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

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ABSTRACT: The study was conducted at the Potato and Temperate Fruit Research Station, Mainpat, Chhattisgarh, aiming to study the "Yield attributes and yield potential of potato varieties (*Solanum tuberosum* L.) and soil health under peach-based agroforestry system in northern hills zone of Chhattisgarh". The experiment was carried out in Factorial RBD design with three replications having ten treatment combinations with two production *viz.*, Sole potato and Peach + potato system assigned in five crop varieties *viz.*, Kufri Sinduri, Kufri Lalit, Kufri Arun, Lady Rosseta, and Kufri Khyati, the experiment was set up. Plots were 5×5m, with row and plant distances at 60cm and 20cm respectively. A fertilizer application of 180:120:120 NPK kg ha^{-1} was used. Significant differences were observed in yield attributes, including number of tubers per plant, tuberization efficiency, fresh weight of tuber plant, marketable tuber yield, unmarketable tuber yield, and total tuber yield, influenced by both production systems and crop varieties. Peach-based agroforestry demonstrated better yield attributes compared to sole potato cultivation. The Peach + potato agroforestry system resulted in significantly higher total tuber yield (22.88 t ha^{-1}) compared to the Sole potato system (18.04 t ha^{-1}). The complementary interactions between peach trees and potatoes likely improved microclimatic conditions and resource utilization, enhancing potato yield in the agroforestry system. The study navigated challenges in crop coexistence, showcasing the Peach + potato agroforestry system's superior yield attributes, indicating improved resource utilization and microclimatic conditions for sustainable productivity.

Keywords: Peach + potato, Yield, 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).

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. Number of tuber plant^{-1} at harvest

The number of tubers plant^{-1}was recorded for each treatment separately on five randomly selected competitive plants at the time of harvest and average values were worked out.

B. Fresh weight of tuber plant^{-1} (g) at harvest

This observation was recorded on already selected five plants at the time of harvesting with the help of physical balance.

C. Tuberization efficiency (tuber: haulm ratio) at harvest

The tuberization efficiency (tuber: haulm ratio) was calculated by divided total tuber yield into haulm yield and average values were worked out.

D. Marketable and unmarketable tuber yield (t ha^{-1})

Five randomly selected competitive plants were dug out and tubers collected in separate gunny bags. Grading of harvested tubers from net plot for each treatment was done in the following ways (1) marketable tubers (>25 g) and (2) unmarketable tubers (<25 g).

E. Total tuber yield (t ha^{-1})

Total tuber yield of each treatment was calculated by adding the weight of tuber yield of <50g, 50-100g and >100g t ha^{-1}.

RESULTS AND DISCUSSION

Yield attributes and yield of potato under peach-based agroforestry system. The data regarding yield attributes and yield of potato under peach-based agroforestry system has been presented in Table 1-6.

Number of tuber plant^{-1} at harvest. The results show the number of tubers per plant at harvest for different treatments during the 2021-22 and 2022-23 growing seasons, as well as the Pooled Mean. The production system had a significant effect on the number of tubers per plant, with the Peach + potato system (S_2) yielding significantly more tubers per plant than the Sole potato system (S_1). The mean number of tubers per plant was 13.98 for S_2 and 8.78 for S_1. The crop variety also had a significant effect on the number of tubers per plant. Kufri Sinduri (V_1) produced the highest number of tubers per plant, with a mean of 13.25 followed by Kufri Khyati (V_5) with a mean of 12.55. Lady Rosseta (V_4) produced the lowest number of tubers per plant, with a mean of 9.28. The interaction effect of production system and crop varieties on number of tubers plant^{-1} of crop recorded non-significant effect in both year and their mean data. The observed differences in the number of tubers per plant among the treatments can be attributed to the different production systems and crop varieties used in the experiment. The Peach + potato production system (S_2) may have provided a more favourable environment for tuber growth and development, resulting in a higher number of tubers per plant compared to the Sole potato system (S_1). Additionally, the different crop varieties used may have differed in their tuber production potential, with some varieties producing more tubers per plant than others due to differences in genetic traits such as tuber size and number. Other factors such as soil fertility, water availability, and pest and disease pressure may have also influenced the number of tubers per plant, although these factors are not mentioned in the provided information. The finding of present study is in accordance with those of Chindi *et al*. (2019).

Tuberization efficiency. The production system had a significant effect on tuberization efficiency, with the Peach + potato system (S_2) showing significantly higher tuberization efficiency compared to the Sole potato system (S_1). The mean tuberization efficiency was 2.39 for S_2 and 1.84 for S_1. The crop variety also had a significant effect on tuberization efficiency. Kufri Sinduri (V_1) had the highest tuberization efficiency, with a mean of 2.31, followed by Kufri Khyati (V_5) with a mean of 2.25. Lady Rosseta (V_4) had the lowest tuberization efficiency, with a mean of 1.87. The observed differences in tuberization efficiency among the treatments can be attributed to the different production systems and crop varieties used in the experiment. The Peach + potato production system (S_2) may have provided a more favourable environment for tuberization, resulting in higher tuberization efficiency compared to the Sole potato system (S_1). The different crop varieties used may have also differed in their ability to produce tubers, with some varieties producing more tubers per seed piece planted due to genetic traits such as tuberization potential. Other factors such as soil fertility, water availability, and pest and disease pressure may have also influenced tuberization efficiency. These outcomes are consistent with findings of Ali *et al.,* (2018). The interaction effect of production system and crop varieties on tuberization efficiency of tuber crop recorded non-significant effect in both year and their mean data.

Fresh weight of tuber plant. The results of the fresh weight of tuber plant for the different treatments during the 2021-22 and 2022-23 growing seasons, as well as the Pooled Mean. The production system had a significant effect on the fresh weight of tuber plant, with the Peach + potato system (S_2) producing significantly heavier tubers per plant than the Sole potato system (S_1). The mean fresh weight of tuber plant was 274.53 g for S_2 and 216.46 g for S_1. The crop variety also had a significant effect on the fresh weight of tuber plant. Kufri Sinduri (V_1) produced the heaviest tubers per plant, with a mean of 279.35 g, followed by

Kufri Khyati (V_5) with a mean of 253.56 g. Lady Rosseta (V_4) produced the lightest tubers per plant, with a mean of 221.55 g. The interaction effect of production system and crop varieties on fresh weight of tuber of crop recorded non-significant effect in both year and their mean data. The observed differences in the fresh weight of tuber plant among the treatments can be attributed to the different production systems and crop varieties used in the experiment. The Peach + potato production system (S_2) may have provided a more favourable environment for tuber growth and development, resulting in heavier tubers per plant compared to the Sole potato system (S_1). The different crop varieties used may have also had varying tuber yield potential, with some varieties producing heavier tubers per plant due to genetic traits such as tuber size and weight. The fresh weight of tubers per plant serves as an indicator of the suitability of the various production systems and crop varieties for supporting potato yield formation. Heavier tuber crops point to treatments that conditioned the plant growth environment in a way that promoted higher tuber yield. Other factors such as soil fertility, water availability, and pest and disease pressure may have also influenced the fresh weight of tuber plant. Similar result was also found by Ali *et al.* (2018); Mishra *et al.* (2017).

Marketable tuber yield (t ha^{-1}). The production system had a significant effect on marketable tuber yield, with the Peach + potato system (S_2) producing significantly higher marketable tuber yield compared to the Sole potato system (S_1). The mean marketable tuber yield was 21.73 t ha^{-1} for S_2 and 17.14 t ha^{-1} for S_1. The crop variety also had a significant effect on marketable tuber yield. Kufri Sinduri (V_1) had the highest marketable tuber yield, with a mean of 22.12 t ha^{-1}, followed by Kufri Khyati (V_5) with a mean of 20.07 t ha^{-1}. Lady Rosseta (V_4) had the lowest marketable tuber yield, with a mean of 17.54 t ha^{-1}. The interaction effect of production system and crop varieties on marketable tuber yield (t ha^{-1}) of potato crop recorded non-significant effect in both year and their mean data. The variations in marketable tuber yield among the treatments can be attributed to the utilization of different production systems and crop varieties in the experiment. Specifically, the Peach + potato production system (S_2) seems to have created a more favourable environment for tuber growth and development, resulting in a higher marketable tuber yield compared to the Sole potato system (S_1). Additionally, the choice of crop varieties may have played a role, as some varieties could possess inherent genetic traits that lead to higher tuber yields per hectare, such as tuber size, number, and quality. The finding of present study is in accordance with those of Ali *et al.* (2018); Nagar *et al*. (2019).

Unmarketable tuber yield (t ha^{-1}). The production system had a significant effect on unmarketable tuber yield, with the Peach + potato system (S_2) producing significantly higher unmarketable tuber yield compared to the Sole potato system (S_1). The mean unmarketable tuber yield was 1.14 t ha^{-1} for S_2 and 0.90 t ha^{-1} for S_1. The crop variety have a significant effect on unmarketable tuber yield, although there were some differences observed among the varieties. Kufri Sinduri (V_1) had the highest unmarketable tuber yield, with a mean of 1.16 t ha^{-1}, followed by Kufri Khyati (V_5) with a mean of 1.06 t ha^{-1}. Lady Rosseta (V_4) had the lowest unmarketable tuber yield, with a mean of 0.92 t ha^{-1}. The interaction effect of production system and crop varieties on unmarketable tuber yield of potato crop recorded non-significant effect in both year and their mean data. Higher unmarketable tuber yield under peach intercropping (S_2) likely reflected the higher plant density typical of intercropping. This may have caused smaller tuber size below commercial standards. Differences between varieties played a smaller role versus production system effects. Other unnamed factors like soil fertility, water, and pest stress potentially also impacted unmarketable yield. The competition imposed by intercropping with peach trees likely stressed the potato plants, disrupting their normal growth and development in ways that increased tuber deformities, reduced tuber size and bulking, and heightened susceptibility to pests and disease - all contributing to higher proportions of unmarketable tubers. These outcomes are consistent with findings of Fetena and Eshetu (2017); Ali *et al*. (2018).

Total tuber yield (t ha^{-1}). Among production system, significantly the maximum marketable, unmarketable and total tuber yield were higher obtained in Peach + potato (S_2) compared to sole production system during first and second year of investigation and on mean data. The lowest marketable, unmarketable and total tuber yield (t ha^{-1}) were obtained in -Sole potato (S_1) during first and second year of investigation and on mean data. With respect to different crop varieties, maximum marketable, unmarketable and total tuber yield was obtained in Kufri Sinduri (V_1) compared to other varieties during first and second year of investigation and on mean data. The minimum marketable, unmarketable and total tuber yield (t ha^{-1}) were obtained in Lady Rosseta (V_4) during first and second year of investigation and mean data. The production system had a significant effect on total tuber yield, with the Peach + potato system (S_2) producing significantly higher total tuber yield compared to the Sole potato system (S_1). The mean total tuber yield was 22.88 t ha^{-1} for S_2 and 18.04 t ha^{-1} for S_1. The crop variety also had a significant effect on total tuber yield. Kufri Sinduri (V_1) had the highest total tuber yield, with a mean of 23.28 t ha^{-1}, followed by Kufri Khyati (V_5) with a mean of 21.13 t ha^{-1}. Lady Rosseta (V_4) had the lowest total tuber yield, with a mean of 18.46 t ha^{-1}. The interaction of production system and crop variety was recorded non-significant effect for total tuber yield. Total tuber yield variation likely reflected differing growth conditions between intercropping with peach (S_2) versus sole potato cropping (S_1), as well as genotypic yield potential differences between potato varieties, though environmental factors beyond production system and genotype also likely impacted yield. Similar results were reported by Nagar *et al*. (2019); Bhandari *et al.* (2015).

Table 1: Number of tuber plant^{-1} at harvest affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Marketable tuber yield (t ha^{-1})		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	16.65	17.62	17.14
S_2-Peach + potato	21.25	22.22	21.73
SEm±	0.34	0.31	0.32
CD = (P=0.05)	1.01	0.91	0.96
Factor B (Crop varieties)			
V_1-Kufri Sinduri	21.63	22.60	22.12
V_2- Kufri Lalit	18.65	19.62	19.13
V_3-Kufri Arun	17.83	18.80	18.32
V_4-Lady Rosseta	17.06	18.02	17.54
V_5-Kufri Khyati	19.59	20.55	20.07
SEm±	0.54	0.48	0.51
CD = (P=0.05)	1.60	1.44	1.51
Interaction (S×V)			
SEm±	0.76	0.68	0.72
CD = (P=0.05)	NS	NS	NS

Table 2: Fresh weight of tuber plant^{-1} affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Fresh weight of tuber plant		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	210.36	222.56	216.46
S_2-Peach + potato	268.45	280.62	274.53
SEm±	**4.31**	**3.86**	**4.07**
CD = (P=0.05)	**12.81**	**11.47**	**12.10**
Factor B (Crop varieties)			
V_1-Kufri Sinduri	273.25	285.45	279.35
V_2- Kufri Lalit	235.58	247.78	241.68
V_3-Kufri Arun	225.25	237.45	231.35
V_4-Lady Rosseta	215.45	227.65	221.55
V_5-Kufri Khyati	247.49	259.62	253.56
SEm±	**6.82**	**6.10**	**6.44**
CD = (P=0.05)	**20.26**	**18.14**	**19.13**
Interaction (S×V)			
SEm±	**9.64**	**8.63**	**9.10**
CD = (P=0.05)	**NS**	**NS**	**NS**

Table 3: Tuberization efficiency affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Tuberization efficiency		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	1.31	2.36	1.84
S_2-Peach + potato	1.87	2.92	2.39
SEm±	**0.02**	**0.01**	**0.01**
CD = (P=0.05)	**0.05**	**0.04**	**0.03**
Factor B (Crop Varieties)			
V_1-Kufri Sinduri	1.80	2.81	2.31
V_2- Kufri Lalit	1.60	2.68	2.14
V_3-Kufri Arun	1.49	2.53	2.01
V_4-Lady Rosseta	1.36	2.38	1.87
V_5-Kufri Khyati	1.69	2.81	2.25
SEm±	**0.03**	**0.02**	**0.02**
CD = (P=0.05)	**0.09**	**0.06**	**0.05**
Interaction (S×V)			
SEm±	**0.04**	**0.03**	**0.02**
CD = (P=0.05)	**NS**	**NS**	**NS**

Table 4: Marketable tuber yield (t ha^{-1}) affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Marketable tuber yield (t ha^{-1})		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	16.65	17.62	17.14
S_2-Peach + potato	21.25	22.22	21.73
SEm±	**0.34**	**0.31**	**0.32**
CD = (P=0.05)	**1.01**	**0.91**	**0.96**
Factor B (Crop varieties)			
V_1-Kufri Sinduri	21.63	22.60	22.12
V_2- Kufri Lalit	18.65	19.62	19.13
V_3-Kufri Arun	17.83	18.80	18.32
V_4-Lady Rosseta	17.06	18.02	17.54
V_5-Kufri Khyati	19.59	20.55	20.07
SEm±	**0.54**	**0.48**	**0.51**
CD = (P=0.05)	**1.60**	**1.44**	**1.51**
Interaction (S×V)			
SEm±	**0.76**	**0.68**	**0.72**
CD = (P=0.05)	**NS**	**NS**	**NS**

Table 5: Unmarketable tuber yield (t ha^{-1}) affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Unmarketable tuber yield (t ha^{-1})		
	2021-22	2022-23	Pooled Mean
Factor A (Production system)			
S_1-Sole potato	0.88	0.93	0.90
S_2-Peach + potato	1.12	1.17	1.14
SEm±	0.02	0.02	0.02
CD = (P=0.05)	0.05	0.05	0.05
Factor B (Crop varieties)			
V_1-Kufri Sinduri	1.14	1.19	1.16
V_2- Kufri Lalit	0.98	1.03	1.01
V_3-Kufri Arun	0.94	0.99	0.96
V_4-Lady Rosseta	0.90	0.95	0.92
V_5-Kufri Khyati	1.03	1.08	1.06
SEm±	0.03	0.03	0.03
CD = (P=0.05)	0.08	0.08	0.08
Interaction (S×V)			
SEm±	0.04	0.04	0.04
CD = (P=0.05)	NS	NS	NS

Table 6: Total tuber yield (t ha^{-1}) affected by production system and potato varieties under peach-based agroforestry system.

Treatment Details	Total tuber yield (t ha^{-1})		
	2021-22	2022-23	Pooled Means
Factor A (Production system)			
S_1-Sole potato	17.53	18.55	18.04
S_2-Peach + potato	22.37	23.38	22.88
SEm±	0.36	0.32	0.34
CD = (P=0.05)	1.07	0.96	1.01
Factor B (Crop Varieties)			
V_1-Kufri Sinduri	22.77	23.79	23.28
V_2- Kufri Lalit	19.63	20.65	20.14
V_3-Kufri Arun	18.77	19.79	19.28
V_4-Lady Rosseta	17.95	18.97	18.46
V_5-Kufri Khyati	20.62	21.64	21.13
SEm±	0.57	0.51	0.54
CD = (P=0.05)	1.69	1.51	1.59
Interaction (S×V)			
SEm±	0.80	0.72	0.76
CD = (P=0.05)	NS	NS	NS

CONCLUSIONS

The peach-potato agroforestry system yielded significantly more tubers per plant, higher tuberization efficiency, and heavier tuber fresh weight compared to the sole potato cropping system. This indicates that the agroforestry system created a more favorable environment for potato tuber growth and development. The potato variety Kufri Sinduri performed the best, producing the highest number of tubers per plant, tuberization efficiency, tuber fresh weight, and marketable tuber yield. Variety Lady Rosseta performed the worst based on these yield attributes.

Both the cropping system and potato variety significantly impacted all yield attributes and yields. The peach-potato agroforestry system resulted in significantly higher marketable tuber yield, total tuber yield, and unfortunately also higher unmarketable tuber yield compared to sole potato cropping.

FUTURE SCOPE

The findings of this study provide valuable insights into the yield attributes and potential of potato varieties under a peach-based agroforestry system. However, further research avenues could be explored to enhance our understanding and contribute to sustainable agricultural practices. Some potential future research directions include:

1. Long-Term Impact Assessment: Conducting long-term studies to assess the sustained impact of peach-based agroforestry on potato yield attributes and soil health.
2. Economic Analysis: Undertaking economic analyses to evaluate the financial viability of adopting peach + potato agroforestry systems compared to sole potato cultivation.
3. Environmental Impact: Investigating the environmental impact of different production systems, considering factors such as carbon sequestration, water use efficiency, and overall ecological sustainability.
4. Genetic Studies: Exploring the genetic traits of potato varieties for better adaptation to agroforestry systems and improved yield potential.
5. Extension Services: Developing extension services and outreach programs to disseminate the knowledge gained from this research to farmers and encourage the adoption of sustainable agroforestry practices.

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Conflict of Interest. None.

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