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Yield, system productivity and economics of foxtail millet-FCV tobacco cropping system as influenced by different nutrient management practices

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Abstract
A field experiment was conducted as a sequence at Black Soil Research Farm of ICAR - National Institute for Research on Commercial Agriculture during *kharif* (foxtail millet) and *rabi* (FCV tobacco) seasons of 2023-24 in clay soil to assess the effect of different nutrient management practices on yield of foxtail millet and FCV tobacco and to work-out the economics and system productivity in foxtail millet- FCV tobacco cropping system. The experiment was laid out in randomised block design and replicated thrice with seven treatments *viz.,* T_1: Absolute Control; T_2: 100% N through organic source, Farmyard manure (FYM); T_3 - 25% N through organic + 75% N through inorganic; T_4 - 50% N through organic + 50% N through inorganic; T_5 - 75% N through organic +25% N through inorganic; T_6 - 100% N through inorganic source (NPK); T_7 - Foxtail millet / tobacco crop residue incorporation using PUSA decomposer + RDF (Recommended dose of fertilizer). Results revealed that combined application of crop residue incorporation through PUSA decomposer along with RDF resulted in significantly higher grain and stover yields of 2095 and 2601 kg ha^{-1}, respectively and higher gross returns, net returns and B:C ratio (₹ 95,577 ha^{-1}, ₹ 69,080 ha^{-1}, 2.61, respectively) in foxtail millet. Similarly, in FCV tobacco T_7 recorded significantly higher green, cured leaf yield 14210, 1953 kg ha^{-1} respectively and gross returns, net returns and B:C ratio of ₹ 563733 ha^{-1}, ₹ 342376 ha^{-1} and 1.55 respectively. Significantly higher system productivity was also recorded under treatment T_7. It was concluded that combined application of crop residue incorporation using PUSA decomposer + RDF along with utilizing the residue resources effectively in pre-tobacco (*kharif*) crop season by introducing foxtail millet increases yield, overall system productivity, profitability of the cropping system.

Keywords: Crop residue, FCV tobacco, foxtail millet, FYM, PUSA decomposer, RDF, system productivity

Introduction
Agricultural sustainability is increasingly challenged by soil degradation, climate variability and rising input costs, necessitating efficient cropping systems and balanced nutrient management strategies. Mono-cropping of crops other than tobacco are not as remunerative as that of tobacco (Krishnareddy *et al.*, 2007) [5]. Therefore, integrating short-duration nutri-cereals (millets) with high-value cash crops offers a viable approach to enhance system productivity and farm profitability. The foxtail millet (*Setaria italica* L.)-FCV tobacco (*Nicotiana tabacum* L.) cropping system holds considerable promise, particularly in the rainfed and *Vertisol* regions of Andhra Pradesh. Foxtail millet, a climate-resilient C_4 nutri-cereal with high nutritional value (Muthamilasaran and Prasad, 2021) [9], efficiently utilizes *kharif* season resources, while FCV tobacco contributes substantial economic returns during *rabi.* Integrated nutrient management, combining inorganic fertilizers with organic sources such as farm yard manure, crop residue incorporation *in-situ e.t.c.,* is essential to improve nutrient availability and restore soil fertility. Balanced nutrient management plays a critical role in influencing crop growth, yield, and quality in both component crops (Raviraja, 2020) [11]. Hence, the present study was conducted to assess the effect of different nutrient management practices on yield of foxtail millet and FCV tobacco and to workout the economics and system productivity in foxtail millet- FCV tobacco cropping system.

Materials and Methods

A field experiment was conducted during *kharif* (foxtail millet) and *rabi* (FCV tobacco) seasons of 2023-24 as a sequence at Black Soil Research Farm of ICAR - National Institute for Research on Commercial Agriculture (formerly CTRI), Rajahmundry, located at 17.04º N and 81.76º E at 14 m above mean sea level coming under the Godavari agro-climatic zone of Andhra Pradesh. The soil texture of the experimental field was clay (sand, silt and clay content in 0-15 cm soil layer was 25, 10, 65%, respectively), moderately alkaline in reaction (pH of 7.31), EC was non-saline (0.31 dS m^{-1}), low in organic carbon (0.35%), low in available Nitrogen (185 kg ha^{-1}), high in available Phosphorus (23 kg ha^{-1}) and Potassium (445 kg ha^{-1}). The experiment was carried out on permanent layout in randomised block design, with seven treatments *viz.*, T_1: Absolute Control; T_2: 100% N through organic source, Farmyard manure (FYM); T_3 - 25% N through organic + 75% N through inorganic; T_4 - 50% N through organic + 50% N through inorganic; T_5 - 75% N through organic +25% N through inorganic; T_6 - 100% N through inorganic source (NPK); T_7 - Foxtail millet / tobacco crop residue incorporation using PUSA decomposer + RDF (Recommended dose of fertilizer) and replicated thrice. The RDF adopted for foxtail millet was 40 N (Urea): 20 P_2O_5 (SSP): 20 K_2O (SOP) kg ha^{-1} and for tobacco it is 50 N (Ammonium Sulphate): 50 P_2O_5 (DAP): 50 K_2O (SOP) kg ha^{-1}. The required quantity of 100%, 75%, 50% and 25% RDN through well decomposed FYM (0.5% N, 0.26% P and 0.5% K) was applied 15 days before sowing of the crop in respective plots and incorporated into soil after spreading uniformly as per the treatment. For *kharif* foxtail millet crop (*i.e.*, start of the experiment) already field grown tobacco stalks from the research farm were collected and incorporated into T_7 plot (the incorporated dry matter of tobacco stalks was about 2.2 t ha^{-1} with N, P and K content of 1.6, 0.1 and 4.3%, respectively) whereas for *rabi* tobacco, the stover residue of *kharif* foxtail millet after harvest of the foxtail millet grain has incorporated *in-situ* in T_7 plot (the incorporated dry matter of foxtail millet stover was about 2.9 t ha^{-1} with N, P and K content of 1.17, 0.46 and 5.25% respectively) using PUSA decomposer (a fungal consortium developed by ICAR-Indian Agricultural Research Institute (IARI), Division of Microbiology, New Delhi) used for rapid degradation of agricultural residues, which are available in liquid/capsule/wettable powder forms. In this experiment wettable powder has been used and procured from IARI-New Delhi, Division of Microbiology. The cultivation practices for both *kharif* foxtail millet and *rabi* FCV tobacco are adopted as per package of practises except the inputs applied as treatments. The gross plot size and net plot size of foxtail was 6.3 m X 6.3 m and 5.4 m x 5.4 m, respectively and for tobacco it was 6.3 m x 6.3 m and 3.5 x 3.5 m, respectively. The cultivar used for foxtail millet is SiA-3088 (Suryanandi) and for FCV tobacco it is FCR-15 (Sreshta). Foxtail millet was sown with a spacing of 22.5 cm x 10 cm on last week of July-2023 and harvested on last week of October-2023, whereas for *rabi* FCV tobacco, sixty days old seedlings were transplanted on last week of November - 2024 with a spacing of 70 cm x 70 cm. Tobacco leaves were harvested at maturity and flue cured. The data on foxtail millet grain yield, tobacco green and cured leaf yields and represented as kg ha^{-1}. Economics was calculated based on the prevailing market prices of the inputs and produce *i.e.*, foxtail millet grain and tobacco cured leaf @ ₹ 45 kg^{-1} and ₹ 288.65 kg^{-1}, respectively. System productivity was calculated by adding foxtail millet grain yield with tobacco leaf yield in terms of tobacco leaf equivalent yield. The mean values were subjected to statistical analysis by adopting Fisher's method of analysis of variance for the design adopted in this study as outlined by Panse and Sukhatme, (1978) [10].

Results and Discussion

Foxtail millet

Grain and Stover Yield

Data on grain and stover yield of foxtail millet grain was presented in Table 1. The treatment involving crop residue incorporation with PUSA decomposer + RDF (T_7) recorded the significantly higher grain and stover yield (2095 and 2601 kg ha^{-1}, respectively). While, treatments T_6 and T_3 exhibited statistically comparable yields. Conversely, the control plot registered the lower grain and stover yield (1039 and 1164 kg ha^{-1} respectively. The grain yield in T_7 was 12.98% higher than 100% N through inorganic source (T_6) and 50.4% higher than control. The higher grain and stover yield recorded under T_7 can be attributed to the synergistic effect of 100% RDF combined with crop residue incorporation using PUSA decomposer. This integration improved nutrient availability and uptake through enhanced root growth, while residue incorporation improved soil moisture retention, sustained nutrient release and more efficient partitioning and assimilation of metabolites. These conditions favoured efficient photosynthate accumulation and translocation during critical growth stages, leading to increased grain productivity. These findings were corroborated with the results of Meena *et al.* (2015) [7] and Aparna *et al.* (2019) [1].

Economics

Significantly higher gross returns, net returns and B:C ratio (₹ 95,577 ha^{-1}, ₹ 69,080 ha^{-1}, 2.61, respectively) was realized from the treatment containing crop residue incorporation through PUSA decomposer + RDF. Nevertheless, T_6 and T_3 were on a par to each other. While the lower values of gross return, net returns and B:C ratio was recorded in control.

Tobacco

Yield

Table 1 represents green leaf yield, cured leaf yield of FCV tobacco. Conjunctive application of crop residue incorporation through PUSA decomposer + RDF (T_7) recorded the higher green and cured leaf yields of 14210, 1953 kg ha^{-1} respectively. However, significantly lower green and cured leaf yield was recorded in control (T_1: 4487, 810 kg ha^{-1}, respectively). The increased green and cured leaf yields of tobacco under residue incorporation with a PUSA decomposer and RDF might be due to a balanced and sustained nitrogen supply, with fertilizers supporting early growth and residue mineralization meeting later crop demand. Improved microbial activity, soil structure, and nutrient use efficiency created a favourable rhizosphere, ultimately resulted in higher leaf yields. These findings align with earlier research by Kumaresan *et al.* (2003) [6] and Krishnareddy *et al.* (2007, 2009) [5,4]. the no fertilizer application i.e., control resulted in the lower yields due to insufficient native soil nutrients to support optimum plant growth

Economics

The higher gross returns, net returns and B:C ratio (₹ 5,63,733 ha^{-1}, ₹ 3,42,376 ha^{-1} and 1.55 respectively) were obtained with T_7 (Table 2) and it was on a par with 100% N through inorganics (NPK) (T_6). Crop residue incorporation through PUSA decomposer + RDF have improved the cured leaf yields leading to increase in gross returns and hence accrued higher net returns and B:C ratio. While the lower values of gross, net returns and

B:C ratio was recorded in control (T_1). ₹ ha^{-1}

System Productivity

Among the different nutrient management practices evaluated, significantly higher tobacco leaf equivalent yield 2284 kg ha^{-1} was recorded with the conjunctive application of crop residue incorporation using microbial consortium + RDF (T_7) While control (T_1: 997 kg ha^{-1}) recorded significantly lower tobacco leaf equivalent yield. The current results are in line with Mukesh Kumar, (2019) [8] and Kiran Kumar *et al.* (2020, 2022) [2,3] who reported that there was a significant improvement in system productivity due to inclusion of *kharif* crop before *rabi* tobacco in *Vertisols* of Andhra Pradesh and also residue in the cropping system.

Table 1: Effect of different nutrient management practices on foxtail millet grain and stover yield, tobacco green leaf and cured leaf and tobacco leaf equivalent yield, expressed in (kg ha^{-1}).

Treatments	Foxtail millet		FCV tobacco		Tobacco leaf
	Grain yield	Stover yield	Green leaf yield	Cured leaf yield	equivalent yield
T_1 - Control	1039	1164	4487	810	997
T_2 - 100% N through organic source (FYM)	1483	1506	6387	1080	1311
T_3 - 25% N through organic + 75% N through inorganic	1794	1868	10808	1431	1710
T_4 - 50% N through organic + 50% N through inorganic	1565	1733	10436	1287	1531
T_5 - 75% N through organic + 25% N through inorganic	1384	1593	8729	1218	1434
T_6 - 100% N through inorganic source (NPK)	1823	2224	12791	1779	2082
T_7 - Crop residue incorporation through Pusa decomposer + RDF	2095	2601	14210	1953	2284
S. Em±	75.41	137.15	151.3	53.9	53.93
CD (P=0.05)	232.3	422.6	471.5	166.2	166.1

Table 2: Economics of foxtail millet and tobacco as influenced by different nutrient management practices

Treatments	Foxtail Millet			Tobacco		
	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1 - Control	47381	26831	1.31	233806	30956	0.15
T_2 - 100% N through organic source (FYM)	67528	33578	0.99	311742	90492	0.41
T_3 - 25% N through organic + 75% N through inorganic	81700	52250	1.77	413058	188926	0.84
T_4 - 50% N through organic + 50% N through inorganic	71312	38982	1.21	371492	144459	0.64
T_5 - 75% N through organic + 25% N through inorganic	63079	27887	0.79	351671	121589	0.53
T_6 - 100% N through inorganic source (NPK)	83160	58363	2.35	518992	299135	1.36
T_7 - Crop residue incorporation through Pusa decomposer + RDF	95577	69080	2.61	563733	342376	1.55
S. Em±	3406.12	3406.12	0.13	15573.99	15587.98	0.07
CD (P=0.05)	10495.3	10495.3	0.40	47988.2	48031.3	0.22

Conclusion

It was concluded that combined application of crop residue incorporation using PUSA decomposer + RDF along with utilizing the resources effectively in pre-tobacco (*kharif*) crop season by introducing foxtail millet increases yield, overall system productivity, profitability of the cropping system.

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