International Journal of Bio-resource and Stress Management https://pphouse.org/ijbsm.php

Crossref

IJBSM December 2022, 13(12):1374-1380 Print ISSN 0976-3988 Online ISSN 0976-4038 Article AR3154

Research Article Social Science

DOI: HTTPS://DOI.ORG/10.23910/1.2022.3154

Productivity and Profitability of Mesta based Cropping Sequences in North Coastal Zone of Andhra Pradesh

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ABSTRACT

The field experiments were conducted at Agricultural Research Station, Amadalavalasa, Andhra Pradesh, India during *kharif* (May and July to October and November) and *rabi* (Novem and December to variable) of 2018–2020 to evaluate mesta based cropping sequences. Mesta variety AMV 5 was grown during *kharif* season followed by groundnut (K6), maize (Madhuri), clusterbean (vegetable), greengram (LGG 460), sunnhemp (SH4) and blackgram (LBG 752) during *rabi* season. Mesta–groundnut/clusterbean crop sequence occupied the field for 256 days followed by mesta–sunnhemp 241 days, mesta–maize (sweet corn) 236 days, mesta–blackgram 231 days mesta–greengram 216 days, while sole mesta occupied the field only for 136 days. Combined analysis of the experimental data revealed that Mesta–Maize (5013 kg ha^{-1}) cropping sequence has produced significantly higher mesta equivalent yield followed by Mesta–Groundnut (4297 kg ha^{-1}) and Mesta–Sunnhemp (2972 kg ha^{-1}). Mesta–Maize has recorded higher system productivity (21.24 kg ha^{-1} day^{-1}), profitability (₹ 325 ha^{-1} day^{-1}, gross returns (₹ 198302 ha^{-1}), net returns (₹ 119253 ha^{-1}), BC ratio (2.51) and Relative Economic Efficiency (5.39) followed by Mesta–Groundnut and Mesta–Sunnhemp cropping sequence. Mesta growing farmers of north coastal zone of Andhra Pradesh can realize high productivity and earn profitable returns by adapting Mesta–Maize or Mesta–Groundnut or Mesta–Sunnhemp cropping sequence instead of growing sole mesta based on the available resources and prevailing market demand.

KEYWORDS: Mesta, cropping sequences, economics, profitability, system productivity

***Citation* (VANCOUVER):** Sadhineni et al., Productivity and Profitability of Mesta based Cropping Sequences in North Coastal zone of Andhra Pradesh. *International Journal of Bio-resource and Stress Management,* 2022; 13(12), 1374-1380. HTTPS://DOI.ORG/10.23910/1.2022.3154.

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.

Conflict of interests: The authors have declared that no conflict of interest exists.

RECEIVED on 29th June 2022 RECEIVED in revised form on 15th November 2022 ACCEPTED in final form on 30th November 2022 PUBLISHED on 16th December 2022

1. INTRODUCTION

Mesta is one of the important commercial crops grown in north coastal zone of Andhra Pradesh particularly in Srikakulam and Vizianagaram districts. It is cultivated mostly in shallow and low fertile light sandy loam soils under rainfed conditions. The increasing demand for food and natural fibres can only be met with intensive cultivation of more productive, efficient, remunerative crops and cropping systems well utilizing the natural resources of the region (Meena et al., 2013). A sustainable cropping system consists of proper sequence of crops to gain positive synergy among crops, increase rainwater use efficiency and reduce pest and disease problems (Tanaka et al., 2005). Cultivation of jute and mesta for fibre is labour intensive, farmers are not getting profitable returns, influencing the choice of crops (Sinha et al., 2009). Dutta (2012) reported that human labour constitutes 52.12% and 48.35% of total operational expenses in jute and mesta cultivation, respectively. Mahapatra et al. (2012) reported increase in cost of production, mainly cost of labour, fertilizers and fluctuating market price for fibre as the key factors for fluctuations and expansion of area under raw jute (jute and mesta). Hence, introduction of high value crops in jute and mesta based cropping system as intercrops or sequence crops is necessary to increase the profitability. Legume or oilseed-based cropping system gives sustainable, profitable production and are economically viable (Mukherjee, 2014). Kharub et al. (2003) reported favourable impact of legumes on the soil fertility and increasing the yield of the succeeding crop in sequence. Inclusion of high yielding, short-duration and disease-resistant grain legumes and vegetable crops into the existing cropping system could improve the productivity and economic viability of the system (Jat et al., 2012; Singh and Verma, 1998; Chapke and Jha, 2006). Growing of toria and dhaincha in between two crops of jute in the cropping sequence effectively reduced the nematode population in soil and increased the seed yield of jute crop in Assam (Neog, 2021). Kumar et al. (2014) reported higher system productivity and profitability, economic efficiency with jute-rice-potato cropping system in eastern Indo-Gangetic plains, rice-potato-jute in new alluvial zone of West Bengal (Gangwar and Katyal, 2001). Biswas et al. (2006) recommended jute–potato–rice, rice–potato–rice, rice–potato–sesame for resource-rich growers and jute–wheat, rice–wheat and jute– rapeseed–rice for small and marginal farmers based on economic considerations. Cultivation of Clusterbean, fodder cowpea, blackgram, groundnut will carry 75, 35–60, 55, 54–58 kg ha^{-1} nitrogen, respectively to succeeding crop (Ghosh et al., 2007). Gangwar et al. (2003) reported cotton-groundnut as the most suitable, efficient cropping sequence with highest productivity, profitability, economic efficiency for central plateau zone of Maharashtra, Rice-wheat-sorghum+cowpea fodder in western Himalyan region (Gangwar et al., 2006). Potato–jute–rice is more productive system than potato–moong– jute, potato–maize–rice and wheat–jute–rice (Mukhopadhyaya and Roy, 2000). Rice–pea–greengram cropping system maintained better soil quality under the sub-humid, summer groundnut–toria+gobhi sarson–fallow under the semi-arid and cluster bean–broccoli–onion under arid ecosystem (Sinha et al., 2014). Kumar et al. (2016) reported highest system productivity, production efficiency, economic efficiency, water and land use efficiency with jute–rice–baby corn–leafy vegetable-jute cropping sequence. Jute-rice-baby corn cropping system recorded significantly higher net energy, energy use efficiency and jute-rice-pea cropping system recorded lowest carbon foot print (Kumar et al., 2021a). Jute–rice–garden pea cropping sequence recorded highest sustainability index followed by jute-rice-mustard-mung cropping sequence (Kumar et al., 2021b).

Gross and net irrigated area in Srikakulam and Vizianagaram districts has increased from 3.44, 2.93 lha in 2009–10 (Anonymous, 2014) to 4.16, 3.34 lha in 2019–20, respectively (Anonymous, 2020). Area under mesta cultivation has been gradually reduced in last two decades from 78000 ha in the year 2000 to 1000 ha in 2020–21 (Anonymous, 2021) due to fluctuating prices in non-regulated market, intervening of maize, rice, cotton and uneven rainfall distribution. Due to the constraints in mesta cultivation and creation of new irrigation facility, farmers started switching over to other crops like maize, cotton, pulses, groundnut and sunflower. Hence, an investigation was conducted to find out the suitable, productive and profitable sequence crops after mesta which will not only reduce the risk in cultivation but also gain higher profits to mesta farmers.

2. MATERIALS AND METHODS

2.1. *Study area*

The experiments were conducted at ANGRAU-Agricultural Research Station, Amadalavalasa, Srikakulam district in north coastal zone of Andhra Pradesh, India. It is located at latitude/longitude of 18.4°N, 83.89°E and 35 m MSL altitude. The soil of experimental site is sandy loam with a pH of 4.5, 0.16% organic carbon, 176 kg ha^{-1} available nitrogen, 16 kg ha^{-1} available phosphorous and 216 kg ha^{-1} available potassium. The normal annual rainfall of ARS, Amadalavalasa is 1053 mm. Out of the total annual rainfall, pre-monsoon period receives 109 mm, 707 mm is received during southwest monsoon, 224 mm occurs in north east monsoon and winter period receive 13 mm rainfall. September (204 mm), August (191 mm) and October (170 mm) are the highest rainfall receiving months. Mean monthly maximum and minimum temperature ranges from 33.3–36.6°C and 23.6–26°C during mesta crop period, 31.6–33.3°C and 17.8–23.6°C during sequence crop period, respectively. Mesta crop is usually sown during May–June and harvested during October–November months and growing period receives a normal rainfall of 760–810 mm rainfall. The rainfall received during north east monsoon period assists the sowing and growth of short and medium duration sequence crops (90–120 days). A successful sequence crop can be grown with 2–3 protective irrigations as per necessity at critical stages.

2.2. Experimental details

Experiments under present investigation were carried out for three consecutive years 2018–19 to 2020–21 during *kharif* (rainfed) and *rabi* (rainfed and protective irrigation) season. Mesta variety AMV 5 was sown during *kharif* followed by various sequence crops during *rabi*. The cropping sequences evaluated includes, Mesta–Groundnut (K6), Mesta–Maize (Sweetcorn–Madhuri), Mesta–Clusterbean (vegetable), Mesta–Greengram (LGG 460), Mesta–Sunnhemp (SH 4), Mesta–Blackgram (LBG 752) and Sole Mesta (AMV 5). These cropping sequences were replicated thrice in randomized block design in a plot of 4.5 m×4.0 m size. Mesta was sown during 1st fortnight of July during 2018 (14 July), 2019 (12 July) and 1st fortnight of May (12 May) during 2020. Harvesting of mesta was done in 2/3rd week of November during 2018, 2019 and last week of October during 2020. Sequence crops were sown 3rd week of December in 2018, 2019 and last week of November during 2020. Mesta, groundnut, clusterbean, greengram, sunnhemp, blackgram crops were sown at spacing of 30 cm×10 cm, while maize crop was sown at 60 cm×20 cm spacing. Fertilizers were applied @ 60:30:30 kg NPK ha^{-1} to mesta and as per the recommended dose to respective sequence crops. Pretilachlor 50% EC @ 900 g a.i. ha^{-1} was applied to mesta within 48 h of sowing. In sequence crops, pendimethalin 30% EC @ 750 g a.i. ha^{-1} was applied to groundnut, greengram, blackgram and Atrazine 50% WP @ 1.0 kg a.i. ha^{-1} was applied to maize crop for effective weed control. Sucking pests in mesta, groundnut, greengram, blackgram, fall army worm in maize were controlled with spraying of dimethoate @ 2 ml L^{-1} and emamectin benzoate @ 0.4 g L^{-1} of water. Foot stem rot incidence in mesta was low to moderate during 2018, 2019 and moderate to high during 2020. It was controlled with drenching of Metaloxyl 8%+Mancozeb 64% @ 3 g L^{-1} of water. The duration of (mean of 2018–19 to 2020–21) mesta–groundnut crop sequence was 256 days; mesta–maize (sweet corn) 236 days, mesta–clusterbean 256 days, mesta–greengram 216 days, mesta–sunnhemp 241 days, mesta–blackgram 231 days, while sole mesta occupied the field only for 136 days.

2.3. Method of data collection and analysis

Plant height and basal diameter of mesta was measured at the time harvest. Mesta crop harvested at 50% flowering was bundled, kept upright in water for half steeping in retting tank for three days followed by full steeping. CRIJAF SONA, a microbial consortium for hastening the retting process was applied on steeped bundles. After completion of retting process, fibre was extracted manually, washed in fresh water, dried in shade and dry fibre yield was recorded. Maize (Sweet corn) was harvested for green cobs, Clusterbean as green vegetable and remaining crops were harvested at maturity for seed. Recorded the fresh weight of sweetcorn cobs, clusterbean pods, dry pod yield of groundnut, seed yield of greengram, sunnhemp and blackgram. Calculated the mesta equivalent yield (MEY) of all sequence crops by considering the minimum support price or sale price of mesta, sequence crops and yield of sequence crops during respective year of cultivation. Mesta equivalent yield of cropping sequence was calculated by adding mesta fibre yield and MEY of sequence crops. Economics of cropping sequence were worked out by adding the cost cultivation and gross returns for mesta and respective sequence crop. Net returns and BC ratio (gross return/cost of cultivation) were calculated for all cropping sequences. System productivity, System profitability and Relative economic efficiency was calculated using the formula suggested by Devasenapathy et al. (2008). Data recorded on plant height, basal diameter, mesta fibre yield, MEY of cropping sequence were pooled and analysed following the procedure for combined analysis of randomized block design over years as suggested by Gomez and Gomez (1984). The crop sequences were tested for significance using LSD at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1. Growth parameters and fibre yield of mesta

Combined analysis of plant height (Table 1) over three years indicated no significant variation across cropping sequences. Among the cropping sequences mesta–blackgram (273 cm)/groundnut (272 cm) recorded relatively taller plants compared to sole mesta (263 cm). Basal diameter of mesta was also not influenced by growing of various crops after mesta.

Basal diameter of mesta was comparatively higher in mesta–greengram (20.1 mm) and sunnhemp (19.8 mm) cropping sequence than sole mesta (19.4 mm). All the sequence crops grown except maize being biological nitrogen fixers, might have resulted in better growth of mesta.

Fibre yield of mesta did not vary significantly with various cropping sequences. The combined analysis of three years data indicated that the fibre yield of mesta was significantly high during 2018 (1845 kg ha^{-1}), 2019 (1749 kg ha^{-1}) compared to 2020 (1216 kg ha^{-1}) (Table 1). During the year 2020, mesta was sown with pre sowing irrigation, crop was subjected to soil moisture deficit due to rainfall deficit during May–September 2020 (Figure 1). The main reason for reduction in fibre yield during 2020, may be moisture stress during initial and mid growth stages of the crop coupled with high incidence of foot and stem disease. Foot and stem incidence could not be controlled completely by drenching with Metaloxyl 8%+Mancozeb 64% @ 3 g l^{-1} of water. Foot and stem rot is the most important disease in mesta and causes 40% and more crop loss when the incidence is severe in roselle. The disease severity is more in roselle than kenaf. Fibre yield of mesta in mesta–groundnut (1675 kg ha^{-1}) cropping sequence was slightly higher over sole mesta (1606 kg ha^{-1}) other crop sequences.

3.2. *Yield of sequence crops*

Pooled yield of sequence crops over three years indicated that, maize (sweetcorn) green cob yield (10696 kg ha^{-1}) was higher than other sequence crops (Table 2) followed by clusterbean pods harvested for vegetable (3576 kg ha^{-1}) and groundnut dry pod yield (2033 kg ha^{-1}). Among the sequence crops, maize crop recorded highest green cob yield followed by clusterbean and groundnut during all the three years of study. Protective irrigations (two) were provided with sprinklers to maize, greengram, blackgram, clusterbean, sunnhemp and three for groundnut crop in 2018, 2020 utilizing the rain water stored in the farm pond.

3.3. *Mesta equivalent yield of sequence crops*

Yield of sequence crops was converted to mesta equivalent yield (MEY). Maize recorded highest MEY (3801, 3067 and 3464 kg ha^{-1}) during all the years of investigation (Table 2 and 3) and combined yield (3444 kg ha^{-1}) among all sequence crops. This was followed by groundnut (3333, 2105, 2428 kg ha^{-1}) and sunnhemp (1460, 1881, 777 kg ha^{-1})

Table 1: Plant height (cm), basal diameter (mm) and fibre yield of mesta in mesta based cropping sequence

Treatment	Plant height (cm) (Pooled 2018-2020)	Basal diameter (mm) (Pooled 2018-2020)	Fibre yield of mesta (kg ha^{-1})			
			2018	2019	2020	Pooled
Mesta–Groundnut	272	19.7	1855	1920	1250	1675
Mesta–Maize	263	19.3	1773	1727	1207	1569
Mesta–Clusterbean	269	19.2	1882	1707	1185	1591
Mesta–Greengram	267	20.1	1868	1745	1172	1595
Mesta–Sunnhemp	268	19.8	1828	1732	1238	1599
Mesta–Blackgram	273	19.4	1842	1662	1225	1576
Sole Mesta	263	19.4	1832	1748	1237	1606
Mean	268	19.6	1840	1749	1216	
			Y	T	Y×T	
SEm±	3.53	0.49	35.2	53.8	93.2	
LSD ($p<0.05$)	NS	NS	101	NS	NS	

Y: Year; T: Treatment; Y×T: Year×Treatment

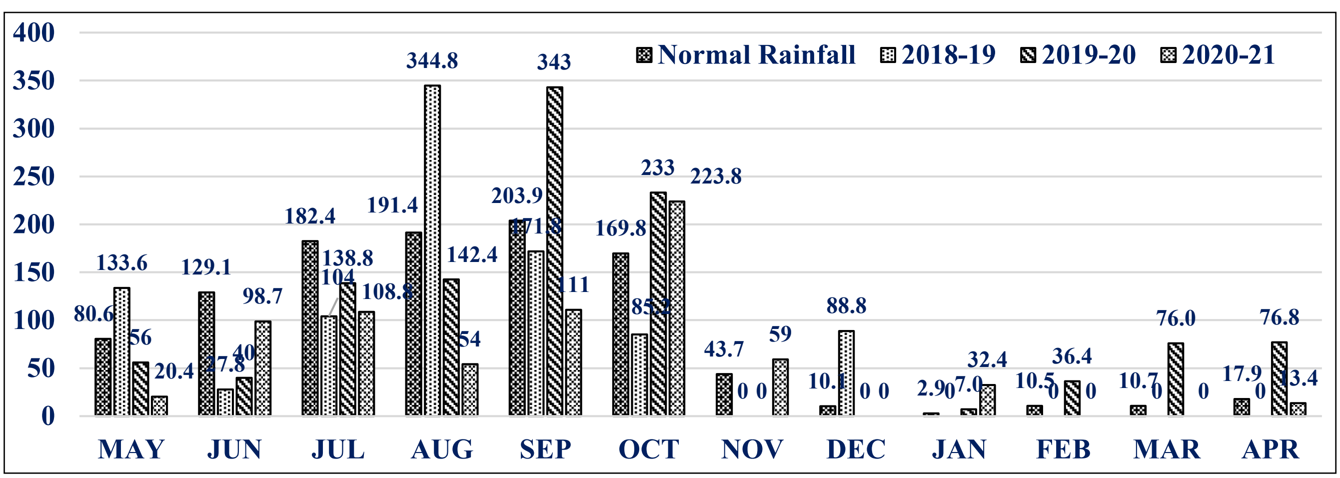

Figure 1: Rainfall (mm) during the crop growing period of Mesta, Sequence crops 2018–19 to 2020–21

Table 2: Yield, mesta equivalent yield of sequence crops, cropping sequence in mesta based cropping sequence

Treatment	Yield of sequence crops (kg ha^{-1})				MEY of sequence crops (kg ha^{-1})				MEY of cropping sequence (kg ha^{-1})			
	2018	2019	2020	Pooled	2018	2019	2020	Pooled	2018	2019	2020	Pooled
Mesta–Groundnut	2522	1633	1944	2033	3333	2105	2428	2622	5188	4025	3678	4297
Mesta–Maize	9377	8077	14633	10696	3801	3067	3464	3444	5575	4794	4670	5013
Mesta–Clusterbean	4503	2567	3659	3576	1217	975	1732	1308	3099	2681	2917	2899
Mesta–Greengram	417	850	140	469	785	1517	238	847	2654	3262	1410	2442
Mesta–Sunnhemp	772	1062	469	767	1460	1881	777	1373	3228	3613	2015	2972
Mesta–Blackgram	375	605	312	431	568	873	443	628	2409	2535	1668	2204
Sole Mesta	-	-	-	-	-	-	-	-	1832	1748	1237	1606
Mean	-	-	-	-	-	-	-	-	3435	3237	2514	
									Y	T	Y×T	
SEm±									63.9	257	169	
LSD (p<0.05)									183	793	485	

during individual years and combined yield (2622, 1373 kg ha^{-1}). This might be due to favourable weather condition for better growth and photosynthate assimilation, less pest and disease incidence during crop growing period of maize and groundnut.

3.4. Mesta equivalent yield of cropping sequence

Mesta equivalent yield (MEY) of cropping sequence was significantly influenced by various cropping sequences over years. (Table 2). The mean MEY of cropping sequences was significantly higher during 2018 (3435 kg ha^{-1}) compared to 2019 (3216 kg ha^{-1}) and 2020 (2514 kg ha^{-1}). Among the cropping sequences, combined MEY of mesta–maize (sweet corn) was significantly higher (5013 kg ha^{-1}) than rest of the cropping sequences and was on par with mesta–groundnut (4297 kg ha^{-1}), while sole mesta recorded only 1606 kg ha^{-1} fibre yield. Mitra et al. (2006) reported mesta–horsegram as a promising cropping sequence for rainfed uplands of Andhra Pradesh. In eastern Indo-Gangetic plains, significantly higher jute equivalent yield was observed in Jute–Rice–Potato sequence (Kumar et al., 2014).

3.5. Economics of mesta based cropping sequences

Pooled data on economics of mesta based cropping sequences (Table 3) revealed that highest gross returns (₹ 198302 ha^{-1}) net returns (₹ 119253 ha^{-1}), BC ratio (2.51) and Relative economic efficiency (5.39) were realized in mesta–maize cropping sequence. Next to maize, groundnut (₹ 79032 ha^{-1}, 1.88, 3.23) and sunnhemp (₹ 55173 ha^{-1}, 1.90, 1.96) recorded higher net returns, BC ratio and REE. The higher returns with maize, groundnut, sunnhemp as sequence crops might be due to high yield and stable market demand.

Table 3: Minimum support price or sale price of mesta and sequence crops (₹ kg^{-1})

MSP/Sale price (₹ kg^{-1})	Groundnut	Maize cobs	Clusterbean	Greengram	Sunnhemp	Blackgram	Mesta
2018	48.90	15.00	10.00	69.75	70.00	56.00	37.00
2019	50.90	15.00	15.00	70.50	70.00	57.00	39.50
2020	52.75	10.00	20.00	71.96	70.00	60.00	42.25

3.6. System productivity and System profitability

System productivity (Figure 2) was higher with mesta–maize (21.24 kg ha^{-1} day^{-1}), mesta–groundnut (16.78 kg ha^{-1} day^{-1}) and mesta–sunnhemp (12.33 kg ha^{-1} day^{-1}) cropping sequences compared to sole mesta (9.79), while mesta–blackgram (9.54) cropping sequence recorded low productivity. Similarly, highest system profitability was recorded in mesta–maize (₹ 325 ha^{-1} day^{-1}) followed by mesta–groundnut (₹ 217 ha^{-1} day^{-1}) (Table 4) and mesta–sunnhemp (₹ 151 ha^{-1} day^{-1}) and lowest was with sole mesta (₹ 51 ha^{-1} day^{-1}). Jute–Rice–Potato sequence recorded highest system productivity, economic efficiency in followed by jute–rice–field bean and jute–rice–garden pea (Kumar et al., 2014).

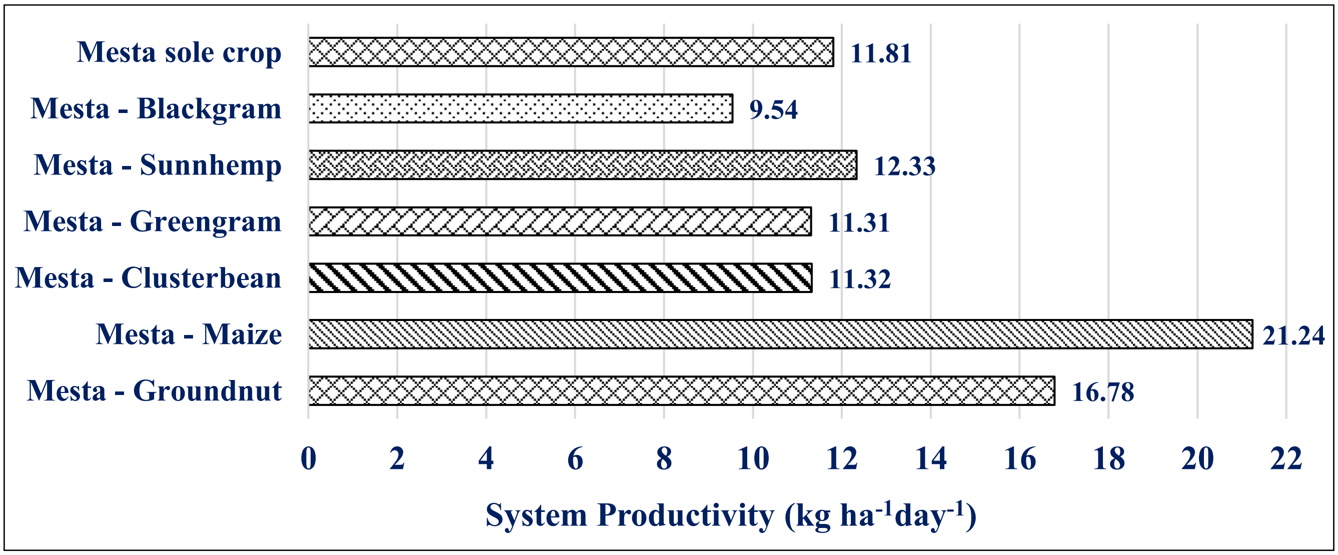

Figure 2: System productivity of Mesta based cropping sequences

Table 4: Economics (₹ ha^{-1}) of Mesta based sequence cropping (pooled data of 2018–2020)

Treatments	Gross Returns (₹ ha^{-1})	Net Returns (₹ ha^{-1})	B:C Ratio	Relative Economic Efficiency (REE)	System profitability (₹ ha^{-1} day^{-1})
Mesta–Groundnut	168768	79032	1.88	3.23	217
Mesta–Maize	198302	119253	2.51	5.39	325
Mesta–Clusterbean	114604	44611	1.64	1.39	122
Mesta–Greengram	95540	31397	1.49	0.68	86
Mesta–Sunnhemp	116504	55173	1.90	1.96	151
Mesta–Blackgram	86584	21841	1.34	0.17	60
Sole Mesta	63027	18667	1.42	-	51

4. CONCLUSION

Mesta–Maize cropping sequence has recorded highest MEY, gross returns, net returns, system productivity, system profitability, BC Ratio and Relative economic efficiency followed by Mesta–Groundnut and Mesta–Sunnhemp. Hence, the farmers of North Coastal zone of Andhra Pradesh can select and go for cultivation of Mesta–Maize or Groundnut or Sunnhemp cropping sequence as per the resource availability and market demand for obtaining high productivity and profitability instead of growing sole mesta.

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