

Assessment of potato (*Solanum tuberosum* L.) performance for yield and quality production under natural farming system in gird region of Madhya Pradesh

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.

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 T₁: Control, T₂: Inorganic practices (standard technology), T₃: NADEP compost @ 25 t/ha + *Azotobacter* @ 1L/ha + PSB (Phosphorus solublizing bacteria) @ 1L/ha, T₄: T₃+ FYM @ 25 t/ha, T₅: T₃ + Vermicompost @ 7.5 t/ha, T₆: T₃+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 g/L, T₇: 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 T₇. 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, T₇- 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.

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 (Muhie, 2022). 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 (Beals, 2019). 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 (Ahmed *et al.*, 2017). 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.

MATERIALS AND METHODS

The experiment was carried in the ICAR-CentralPotatoResearchInstitute-RS, research farm inGwaliorwhichislocatedat26°13' Northlatitude, 78°14' East longitude and 206 meters above mean sea levelintheNorthtractofM.P.Gwalior's climate is subtropical, with summer temperatures reaching up to48°C and minimum temperature as low as 4.0°C during the winterseason. 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 wintermonths. Meanmonthlymeteorologicaldata(maximumandminimumtemperature, 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% to 73.4%.

Treatment details

T₁: Control, T₂: Inorganic practices (standard technology), T₃: NADEP compost @ 25 t/ha + *Azotobacter* @ 1L/ha + PSB @ 1L/ha, T₄: T₃+ FYM @ 25 t/ha, T₅: T₃+ Vermicompost @ 7.5 t/ha, T₆: T₃+ neem cake @ 5 t/ha + foliar spray of copper oxychloride @ 3 g/L (for management of foliar diseases), T₇: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha.

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 determined 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 (1986).

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

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 (Houghland, 1966). It was estimated as follows:

$$\text{Tuber dry matter content (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

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.

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

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.

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 T₇. This could be 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 T₇. 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 T₇. 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 table 1. Highest number of tubers per ha (591286 at harvest) were recorded in treatment T₇. 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* (2015) and Yadav *et al* (2014). Barman *et al.* (2018) reported that significant increase towards number and weight of B grade tubers (50-75 g) was recorded under treatment T₅ (Vermicompost @ 2.5 t/ha + half NPK through inorganic fertilizer). Singh *et al.* (2018) found that highest number of tubers is recorded with the 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 T₇. 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 T₇. 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 T₇. This might be due to combined use of organic and inorganic fertilizers, which provide balance nutrition to plant. Henshet *al.* (2020) found that higher yield of larger size tubers i.e. grade A (>100 g) and B (50-99 g) tubers was recorded with treatment T₁₀-80% RDN through chemical fertilizer + 20% through vermicompost + biofertilizer, while yield of grade C (<50 g) found higher with treatment T₂-80% RDN through chemical fertilizer + 20% through Farm Yard Manure. Dev *et al.* (2020) reported maximum tuber yield grade wise with treatment T₅(RDF 75% + 25% FYM-N+ZnSO₄@ 40kg ha⁻¹). Islam (2013) revealed that maximum no. of tubers found in treatment T₇ (Poultry Manure @ 3 t ha⁻¹ + rest nutrients from RDF). Narayan (2010) 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 (N₆) treatment.

3. Total tuber yield (t/ha)

Total yield of tubers per ha have been presented in the Table2. Highest yield of tubers per ha (37.665 t/ha at harvest) was recorded in treatment T₇. 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* (2018). Henshet *al.* (2020) 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 T₁₀-80% RDN through chemical fertilizer + 20% through vermicompost + biofertilizer) which was statistically at par with treatments T₁₁(80% RDN through chemical fertilizer + 20% through mustard oil cake + biofertilizer), T₉(80% RDN through chemical fertilizer + 20% through FYM + biofertilizer) and T₃ (80% RDN through chemical fertilizer + 20% through vermicompost). Dev *et al.* (2020) reported maximum total tuber yield found with treatment T₅(RDF 75% + 25% FYM-N+ZnSO₄@ 40kg ha⁻¹). Singh *et al.* (2018) revealed that the highest tuber yield was recorded with the application 75% RDF + 2 tonnes ha⁻¹FYM + 20 kg ha⁻¹sulphur + 20 kg ha⁻¹ zinc sulphate + 1 tonnes ha⁻¹ vermicompost + Azotobacter (seed treatment). Islam (2013) revealed that maximum yield tubers found in treatment T₇ (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 T₇. This is due to more and continuous availability of nutrients. Therefore, greater photosynthates developed in tubers hence greater the density. Findings are supported by Ram *et al.* (2017).

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
T₁ - Control	167.30	104.40	111.76	191.83	129.08	80.55	86.23	148.0195
T₂ - RDF- Inorganic	127.80	161.54	157.30	317.46	98.611	124.64	121.37	244.9588
T₃ - NADEP+PSB+Azotobacter	160.90	148.45	147.16	209.26	124.1512	114.544	113.55	161.4712
T₄ - T ₃ + FYM @ 25 t/ha	160.30	137.00	157.16	218.33	123.688	105.7099	121.27	168.4671
T₅ - T ₃ + vermi-compost @ 7.5 t/ha	166.40	154.75	114.30	237.50	128.39	119.40	88.19	183.2562
T₆ - 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
T₇ - 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

5. Tuber dry matter (%):

Tuber dry matter has been presented in the Table 3. Highest tuber dry matter (17.173%) is recorded in treatment T₇. 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.* (2017). Chaudhary and Rawat (2022) revealed that maximum tuber dry matter found in treatment T₄- 75% RDF of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha. Mohammed *et al.* (2018) found that the maximum tuber dry matter in treatment - 10 t FYM ha⁻¹ + 111 kg N ha⁻¹ + 92 kg P₂O₅ ha⁻¹. Islam (2013) revealed that maximum no. of tubers found in treatment T₇ (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 T₇. 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.* (2017). Chaudhary and Rawat (2022) revealed that maximum starch content found in treatment T₄- 75% RDF of NPK + FYM @ 50 t/ha + PSB @ 10 kg/ha.

Table 3: Effect of treatments ontotal 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

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, T₇- 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*i.e.*, True density (g/cc), Tuber dry matter (%) and Tuber starch content (%) and T₁- control found lowest number of tubers as well as yield per ha and also content lowest quality tubers.

References:

- Ahmed, U.I.; Ying, L.; Bashir, M.K.; Abid, M. andZulfigar, F. (2017). Status and determinants of small farming households’ food security and role of market access in enhancing food security in rural Pakistan. *PLoS ONE*, 12, e0185466.
- Barman, K.S.; Kumar, A.; Kasera, S. and Ram, B. (2018). Integrated nutrient management in potato (*Solanum tuberosum*) cv. Kufri Ashoka. *Journal of Pharmacognosy and Phytochemistry*, SP1: 1936-1938.
- Beals, K.A. (2019). Potatoes, Nutrition and Health. *Am. J. Potato Res.* 96: 102-110. doi: 10.1007/s12230-018-09705-4.
- Chaudhary A. and Rawat, M. (2022). Response of Potato (*Solanum tuberosum* L.) to Integrated Nutrient Management in Sandy Loam Soils of Punjab. *Biological Forum – An International Journal*, 14(1): 1235- 1240
- Dev, A. Suresh Kumar, Deepak Kumar, Vivek Kumar Patel, Abhay Kumar, Rohit Kumar Sahu and Pratibha Singh. (2020). The Effect of Integrated Nutrient Management (INM) and Zn Fertilization on Yield of Potato. *Int.J.Curr.Microbiol.App.Sci.*, 9(04): 1518-1526. doi: <https://doi.org/10.20546/ijcmas.2020.904.17>
- Hensh, S.; Malik, G.C.; Banerjee, M. and Shankar, T. (2020). Studies on integrated nutrient management in productivity and economics of potato (*Solanum tuberosum* L.) under red and lateritic belt of West Bengal. *The Pharma Innovation Journal*, 9(12): 15-18.
- Houghland, G.V.C. (1966). New conversion table for specific gravity, dry matter, and starch in potatoes. *American Potato journal*. 43(138).<https://doi.org/10.1007/BF02862626>.

- Islam, M.; Sajeda, A.; Nik, M.; Majid, J.; Ferdous, M. and Shamsul, A. (2013). Integrated nutrient management for potato (*Solanum tuberosum*) in grey terrace soil (Aric Albaquipt)*Australin J.Crop.Sci.*, 7(9):12351241.
- Mohammed, A.; Mohammed, M.; Dechasa, N. and Abduselam, F. (2018). Effects of Integrated Nutrient Management on Potato (*Solanum tuberosum* L.) Growth, Yield and Yield Components at Haramaya Watershed, Eastern Ethiopia. *Open Access Library Journal*.5: 1-20 (DOI:10.4236/oalib.1103974).
- Mohammed, A.; Yusuf, M.M.; Dechasa, N. and Abduselam, F. (2018). Effects of Integrated Nutrient Management on Potato (*Solanum tuberosum* L.) Growth, Yield and Yield Components at Haramaya Watershed, Eastern Ethiopia. *Open Access Library Journal*, 5(e3974): 3974. DOI: [10.4236/oalib.1103974](https://doi.org/10.4236/oalib.1103974)
- Mohsenin, N.N. (1986). Physical Properties of Plant and Animal Materials. Structure, Physical Characteristics and Mechanical Properties. Gordon and Breach Science Publishers, New York.
- Muhie, S.D. (2022). Novel approaches and practices to sustainable agriculture. *Journal of Agriculture and Food Research*, 10. <https://doi.org/10.1016/j.jafr.2022.100446>
- Narayan, S.; Kanth, R.H.; Narayan, R.; Khan, A.R.; Singh, P.; Rehman, U.S. (2013). Effect of integrated nutrient management practices on yield of potato. *Potato Journal*, 40(1):84-86.
- Ram, B.; Singh, B.N.; and Kumar, H. (2017). Impact of various organic treatments on growth, yield and quality parameters of potato. *International journal of pure and applied bioscience*. 5(3):643-647.
- Sayed, F.E.S.; Hassan, A.H. and Mohamed, M.E.O. (2015). Impact of Bio and Organic Fertilizers on Potato Yield, Quality and Tuber Weight Loss After Harvest. *Potato Research*. 58(1):67-81.
- Singh, G.; Kumar, A.; Singh, G.; Kaur, M.; Jatana, M.S. and Sunita Rani. (2018). Effect of Integrated Nutrient Management on Growth and Yield Attributes of Potato (*Solanum tuberosum* L.). *Int.J.Curr.Microbiol.App.Sci.*, 7(06): 2051-2056.
doi: <https://doi.org/10.20546/ijemas.2018.706.242>

Yadav, S.K.; Srivastava, A.K. and Bag, T.K. (2014). Effect of integrated nutrient management on production of seed tubers from true potato (*Solanum tuberosum*) seed. *Indian Journal of Agronomy*. **59**(4):646-650.