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Assessment of potato (*Solanum tuberosum* L.) production for economical attributes under gird region of Madhya Pradesh

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Abstract

The present study was conducted at ICAR-Central Potato Research Institute- RS, research farm Gwalior during winter (*Rabi*) season of 2022-2023. The experiment was laid out using Randomized Design with treatments 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. The findings of results reveals that treatment T_7 found better for tuber yield (37.654 t/ha), biological yield (55.277 t/ha), harvest index (68.12 %), gross return (Rs 376540/ha), net return (Rs. 289311/ha) and benefit-cost ratio (3.32). While, haulm yield found higher in treatment T_2 (17.816 t/ha) and cost of cultivation reported higher for treatment T_6 (Rs.200100/ha).

Keywords: Compost, FYM, neem cake, potato, RDF

Introduction

The potato (*Solanum tuberosum* L.) is an annual herbaceous tuber crop of the Solanaceae family that contains all the essential food ingredients required for maintaining proper human health. Potato is the staple food of almost half of the world's population (Thiele *et al*., 2010). Potato is the fourth most important food crop in the world, after corn, rice, and wheat (FAO STAT, 2016). It is known as a protective food because potato protein is rich in lysine, which is one of the most important amino acid. It is also the most important food crop in the world, and it contains approximately 78% water, 22% dry matter, 20.6% carbohydrates, 2.1% protein, 1.1% crude fiber, 0.9% ash, and 0.3% fat (Zhang *et al*., 2017) [23]. In India, about 68% of potatoes are utilized for table purposes, 7.5% for processing, 8.5% for seed, and the remaining 16% of produce goes waste during pre- and post-harvest handling (Gupta *et al*., 2014) [7].

In India, it is grown on an area of 2.14 million hectares with a production of 51.31 million tonnes and a productivity of 24.0 tonnes ha^{-1} (Agriculture Statistics at a Glance, 2021). Currently, Madhya Pradesh contributes about 6.96 percent of area and 6.58 percent of production of potatoes in the country. Its productivity in Madhya Pradesh is 22762 kg ha^{-1} (Agriculture statistics at a glance, 2021).

Assessing the economics of potato cultivation in natural farming conditions involves considering various factors such as input costs, yield, market prices, and environmental impact. Conducting a comprehensive analysis, including soil health, water usage, and pest control methods, is essential for a holistic evaluation. Additionally, compare the results with conventional farming practices to determine the economic viability and sustainability of natural farming methods for potato cultivation in your specific location.

This research endeavors to delve into the assessment of potato production in the Gird region within the context of natural farming practices. Natural farming, characterized by reduced dependence on synthetic inputs and the promotion of ecological balance, presents a compelling avenue for improving the resilience and sustainability of agricultural systems. By focusing on the cultivation of potatoes, a key cash crop for the region, this study aims to explore the impact of natural farming on both the quantitative and qualitative aspects of potato production.

The Gird region, nestled in the heart of Madhya Pradesh, showcases unique agro-climatic conditions that influence crop growth and yield. Understanding the intricate interplay between these factors and the application of natural farming techniques is essential for devising strategies that align with the region's specific needs and challenges. Moreover, evaluating the economic attributes of potato cultivation under the natural farming paradigm is crucial for assessing the overall feasibility and viability of transitioning towards sustainable agricultural practices in the region.

Through a comprehensive examination of yield outcomes, economic indicators, and environmental parameters, this research endeavors to contribute valuable insights to the ongoing discourse surrounding sustainable agriculture in India. The findings are anticipated to inform policymakers, farmers, and researchers alike, guiding the formulation of strategies that foster a harmonious balance between agricultural productivity, economic viability, and ecological stewardship in the Gird region and beyond.

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. 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 8°c and10°c, respectively. The relative humidity ranged from 37.2% to 73.4%.

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].

Observations taken

Total tuber yield (t/ha)

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

Biological yield (t/ha)

Each net plot's produce was recorded separately, dried haulm as well as the tuber yield. After that, the biological yield per net plot was translated to a hectare basis.

Harvest index (%)

The harvest index is defined as the economic yield represented as a percentage of total biological yield in terms of dry matter.

$$\text{Harvest Index} = \frac{\text{Economic yield (in case of tuber yield)}}{\text{Biological yield (biomass in this case)}} \times 100$$

Cost of cultivation

Total costs for various treatments were determined using current market rates for fertilizer, field preparation, seed planting, manpower charges, cultural and intercultural activities, and so on.

Gross return (Rs /ha)

Gross returns for various treatments were computed by multiplying yield by produce sale rate. The sale rate was shown based on the current market rate of product.

Net returns (Rs/ha)

It was estimated in terms of treatments. To compute net returns for each treatment, the cost of cultivation per hectare was removed from the gross income.

Net return (Rs/ha) = Gross return (Rs/ha) - Cost of cultivation (Rs/ha)

Benefit cost Ratio

It is the ratio of gross returns to cultivation costs. It is measured in terms of returns per rupee invested. This index estimates the benefit a farmer receives in exchange for the cost of implementing a specific treatment. Any value more than 2.0 is regarded secure since the farmer receives Rs 2 for every rupee invested.

$$\text{Benefit: cost} = \frac{\text{Net Returns(Rs/ha)}}{\text{Cost of cultivation(Rs/ha)}}$$

Statistical analysis

The treatment's importance is assessed using critical difference (C.D.). The data from each character's set of observations were submitted to "Analysis of Variance" as proposed by Panse and Sukhatme (1985) [17].

Results and Discussion

Total tuber yield (t/ha)

Total yield of tubers per ha have been presented in the table1. Highest yield of tubers (37.654 t/ha) was recorded in treatment T_7. This is due to more and continuous availability of nutrients. Therefore, a greater number of tubers and higher tuber weight. Findings are supported by Mohammed *et al* (2018) [15]. It was found that conventional potato farming was more productive and profitable than organic farming in West-Central Bhutan (Lepcha *et al.* 2021) [12]. The study found that the conventional potato’s productivity was significantly higher than the organic potato at $p< 0.001$; on average, it was 2.57 times higher. Similar findings on organic potatoes were reported by Ierna and Parisi (2013) [8] and Maggio *et al*. 2008. Qadri *et al.* (2015) [18] concluded that potato supplied foliar nutrient, increased leaf nutrient contents, thus accelerates photosynthesis and develop a strong source sink relationship. Hence mode of fertilizer application also matters a lot specifically when plants need quick access to nutrients. They also observed that fertilizer dose for foliar application is too low than soil applied nitrogen. Some scientist like- Mehta *et al*. (2017) [14], Pandey *et al*. (2017) [16] and Bhatt *et al*. (2020) [4] who reported the maximum marketable yield with foliar application of nutrient and minimum in recommended practice treatment.

Haulm yield (t/ha)

The maximum haulm yield (17.816 t/ha) was found in T_2: Inorganic practices (standard technology). This is due to the adequate and proper supply of nutrients. Similar investigation was also reported by Rizk *et al*. (2013) [19], Sati *et al*. (2017) [20] and Bhatt *et al*. (2020) [4].

Biological yield (t/ha)

The maximum biological yield (55.277 t/ha) was found in T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha]. This is due to the adequate and proper supply of nutrients and higher tuber and haulm yield.

Harvest index (%)

Among the harvest index maximum harvest index (68.12 %) was found in T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha]. This is due to higher tuber yield/ha area. These results are in close conformity with the findings of Kumar *et al*. (2017) [11], Pandey *et al*. (2017) [16] and Bhatt *et al*. (2020) [4]. According to Beukema and Van der Zaag (1990) [3] study in temperate zone harvest indices of 0.75-0.85 are quite common but in warmer climates, the harvest index tend to be lower and often a wider variation is also observed between cultivars or growing conditions.

Economics

Cost of cultivation

Economics of treatments has been presented in the table 1. Highest total cost of cultivation (Rs. 200100/ha) is recorded in treatment T_6. Islam *et al*. (2000) [9] also found the tuber seed cost as 35 to 40 percent of total cost of production. Lack of quality seed in sowing time is one of the major causes for higher seed cost and government subsidy on fertilizer is the major cause for lower fertilizer cost. Also, Kirumba *et al*. (2004) [10] reported that seed costs contribute a significant 42% of the total production costs.

Gross return (Rs/ha): Highest gross return (Rs. 376540/ha) was recorded in T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha]. This is due to higher tuber yield which gives higher gross income. A positive gross margin suggests that potato production is economically feasible.

Net return (Rs/ha)

Highest net return (Rs. 289311/ha) is recorded in T_7: Integrated practice [90% RDF through inorganic sources {urea, SSP, MOP}, 10% RDF through organic sources i.e., FYM @ 25 t/ha]. This is due to higher tuber yield and lower cost of cultivation than T_5 and T_6. The gross margin provides a clear indication of whether the value of the product outweighs the variable costs paid during production. To achieve economic optimization, gross margin estimation is necessary (Gujrati, 2003) [6].

Benefit: Cost ratio

B:C ratio is recorded highest (3.32) in T_7 which was statistically similar with treatment T_2 (3.31). This is because of its low cost as compared to other treatments and high value of sell price obtained because of organic. In a comparable fashion, a study conducted on economics of potato cultivation in Taplejung estimated the benefit cost ratio to be 2.9 (Timsina *et al*., 2011) [22]. On the other hand, a study conducted in the Baglung district of western Nepal's midhills estimated that the benefit-cost ratio of potato production was 1.44 (Bajracharya and Sapkota, 2017) [2]. The research area's BCR was found to be more than one, indicating that potato production is financially feasible. The benefit cost ratio, also known as return per rupee spent, is the ratio of gross profits to cultivation costs. This means that for every rupee invested, we may expect to receive returns of Rs 3.32.

Conclusion

The findings of results reveals that treatment T_7 found better for tuber yield, biological yield, harvest index, gross return, net return and benefit-cost ratio. While, haulm yield found higher in treatment T_2 and cost of cultivation reported higher for treatment T_6.

Table 1: Effect of treatment on tuber yield, haulm yield, biological yield and economics (cost of cultivation, gross return, net return and B:C ratio) of potato

Treatments	Tuber yield (t/ha)	Haulm yield (t/ha)	Biological yield (t/ha)	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C Ratio
T_1	24.807	14.197	39.004	69700	248070	178370	2.56
T_2	36.175	17.816	53.991	83909	361750	277841	3.31
T_3	29.452	14.066	43.518	75100	294520	219420	2.92
T_4	30.108	17.585	47.693	80100	301080	220980	2.76
T_5	29.552	17.502	47.054	97600	295520	197920	2.03
T_6	31.905	16.744	48.649	200100	319050	118950	0.59
T_7	37.654	17.623	55.277	87229	376540	289311	3.32
S.Em.	1.08	0.56	1.312				
CD at 5%	3.23	1.68	3.915				

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Appendix I: Variable cost of treatments

	Treatments	Item	Unit/ha	Cost(₹/unit)	Cost (₹/ha)
1	Control	-	-	-	-
2	100%RDF NPK	Urea	390 kg	5.92/kg	2309
		SSP	500 kg	9.4/kg	4700
		MOP	200.00 kg	36/kg	7200
3	Residue based compost + biofertilizer(*Azotobacter* and PSB)	Residue	25000 kg	0.20/kg	5000
		Azotobacter	1 lit	200.00/lit	200
		PSB	1 lit	200.00/lit	200
4	T_3 + FYM@25 t/ha	Residue	25000 kg	0.20/kg	5000
		Azotobacter	1 lit	200.00/lit	200
		PSB	1 lit	200.00/lit	200
		FYM	25 t	0.20/kg	5000
5	T3+VC@7.5 t/ha	Residue	25000 kg	0.20/kg	5000
		Azotobacter	1 lit	200.00/lit	200
		PSB	1 lit	200.00/lit	200
		VC	7.5 t	3.00/kg	22500
6	: T3+ neem cake @ 5 t/ha	Residue	25000 kg	0.20/kg	5000
		Azotobacter	1 Lit	200/l	200
		PSB	1 Lit	200/l	200
		Neem cake	5 t	25.00/kg	125000
7	90%RDFNPK +25t FYM	FYM	25 t	0.20/kg	5000
		Urea	351 kg	5.92/kg	2078
		SSP	450 kg	9.4/kg	4230
		MOP	172.8 kg	36 /kg	6221

Appendix II: Common cost of treatments

Particulars	Items	Cost (Rs/ha)
Tillage and land preparation @625 /hr	4 hours	2500
Seed @1250`/q	30 qtl	37500
Planting	15 Labour	4500
Irrigation	5 irrigation	5000
Weed control / hoing		2400
Harvesting	20 labours	6000
Grading @ 250/man day	25 men days	7500
Transportation		1800
Miscellaneous		2500
Total		69700