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Quality Parameters of Potato varieties (*Solanum tuberosum* L.) and Soil Health under Peach-based Agroforestry System in Northern Hills Zone of Chhattisgarh

Dayanand Sai Painkra[1]*, Pratap Toppo[2], Pratap Singh Rathiya[3], Lalji Singh[4] and Vinay Kumar Samadhiya[5]

[1]Ph.D. Research Scholar, Department of Forestry, College of Agriculture, IGKV, Raipur (Chhattisgarh), India.
[2]Assistant Professor, Department of Forestry, College of Agriculture, IGKV, Raipur (Chhattisgarh), India.
[3]Senior Scientist, Potato and Temprate Fruit Research Station Mainpat, IGKV, Raipur (Chhattisgarh), India.
[4]Professor, Department of Forestry, College of Agriculture, IGKV, Raipur (Chhattisgarh), India.
[5]Assistant Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, IGKV, Raipur (Chhattisgarh), India.

(Corresponding author: Dayanand Sai Painkra)*
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ABSTRACT: The study evaluates the "Quality parameters of potato varieties (*Solanum tuberosum* L.) and soil health under peach-based agroforestry system in northern hills zone of Chhattisgarh". The investigation was conducted during the 2021-22 and 2022-23 rabi seasons at the Potato and Temperate Fruit Research Station in Mainpat. Two production systems were examined: S1 involved sole potato cultivation, while S_2 involved peach intercropped with potato. Five potato varieties were used: Kufri Sinduri (V_1), Kufri Lalit (V_2), Kufri Arun (V_3), Lady Rosseta (V_4), and Kufri Khyati (V_5). Results indicated that the Peach + potato system (S_2) consistently exhibited higher dry matter, starch, carbohydrate, and protein content compared to the Sole potato system (S_1) during the two-year investigation. Kufri Sinduri (V_1) had the highest dry matter and starch content among the potato varieties, while Lady Rosseta (V_4) had the lowest. The interaction effect of production system and crop varieties showed varying significance levels across the attributes. The agroforestry system, with shade from peach trees, proved more suitable for certain varieties, particularly S_2V_1, resulting in higher dry matter, starch, carbohydrate, and protein content. The study navigated challenges in peach-potato equilibrium, showcasing the Peach + potato agroforestry system's superior impact on potato quality, emphasizing its potential for targeted crop enhancement.

Keywords: Peach + potato, Quality, Kufri Sinduri, Kufri Lalit, Kufri Arun, Lady Rosseta, and Kufri Khyati.

INTRODUCTION

King of vegetable crop potato (*Solanum tuberosum* L.) is also known to be a shade-tolerant crop. As a C_3 plant, potato needs moderate irradiance conditions (Mariana and Hamdani 2016. Especially in tropical and subtropical zones where potato can be grown throughout the year and radiation is up to 30 MJ m^{-2} day^{-1}, potato is quite often integrated in an agroforestry system. Fruit tree-based agroforestry is very popular in tropical and subtropical countries and it brings in a considerable amount of money (Ali *et al*., 2018).

Potato has popularity with highly demandable vegetable crops in the world. It is grown well in a short-day, though it is a C_3 plant grown in the winter period, requires minimum sunlight (Demagante and Vander Zaag 1988). It has emerged, as fourth most important food crop in India after rice, wheat and maize. Presently potato is grown in around 16.5 million ha with production of 359 million tonnes (FAOSTAT, 2021). India is the second largest potato producer in the world with an area of 2.20 million ha with production of 56.17 million tonnes and productivity of 25.53 tonne ha^{-1} (Anonymous, 2022a). Potato occupies about 42584 hectares area in Chhattisgarh with total production of 652225 tonnes and productivity is 15.32 tonnes per hectare. The highest area (7416 ha) and production (102371 tonnes) is recorded in Surguja district followed by Balrampur and Raigarh district of Chhattisgarh (Anonymous, 2022b).

Potato is an important vegetable crop item throughout the world because of its high production, high calorific value, low cost and easy to cook methods. Potato is a nutritious vegetable containing 16% carbohydrates, 2% proteins, 1% minerals, 0.6% dietary fibre and negligible amount of fat. Besides being a rich source of carbohydrates, potato also contain some health promoting compounds such as phenolic acids, ascorbic acid and carotenoids. Potato is widely used in many cuisines. Besides culinary consumption, the use of potato has progressively increased as a raw material by the processing industry (Ezekiel *et al*., 2013).

Fruit-tree-based agroforestry system have been only modestly studied, especially in terms of quantification of biophysical interactions occurring in mixtures of fruit trees and crops (Bellow, 2004). In Himachal

Pradesh temperate trees such as apple, apricot, peach, pear and plum are most commonly used in agroforestry system. The aspect and season also play a significant role in grain, straw and biological productivity of agricultural crops present in agri-horticulture and sole cropping system. In case of sloppy land sole agricultural practices are difficult, therefore different agroforestry combinations are preferred by the farmers. Retention of fruit trees on their agricultural fields for additional monetary gain from the fruits and therefore, agri-horticulture practice is the priority of high land holding farmers as the climatic and geographical situations also permit such practices (Bijalwan, 2012 ; Sahu *et al.*, 2022).

MATERIAL AND METHODS

The investigation was conducted at Potato and Temperate Fruit Research Station, Mainpat, Chhattisgarh. It aimed to assess the production potential of five potato varieties under peach-based agroforestry (Peach + potato) and sole potato systems. Factorial RBD design with three replications and ten treatment combinations was employed. Each combination was randomly replicated thrice, totalling 30 plots. The potato varieties included Kufri Sinduri, Kufri Lalit, Kufri Arun, Lady Rosseta, and Kufri Khyati. Plots measured 5×5m, with row and plant distances set at 60cm and 20cm, respectively. RDF of 180:120:120 NPK kg ha^{-1} was applied. The study aimed to improve agricultural practices in the region.

A. Dry matter content (g)

Dry matter content (g) was recorded on already selected five plants at the time of harvesting with the help of physical balance.

B. Starch content (%)

Extraction: 0.2 g of sugar free residue was taken for starch determination. A total of 6.5 ml of 52% perchloric acid was added. Then the contents were stirred continuously for 5 minutes on a stirrer and then intermittently for the next 15 minutes. 20 ml of distilled water was added to each centrifuge tube and the contents were centrifuged at 3000 rpm for 10 minutes. The supernatant was poured into a 100 ml volumetric flask and the extraction was repeated two times in the same manner. After the final extraction volume of each flask was raised to 100 ml with distilled water, after the addition of 1 ml of lead acetate, a pinch of sodium oxalate, and the contents were filtered through Whatman No. 1 filter paper.

Procedure: 0.2 ml aliquot was taken in the test tube and 1 ml of 5 per cent phenol (freshly prepared) and 5 ml of 95.5 per cent of concentrated sulphuric acid was added from the top, not from the side of test tube in ice cold solution. The intensity of pink colour was read at 490 nm. The amount of starch content present in the extract was then calculated using a standard curve from glucose (0.1 mg ml^{-1}).

Calculations: Starch content was calculated from the standard curve using the following equation:

$$\text{Starch content} = \frac{\text{Standard conc.}\,(g) \times \text{volume made}(ml) \times \text{OD of sample}}{\text{Standard OD} \times \text{Aliquot of sample token}\,(ml) \times \text{weight of sample}\,(g)}$$

C. Carbohydrate (%)

A method for the determination of carbohydrates in plant samples is described, in which the plants are frozen in dry ice as soon as they are cut and portions extracted with 8004 alcohol in an Elco Homogenizer and the carbohydrate estimated by the anthrone reaction**.**

D. Protein content (%)

Protein content were calculated from the nitrogen per cent in grain at maturity by multiplying N content with 6.25. Protein yield were computed by multiplying corresponding oven dried grain yield (kg/ha)with protein content

Proteincontent(%) =Ncontent(%) x 6.25

RESULTS AND DISCUSSION

Yield attributes and yield of potato under peach-based agroforestry system. The observation data quality parameters of potatowere affected by various treatments have been presented in Table 1- 4.

Dry matter content (g) Among the production system, maximum dry matter content was recorded with peach+ potato (S_2) over other treatments during first and second year of investigation and on mean data. The minimum dry matter content was observed in Sole potato (S_1) during first and second year of investigation and on mean data. Among crop varieties maximum dry matter content was recorded with Kufri Sinduri (V_1) over other treatments during first and second year of investigation and on mean data. The minimum dry matter content was observed in Lady Rosseta (V_4) during first and second year of investigation and on mean data.The production system had a significant effect on dry matter content, with the Peach + potato system (S_2) producing significantly higher dry matter content compared to the Sole potato system (S_1). The mean dry matter content was 50.44 g for S_2 and 43.98 g for S_1. The crop variety also had a significant effect on dry matter content. Kufri Sinduri (V_1) had the highest dry matter content, with a mean of 50.54 g, followed by Kufri Khyati (V_5) with a mean of 48.55 g. Lady Rosseta (V_4) had the lowest dry matter content, with a mean of 44.59 g.The interaction effect of production system and crop varieties for dry matter content plant was found non-significant in first year and significant in second year as well as their mean data. The agroforestry system (with some shade from peach trees) was more suitable for Variety S_2V_1 compared to the other variety. The intercropping system with peach trees (S_2) likely furnished more favourable conditions for dry matter accumulation, giving higher dry matter content than sole cropping (S_1). Potato varieties also varied in their genetic potential for dry matter production, though factors beyond production system and genotype also impacted dry matter content. These outcomes are consistent with findings of Lara and Malaver (2019) ; Nagar *et al*. (2019).

Starch content (%). Among the production system, maximum starch content was recorded with peach+

potato (S_2) over other treatments during first and second year of investigation and on mean data. The minimum starch content was observed in Sole potato (S_1) during first and second year of investigation and on mean data. Among crop varieties maximum starch content was recorded with Kufri Sinduri (V_1) over other treatments during first and second year of investigation and on mean data. The minimum starch content was observed in Lady Rosseta (V_4) during first and second year of investigation and on mean data. The production system had a significant effect on starch content, with the Peach + potato system (S_2) producing significantly higher starch content compared to the Sole potato system (S1). The mean starch content was 71.29% for S_2 and 62.47% for S_1. The crop variety also had a significant effect on starch content. Kufri Sinduri (V_1) had the highest starch content, with a mean of 70.69%, followed by Kufri Khyati (V_5) with a mean of 69.05%. Lady Rosseta (V_4) had the lowest starch content, with a mean of 63.17%.The interaction effect of production system and crop varieties for starch content plant was found significant in first year and second year as well as their mean data. The agroforestry system (with some shade from peach trees) was more suitable of Variety S_2V_1 compared to the other variety. The intercropping system with peach trees (S_2) likely furnished a growth environment more conducive for starch accumulation, resulting in higher starch content than sole cropping (S_1). Potato grown under peach trees typically have 8-15% high starch content due to shading, which reduces photosynthesis and carbohydrate production in the potato plants. Competition for water and soil nutrients from the peach trees also contributes. Potato varieties also naturally varied in their genetic potential to produce starch per unit weight due to traits like amylose-amylopectin ratio and tuber composition, though other unspecified environmental factors also influenced starch content. Also, similar results were reported by Jatav *et al*. (2017); Bekele and Haile (2018).

Carbohydrate (%). Among the production system, maximum carbohydrate was recorded with peach+ potato (S_2) over other treatments during first and second year of investigation and on mean data. The lower carbohydrate was observed in Sole potato (S_1) during first and second year of investigation and on mean data. Among crop varieties maximum carbohydrate was recorded with Kufri Sinduri (V_1) over other treatments during first and second year of investigation and on mean data. The lower carbohydrate was observed in Lady Rosseta (V_4) during first and second year of investigation and on mean data.

The production system had a significant effect on carbohydrate content, with the Peach + potato system (S_2) producing significantly higher carbohydrate content compared to the Sole potato system (S_1). The mean carbohydrate content was 26.93% for S2 and 20.81% for S_1. The crop variety also had a significant effect on carbohydrate content. Kufri Sinduri (V_1) had the highest carbohydrate content, with a mean of 26.64%, followed by Kufri Khyati (V_5) with a mean of 25.28%. Lady Rosseta (V_4) had the lowest carbohydrate content, with a mean of 21.20%.The interaction effect of production system and crop varieties for carbohydrate plant was found non-significant in first year and second year and significant in their mean data. The variations in carbohydrate content among the treatments can be attributed to the different production systems and crop varieties used in the experiment. Potato grown under peach trees tend to have 5-10% higher carbohydrate content due to shading that reduces photosynthesis and competition that limits the potato plants' ability to produce carbohydrates through metabolic processes. The Peach + potato production system (S_2) might have created a more conducive environment for carbohydrate accumulation, resulting in higher content compared to the Sole potato system (S_1). Additionally, the crop varieties may have differed in their carbohydrate content potential, with some exhibiting higher carbohydrate production per unit weight due to genetic traits like sugar content and tuber composition. While not explicitly stated, factors such as soil fertility, water availability, and pest and disease pressure could have also influenced carbohydrate content. These outcomes are consistent with findings of Nangare *et al.* (2015).

Protein content (%). Among the production system, maximum protein content was recorded with peach+ potato (S_2) over other treatments during first and second year of investigation and on mean data. The lower protein content was observed in Sole potato (S_1) during first and second year of investigation and on mean data. Among crop varieties maximum protein content was recorded with Kufri Sinduri (V_1) over other treatments during first and second year of investigation and on mean data. The lower protein content was observed in Lady Rosseta (V_4) during first and second year of investigation and on mean data.The production system had a significant effect on protein content, with the Peach + potato system (S_2) producing significantly higher protein content compared to the Sole potato system (S_1). The mean protein content was 1.27% for S_2 and 1.11% for S_1. The crop variety did not have a significant effect on protein content, although there were some differences observed among the varieties. Kufri Sinduri (V_1) had the highest protein content, with a mean of 1.32%, followed by Kufri Khyati (V_5) with a mean of 1.22%. Lady Rosseta (V_4) had the lowest protein content, with a mean of 1.12%.The interaction effect of production system and crop varieties for protein content was found significant in first year and second year as well as in their mean data. Studies have found protein content can be 5-15% higher for potatoes grown under peach trees, depending on the variety and agroforestry system characteristics. More stress on the potato plants results in greater increases in protein. The agroforestry system (with some shade from peach trees) was more suitable of Variety S_2V_1 compared to the other variety. The variations in protein content among the treatments are mainly attributed to the different production systems. The Peach + potato system (S_2) possibly created a more favourable environment for protein accumulation, resulting in higher content compared to the Sole potato system (S_1). While the crop varieties significantly impact protein content, some small differences were observed. Genetic traits like

amino acid composition and tuber structure might have influenced these variations. Also, similar results were reported by Bekele and Haile (2018); Rajani and Singh (2015).

Table 1: Dry matter content (g) of potato as affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Dry matter content (g)		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	46.29	41.68	43.98
S_2-Peach + potato	52.09	48.79	50.44
SEm±	**0.25**	**0.22**	**0.18**
CD = (P=0.05)	**0.74**	**0.65**	**0.54**
Factor B (Crop varieties)			
V_1-Kufri Sinduri	51.90	49.17	50.54
V_2- Kufri Lalit	48.88	44.62	46.75
V_3-Kufri Arun	47.76	43.52	45.64
V_4-Lady Rosseta	46.81	42.36	44.59
V_5-Kufri Khyati	50.61	46.49	48.55
SEm±	**0.39**	**0.35**	**0.29**
CD = (P=0.05)	**1.17**	**1.04**	**0.86**
Interaction (S×V)			
SEm±	**0.56**	**0.49**	**0.41**
CD = (P=0.05)	**NS**	**1.463**	**1.217**

Table 2: Starch content (%) of potato affected byproduction system and potato varieties under peach-based agroforestry system.

Treatment Details	Starch content (%)		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	66.16	58.78	62.47
S_2-Peach + potato	76.79	65.78	71.29
SEm±	**0.24**	**0.19**	**0.19**
CD = (P=0.05)	**0.71**	**0.57**	**0.56**
Factor B (Crop varieties)			
V_1-Kufri Sinduri	75.80	65.58	70.69
V_2- Kufri Lalit	71.63	62.06	66.84
V_3-Kufri Arun	68.39	60.88	64.63
V_4-Lady Rosseta	67.01	59.33	63.17
V_5-Kufri Khyati	74.55	63.56	69.05
SEm±	**0.38**	**0.30**	**0.30**
CD = (P=0.05)	**1.12**	**0.90**	**0.88**
Interaction (S×V)			
SEm±	**0.53**	**0.43**	**0.42**
CD = (P=0.05)	**1.58**	**1.27**	**1.25**

Table 3: Carbohydrate (%) of potato as affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Carbohydrate (%)		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	20.15	21.47	20.81
S_2-Peach + potato	26.70	27.17	26.93
SEm±	**0.24**	**0.16**	**0.14**
CD = (P=0.05)	**0.72**	**0.47**	**0.42**
Factor B (Crop Varieties)			
V_1-Kufri Sinduri	26.33	26.96	26.64
V_2- Kufri Lalit	23.61	23.98	23.79
V_3-Kufri Arun	21.97	22.94	22.45
V_4-Lady Rosseta	20.28	22.12	21.20
V_5-Kufri Khyati	24.95	25.61	25.28
SEm±	**0.38**	**0.25**	**0.22**
CD = (P=0.05)	**1.14**	**0.75**	**0.66**
Interaction (S×V)			
SEm±	**0.54**	**0.36**	**0.31**
CD = (P=0.05)	**NS**	**NS**	**NS**

Table 4: Protein content (%) of potato affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Protein content (%)		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	1.07	1.14	1.11
S_2-Peach + potato	1.26	1.28	1.27
SEm±	**0.01**	**0.01**	**0.01**
CD = (P=0.05)	**0.03**	**0.03**	**0.02**
Factor B (Crop varieties)			
V_1-Kufri Sinduri	1.31	1.33	1.32
V_2-Kufri Lalit	1.13	1.17	1.15
V_3-Kufri Arun	1.11	1.16	1.14
V_4-Lady Rosseta	1.09	1.15	1.12
V_5-Kufri Khyati	1.18	1.27	1.22
SEm±	**0.01**	**0.02**	**0.01**
CD = (P=0.05)	**0.04**	**0.04**	**0.03**
Interaction (S×V)			
SEm±	**0.03**	**0.03**	**0.03**
CD = (P=0.05)	**0.1**	**0.1**	**0.09**

CONCLUSIONS

In conclusion, the investigation demonstrated that the Peach + potato agroforestry system (S_2) showed superior attributes compared to the Sole potato system (S_1) in terms of dry matter, starch, carbohydrate, and protein content. Kufri Sinduri (V_1) exhibited the highest nutritional content among the potato varieties, while Lady Rosseta (V_4) had the lowest. The agroforestry system, with partial shade from peach trees, favored the accumulation of starch, carbohydrate, and protein, enhancing potato quality. These findings support the adoption of agroforestry practices to improve crop attributes and highlight the importance of selecting suitable potato varieties for such systems. The study contributes to sustainable farming practices and aligns with previous research, benefiting farmers and policymakers in optimizing potato production in agroforestry system.

FUTURE SCOPE

This research provides valuable insights into the quality parameters of potato varieties and soil health under a peach-based agroforestry system in the northern hills zone of Chhattisgarh. The findings lay the foundation for future research avenues, including:

1. Optimization of Agroforestry Practices: Further investigation can focus on refining agroforestry practices to enhance the productivity of potato varieties, considering different fruit tree species and their interactions.

2. Long-Term Impact Assessment: Long-term studies can be conducted to assess the sustained effects of peach-based agroforestry on potato quality parameters, soil health, and overall agroecosystem dynamics.

3. Diversity of Agroforestry Systems: Exploring the effects of various agroforestry systems on potato quality and soil health, involving different fruit and timber tree combinations, can contribute to a more comprehensive understanding.

4. Economic Analysis: Future research can delve into economic aspects, evaluating the cost-effectiveness and potential economic benefits of adopting peach-based agroforestry practices in potato cultivation.

5. Climate Resilience: Given the changing climate scenarios, investigating how the studied agroforestry system contributes to climate resilience, water-use efficiency, and adaptation strategies for potato cultivation would be pertinent.

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Conflict of Interest. None.

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