**	**0.464**

4. CONCLUSION

The research title "Assessment of potato (*Solanum tuberosum* L.) for yield and quality production under natural farming system in gird region of Madhya Pradesh" conclude that among 7 treatments, T_7- Integrated practice (90% inorganic practices, 10% organic) found better for number of tubers in different grades, yield of tubers in different grades, total tuber yield (t/ha) and for quality parameters *e.i.*, True density (g/cc), Tuber dry matter (%) and Tuber starch content (%) and T_1- control found lowest number of tubers as well as yield per ha and also content lowest quality tubers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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