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Studies on Growth, Productivity and Economics of Potato as Influenced by Nutrient Management in Potato-sesame Cropping Sequence under Red and Lateritic Soil

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ABSTRACT

A field experiment was carried out at agricultural farm of the Institute of agriculture,Sriniketan Birbhum, West Bengal, India during winter months (November to February) of 2021–2022 and 2022–2023 to study growth, productivity and economics of potato as influenced by nutrient management in potato-sesame cropping sequences under red and lateritic soil. The experiment was laid out in randomized block design having nine treatments with each treatment replicated thrice. Growth attributes, yield components, yield and economics of potato were influenced significantly by nutrient management in potato-sesame cropping sequences on pooled data basis. Among different nutrient management practices in potato-sesame cropping sequences, highest growth and yield attributes of potato was achieved from treatment having 100% NPK in potato+100% NPK in sesame in potato-sesame sequence. This was statistically at par with 100% NPK in potato+75% NPK in sesame+crop residues of potato and 100% NPK in potato+75% NPK in sesame. Higher tuber yield (23.7 t ha^{-1}), haulm yield (1.4 t ha^{-1}), gross return (₹ 283.78×10^3 ha^{-1}), net return (₹ 189.49×10^3 ha^{-1}) and return $rupee^{-1}$ investment (₹ 3.0) was fetched from 100% NPK in potato+100% NPK in sesame which was at par with 100% NPK in potato+75% NPK in sesame+crop residues of potato. So, use of 100% NPK in potato+75% NPK in sesame+crop residues of potato was promising in terms of productivity and profitability of potato in potato-sesame cropping sequence by reducing 25% NPK fertilizers in potato-sesame cropping sequence.

KEYWORDS: Potato, nutrient management, cropping sequence, growth, productivity, economics

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Continuous adoption of rice-wheat cropping system, particularly in Indo-Gangetic Plains, has been responsible for declining soil fertility, emergence of multiple micronutrients deficiencies, excess emission of greenhouse gases and decline in water table, etc. (Mal et al., 2018, Shahane and Shivay, 2019, Srivastava et al., 2020). One such measure could be adoption of altogether an alternative cropping system that overcomes these problems (Lama et al., 2018). Most of the lower gangetic plain is located in the state of West Bengal, India, which is primarily a traditional rice-growing area. Crop intensification and or diversification has now further increased with inclusion of short duration rapeseed and potato in between wet season rice or jute and dry season rice, resulting in higher production unit^{-1} area unit^{-1} time, higher nutrient removal, and varying changes in soil fertility as compared with rice–rice (R–R) and rice–wheat (R–W) systems, the two predominant cropping systems of the Indo-Gangetic Plain (Saha et al., 2022). Crop diversification is recognized as an effective strategy for achieving the objectives of food and nutritional security, poverty alleviation, employment generation, judicious use of resources and sustainable agricultural development (Barman et al., 2022; Hufnagel et al., 2020). It improves the quality of food security mainly because of more availability of pulses/oilseed and vegetables in addition to the cereals (Kumar et al., 2015; Kumar et al., 2016). Hence, selection of crops should be suitably planned for efficient utilization of available resources (Bohra and Kumar, 2015; Kumar et al., 2018). Growing of winter crops (carrot, potato, tomato, French bean, pea and lentil) after rice harvest increases the incomes of rural poor's (Kumar et al., 2017). There is sufficient residual soil moisture in crop fields even after harvest of paddy to raisesucceeding winter crops (Gautam et al., 2021; Kaur et al., 2022). Thus, there is potential for growing of winter crops, i.e. vegetable pea, toria, tomato, cabbage on residual soil moistures, which increases cropping intensity (Kumar et al., 2019). However, different cropping systems have different productivity levels (Saha et al., 2021; Derpsch et al., 2024). In the past, aman rice-potato-sesame was the predominant cropping system in the state. However, with increasing irrigation facilities, aman rice-potato-boro rice is emerging as a dominant crop sequence in the Gangetic plains of the state, particularly in Hooghly, Burdwan and Midnapore districts. Sesame is being replaced by boro rice where irrigation is not a constraint (Maniruzzaman et al., 2019; Srivastava et al., 2023; Dhanda et al., 2022). West Bengal, a state contributing over 2% of the country's oilseeds, faces a perennial problem of low productivity due to cultivation in marginal land and lack of fertilizer (Von Cossel et al., 2019). The state needs to provide at least 15 lakh tonnes of oilseeds year^{-1}, but its annual average production is only 5 lakh tonnes. A reorientation in agricultural strategy is needed to achieve rapid breakthrough in oilseed productivity, particularly sesame, while maintaining sustainability (Lokesh and Dandoti, 2023). Potato Is a food security crop in the current global foods system (Devaux et al., 2021). Sustainable potato production and efficient use of resources will require adjustments and redesigns of the current cropping and processing systems (Hatai, 2022). Sustainable intensification of rice-based systems with potatoes in the Eastern Indo-gangetic plains of India can lead to improved productivity and increased input use efficiency (Gatto et al., 2020; Kumar et al., 2024a). Hence, a feasible strategy is needed to improve the overall profitability and productivity of the small-holder farmers of the region. Therefore, the present investigation was conducted to evaluate the most productive and profitable nutrient management in potato-sesame cropping sequence under red and lateritic soil.

2. MATERIALS AND METHODS

2.1. *Experimental period and location*

A field experiment was conducted at agricultural farm of Palli Shiksha Bhavana (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum, India situated at 23°39'N latitude, 87°42'E longitude with an altitude of 58.9 m from mean sea level during winter seasons from November to March of 2021–22 and 2022–23. The experimental soil was low in available nitrogen (150.85 kg ha^{-1}) and available phosphorus (27.45 kg ha^{-1}) and medium in available potassium (142.37 kg ha^{-1}).

2.2. *Experimental design and treatment details*

The experiment was laid out in randomized block designwith nine treatments (viz. T_1, 100% NPK in potato+No NPK in sesame; T_2, 100% NPK in potato+100% NPK in sesame; T_3, 100% NPK in potato+75% NPK in sesame; T_4, 100% NPK in potato+50% NPK in sesame; T_5, 100% NPK in potato+50% N in sesame; T_6, 100% NPK in potato+50% N+Crop residues of potato in sesame; T_7, 100% NPK in potato+75% NPK+Crop residues of potato in sesame; T_8, 100% NPK in potato+50% NPK+Crop residues of potato in sesame and T_9, 100% NPK in potato+Crop residues of potato in sesame) with each treatment replicated thrice.

2.3. *Package and practices*

A recommended dose of fertilizers (200:150:150 of N: P_2O_5:K_2O in kg ha^{-1}) was applied in potato where half of total nitrogen, entire P_2O_5 and K_2O was applied as basal. Top dressing of remaining nitrogen was applied at the time of first earthing up or when plants became 25 to 30 cm in height. For sesame, recommended dose of fertilizers was 80:40:40 kg of N: P_2O_5 :K_2O in kg ha^{-1}. Potato (variety- Kufri Jyoti) was planted with a spacing of 50×25 cm^2 and sesame (variety-Roma) was sown with a spacing of 30×10 cm^2, respectively. The potato and sesame crops were raised following proper package of practices. Potato was planted during last week of November in 2021 and 2022 and harvested during first week of March, 2022 and 2023. Sesame crop was sown during last week of March, 2021 and 2022 and harvested during June, 2022 and 2023, respectively.

2.4. Observations and procedure of data recorded

The biometric observations for different growth attributes, yield components and yield of potato were recorded at regular interval. Plant height, leaf area index, dry matter accumulation, CGR, tuber growth rate and tuber bulking rate were measured and calculated. Whereas, at harvest, yield components like number of tubers hill^{-1} and weight of tubers hill^{-1} as well as tuber yield and haulm yield were measured and recorded for estimation of yield of potato. The cost of cultivation, gross return, net return and return rupee^{-1} invested (gross return/cost of cultivation) were calculated on the basis of prevailing market price of different inputs and selling price of crop produce.

2.5. Methods of statistical analysis

Statistical analysis of two years ofexperimental data was done as described by Gomez and Gomez (1984) at 5% level of significance. Two years of data were subjected to pooled analysis and pooled data are presented in tabular forms.

3. RESULTS AND DISCUSSION

3.1. Growth attributes

During two years of field experiments, growth attributes of potato (viz. plant height, leaf area index, dry matter accumulation, CGR, tuber growth rate and tuber bulking rate) at various growth stages were significantly influenced by various nutrient management practices in potato-sesame cropping sequence based on pooled data (Table 1). Highest plant height (89.5 cm),leaf area index (5) and dry matter accumulation (645.1 g^{-2}) was found at harvest.. An increasing trend was observed in CGR, tuber growth rate and tuber bulking rate with the advancement in age of the crop. The highest CGR (12.9 g m^{-2} day^{-1}), tuber growth rate (20.6 g m^{-2} day^{-1})and tuber bulking rate (88.1 g m^{-2} day^{-1}) was noticed during 60–75 DAS and a decreasing trend was noticed thereafter.

Table1: Growth attributes of potato as influenced by nutrient management in potato-sesame cropping sequences

Treatment	Plant height at harvest (cm)	Leaf area index at 45–60 DAS (LAI)	Dry matter accumulation at harvest (g^{-2})	Crop growth rate at 60–75 DAS (g^{-2} day^{-1})	Tuber growth rate at 60–75 DAS (g^{-2} day^{-1})	Tuber bulking rate at 60–75 DAS (g^{-2} day^{-1})
T_1: 100% NPK in potato+No NPK in sesame	80.8	4.5	546.0	9.2	17.4	78.0
T_2: 100% NPK in potato+100%NPK in sesame	89.5	5.0	645.1	12.9	20.6	88.1
T_3: 100% NPK in potato+75% NPK in sesame	88.7	4.8	615.7	11.8	19.5	86.6
T_4: 100% NPK in potato+50% NPK in sesame	82.0	4.7	561.6	10.1	17.8	82.2
T_5: 100% NPK in potato+50% N in sesame	81.1	4.6	553.7	9.5	17.7	79.4
T_6: 100% NPK in potato+50% N in sesame+CR*	81.9	4.6	561.6	9.5	17.7	81.4
T_7: 100% NPK in potato+75% NPK in sesame+CR*	89.1	4.8	644.1	12.3	19.8	87.4
T_8: 100% NPK in potato+50% NPK in sesame+CR*	82.0	4.7	569.1	10.9	18.1	82.6
T_9: 100% NPK in potato+CR*	81.0	4.6	551.5	9.4	17.6	78.6
SEm±	2.6	0.1	28.9	0.7	0.9	1.8
CD (p=0.05)	7.5	0.4	83.2	2.0	2.5	5.5

CR*=Crop residues of potato

Application of 100% NPK in potato+100% NPK in sesame achieved highest growth attributes of potato which was at par with 100% NPK in potato+75% NPK in sesame+crop residues of potato in sesame, 100% NPK in potato+75% NPK in sesame and 100% NPK in potato+50% NPK+crop residues of potato in sesame.

Similar findings in terms of higher growth attributes of potato like plant height, LAI, dry matter accumulation, CGR, tuber growth rate and tuber bulking rate which were significantly influenced by crop diversification in potato based cropping sequences was reported by Kumar et al. (2024b). Das and Barik (2008) also pointed out significant influence of integrated use of plant nutrients on various growth attributes of potato in potato-sesame-rice cropping sequence.

3.2. Yield components and yield of potato

In potato-sesame cropping sequence, a significant response was found from various nutrient management practices on yield components and yield of potato on pooled data basis (Table 2). In potato, significantly higher number of tubers hill^{-1} (7.4) and weight of tubers hill^{-1} (248.8 g) at harvest was obtained with the use of 100% NPK in potato+100% NPK in sesame which was at par with 100% NPK in potato+75% NPK in sesame+crop residues of potato in sesame and 100% NPK in potato+75% NPK in sesame. With respect to yield of potato significantly higher tuber yield (23.7 t ha^{-1}) and haulm yield (1.4 t ha^{-1})was produced with the application of 100% NPK in potato+100% NPK in sesame which was at par with 100% NPK in potato+75% NPK in sesame+crop residues of potato. Enhanced tuber yield and haulm yield of potato may be attributed to more number of tubers hill^{-1} and weight of tuber hill^{-1} in this treatment.

Table 2: Yield components and yield of potato as influenced by nutrient management in potato-sesame cropping sequences

Treatment	No. of tubers hill^{-1} at harvest	Weight of tubers (g hill^{-1})	Tuber yield (t ha^{-1})	Haulm yield (t ha^{-1})
T_1: 100% NPK in potato+ No NPK in sesame	6.02	195.5	20.04	1.12
T_2: 100% NPK in potato+100%NPK in sesame	7.40	248.8	23.65	1.41
T_3: 100% NPK in potato+75% NPK in sesame	6.90	225.9	21.33	1.18
T_4: 100% NPK in potato+50% NPK in sesame	6.19	211.2	20.51	1.19
T_5: 100% NPK in potato+50% N in sesame	6.12	207.5	20.34	1.17
T_6: 100% NPK in potato+ 50% N in sesame+CR*	6.16	209.2	20.34	1.18
T_7: 100% NPK in potato +75%NPK in sesame+CR*	7.27	236.9	22.69	1.36
T_8: 100% NPK in potato +50%NPK in sesame+CR*	6.29	212.7	20.40	1.16
T_9: 100% NPK in potato+CR*	6.05	203.3	20.22	1.16
SEm±	0.38	12.3	0.79	0.07
CD (p=0.05)	1.1	35.4	2.27	0.21

CR*=Crop residues of potato

These experimental results of higher yield components and tuber yield of potato in rice-potato-sesame cropping sequence was in conformity with the findings of Khanda et al. (2008) where tuber yield of potato was influenced significantly with increasing NPK dose in potato-sesame-rice cropping system. Similarly, highest productivity of rice- potato-lady's finger system was reported by Ray et al. (2009) followed by rice- potato- sesame sequence.

3.3. Economics

A significant response was found from nutrient management practices in various potato-sesame cropping sequences on gross return, net return and return rupee^{-1} invested in potato based on pooled data (Table 3) Highest gross return (₹ 283.78×10^3 ha^{-1}), net return (₹ 189.49×10^3 ha^{-1}) and return rupee^{-1} investment (₹ 3.0) was achieved with the use of 100% NPK in potato+100% NPK in sesame which was at par with 100% NPK in potato+75% NPK in sesame+crop residues of potato with gross return of ₹ 272.24×10^3 ha^{-1}, net return of ₹ 177.95×10^3 ha^{-1} and return rupee^{-1} investment of ₹ 2.89 and significantly higher than all other treatments. Higher economic return from potato in potato- sesame sequence might be due to higher tuber yield in this treatment.

Higher profitability of potato in potato-sesame cropping sequence was also in agreement with the findings of Biswas et al. (2006) which revealed highest levels of yield, net return and benefit to cost ratio in cropping systems containing potato of jute-potato-rice, rice-potato-rice and rice-potato-sesame. Saha et al. (2020) also mentioned higher gross return, net return and return rupee^{-1} investment in cropping systems of rice-potato-green gram followed by rice-lentil-okra and rice-yellow sarson-green gram.

Table 3: Economics of potato as influenced by nutrient management in potato-sesame cropping sequences

Treatment	Cost of cultivation ($\times10^3$ ₹ ha^{-1})	Gross return ($\times10^3$ ₹ ha^{-1})	Net return ($\times10^3$ ₹ ha^{-1})	Return $rupee^{-1}$ investment (₹)
T_1: 100% NPK in potato+ No NPK in sesame	94.29	240.42	146.13	2.55
T_2: 100% NPK in potato+100%NPK in sesame	94.29	283.78	189.49	3.01
T_3: 100% NPK in potato+75% NPK in sesame	94.29	255.90	161.61	2.71
T_4: 100% NPK in potato+50% NPK in sesame	94.29	246.16	151.87	2.61
T_5: 100% NPK in potato+50% N in sesame	94.29	244.02	149.73	2.59
T_6: 100% NPK in potato+ 50% N in sesame+CR*	94.29	244.10	149.81	2.59
T_7: 100% NPK in potato +75%NPK in sesame+CR*	94.29	272.24	177.95	2.89
T_8: 100% NPK in potato +50%NPK in sesame+CR*	94.29	244.82	150.53	2.60
T_9: 100% NPK in potato+CR*	94.29	242.68	148.39	2.58
SEm±		9.44	9.44	0.10
CD (p=0.05)		27.19	27.19	0.29

CR*: Crop residues of potato; 1US$= 82.57 INR (average value of the harvesting month march)

4. CONCLUSION

So, 25% NPK fertilizers may be lessened in potato-sesame cropping sequence using 100% NPK in potato+75% NPK in sesame+crop residues of potato in place of 100% NPK in potato+100% NPK in sesame for achieving higher productivity and profitability from potato in potato-sesame cropping sequence.

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