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INTRODUCTION AND EVALUATION OF SINGLE AND MULTICUT FODDER CROPS FOR AUGMENTING FODDER SUPPLIES IN ANDAMAN & NICOBAR ISLANDS FOR SUPPORTING DAIRY FARMING

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SUMMARY

Andaman & Nicobar Islands dairy farming progress was severely constrained by fodder shortages and stakeholders were not aware of fodder cultivation. In this context, 4 fodder crops were introduced for the first time (4 sole and 2 intercrops) and tested for their fodder production in RBD with three replications at Port Blair under rain fed situations for two *kharif* seasons (2015 and 2016). The results revealed that additive series (1:1) intercropping of sweet sorghum/maize with cowpea having 19.5 & 1.5 t/ha and Rs. 52, 223/ha of cereal fodder equivalent & crude protein yield and gross income as the best system. Intercropping systems on average have a Land and income equivalent ratio (L/IER) values of 1.30 / 1.25 as compared to their sole crops. Hence, additive series intercropping of sweet sorghum / maize with cowpea (1:1) was recommended for augmenting fodder supplies in the islands.

Key words : Additive series, cowpea, fodder, intercropping, land equivalent ratio, maize, multicut sorghum, sweet sorghum and crude protein

Andaman and Nicobar Islands (ANI), a Union Territory of India situated in Bay of Bengal spreading on 0.825 million ha geographical area was inhabited by 3, 79,944 people (2011 Census). Islands farming is mostly a homestead plantation based farming of sloppy terrains that transforms into rice based farming in coastal lowlands was practiced on ~45,000 ha area that however have no presence of cultivated fodder crops. This was evident from the fact that only 10 ha area was under cultivated fodder crops in the islands. Thus dairy animals (29,161 cows and 3,823 buffaloes, Livestock Census, 2012) have to heavily depend on poor quality grazing resources of grass lands spread on 14,840 ha (Reddy *et al.*, 2016). The grasslands distribution is also disproportionate to livestock numbers. Nicobar district has 81.3% of grasslands area but have only 5.8 & 0.4% of the total cattle & buffaloes (45625 & 7863). In contrast, North & Middle Andaman (54.9 & 87.1% cattle & buffalo) and South Andaman district (39.3 & 12.5% cattle & buffalo) having majority of bovine population producing 95.9% of annual milk (13,426 tonnes; DES-2016-17) has only 19.7% of grazing lands. With the use of concentrates and mineral mixtures almost non-existent, dairy animals have to exclusively depend on grazing on degraded grasslands with poor soil fertility and mineral deficiencies and toxicities. Jaisundar *et al.* (2007) have established that grazing on grasslands of South Andaman district results in biomagnifications of nutrient deficiency/ toxicity of soil, grass components in the livestock blood samples mineral profile and leads to their poor performance. This utter deficiency of fodders and the poor quality of grasslands are the prime reasons for low milk productivity of dairy animal in N & M Andaman and S. Andaman districts. The start of milk procurement once a day in the morning, their processing and marketing by Andaman & Nicobar Islands Development Corporation (ANIDCO) in 2017 with a price of Rs. 45/ liter milk to farmer has renewed their interest in dairy farming. Thus it was inevitable to produce fodders for feeding dairy animals and no scientific information on suitable fodder crops and their performance and fodder quality were available in the islands. In this context the current investigation was made to introduce fodder crops and assess their productivity and quality and come out with suitable recommendation for promoting dairy farming in the islands.

MATERIAL AND METHODS

Field investigations was carried out during two *kharif* (July - January) seasons of 2015 and 2016 at Garacharma Research Farm of ICAR-Central Island Agricultural Research Institute (CIARI), Port Blair, Andaman & Nicobar Islands situated at 11^0 38' 06" N latitude and 92^0 39' 15'' E longitude at an altitude of 62 m above mean sea level. Each year a new field site was used for conduct of the experiment and both the sites were adjacent to each other. The experimental clay loam soil in the top 20 cm depth has 6.8 pH (neutral in reaction) rated as non saline (668 µs/m electrical conductivity) was rated as high in organic carbon (1.0% during both the years), low in available nitrogen (151.6 and 161 kg/ha) and potassium (100 and 103 kg/ha) and medium for available phosphorous (13.2 and 11.6 kg/ha) at the start of experiment in 2015 and 2016. The experimental site has an isothermal tropical humid climate with a mean minimum and maximum temperature range of 24-25^0 C and 29.1-32.0^0 C and a relative humidity of above >80% all through the crop growth period.

Six fodder crops as treatments formed by four sole fodder crops *i.e.* sweet sorghum (*Sorghum bicolor* L. Moench), maize (*Zea mays* L), cowpea (*Vigna unguiculata* (L.) Walp) and multicut sorghum (*Sorghum sudanense* L.), and two additive series intercropping (1:1) systems of sweet sorghum / maize with cowpea were tested in randomized block design (RBD) with three replications. The experimental field was prepared by ploughing with a tractor drawn cultivator twice. A gross plot size of 18 m^2 was used for the study during both the years. Maize (African tall) and sweet sorghum (SSV-74) crops were sown in solid rows 45 cm apart in both sole and intercropping systems. Cowpea (CoFC-8) was sown in solid rows 25 cm apart in sole stands where as in intercropping an additional row of cowpea was sown between two rows of sweet sorghum / maize. Multicut sorghum (CoFS-29) was sown in rows 45 cm apart. Manually drawn seed drill was used for sowing of crops by *pora* method. Fodder crops were sown on 22^{nd} June, 2015 and 7^{th} July, 2016 using recommended seed rates. On 10^{th} day of sowing, thinning / gap filling was done to maintain a plant to plant spacing of 10 cm (sweet sorghum and maize), 20 cm (multicut sorghum) and 5 cm (cowpea). Thus a plant population of 0.222 (sorghum / maize), 0.111 (multicut sorghum) and 0.8 million/ha (cowpea) was maintained in sole stands. In intercropping 100% population of cereal was maintained to which 27.5% cowpea population was added. A fertilizer dose of 60-30-30 and 20-30-30 kg N-P-K/ha were given for sole & intercrop cereal and legume crops. In intercropping, legume crop received no additional fertilizers. All the fertilizers were applied in the last ploughing for sole cowpea. For sole and intercropped maize and sweet sorghum, entire P and K along with 50% of N fertilizers were applied in the last ploughing. Remaining 50% N was top dressed at 20 days after seeding. In multicut sorghum, in addition to above fertilizer schedule of maize, 30 kg N was placed into the soil by seed drill after each harvest. Prilled urea, single super phosphate and muriate of potash were used as sources of nitrogen (N), phosphorus (P) and potassium (K). For emerging weeds management, pendimethalin 38.7% CS @ 0.75 kg a.i/ha was applied immediately after seeding. The green weeds that could not be effectively killed due to poor land preparation by cultivator were killed by spraying glyphosate @ 5 ml/ litre water uniformly. All crops were harvested at 100% flowering stage of maize/ sweet sorghum on 14^{th} September, 2015 and 18^{th} October, 2016. From regrowth, 2^{nd} harvest was taken at 60 days after first cut (2015 & 2016) and third harvest at 50 days later (2016) in multicut sorghum.

TABLE 1
Climatic data during the study period at Port Blair, the experimental site

Month	Rainfall (mm)		Rainy days		Mean monthly Temperature (°C)			
	2015	2016	2015	2016	2015		2016	
					Maximum	Minimum	Maximum	Minimum
From 22 June 2015	141.7	-	8	-	30.5	25.1	-	-
July	292.4	417.2	19	11	30.6	25.3	30.6	25.2
August	557.3	332.7	18	14	29.1	24.5	31.0	25.2
September	125.7	991.2	12	23	30.0	24.3	29.5	24.0
Up to 18th October	-	239.4	-	7	-	-	31.0	24.3
Total	1117.1	1980.5	57	55				

Fodder crops were grown under rain fed situation. A rainfall of 1117.1 and 1980.5 mm was received in 57 and 55 days during 2015 and 2016 single cut fodder crops life cycle. Multicut sorghum (MCS) crop has received 342 mm rainfall in 2015 and there was 731.1 mm rainfall during 2016 after the first harvest. The monthly rainfall (cm), rainy days (number), maximum and minimum temperature (^{o}C) of two years during single cut fodder crops growth period was given in Table 1. No plant protection measures were undertaken to the fodder crops.

The fodder crops were harvested at 2 cm above the ground level. Plant height (cm) was recorded for 5 selected plants at harvest stage. In multicut sorghum tillers were counted at each harvest time. The harvested biomass from each plot was weighed and reported as green fodder yield (kg/plot). The green fodder of five observation hills was dried at 60^{0}C for 48 hours in a ventilated oven and weight was recorded as dry weight. The ratio of dry to green fodder weight so obtained from the samples was used to convert the green fodder yield of plot into dry fodder yield (kg/plot). The fodder yields (t/ha) was estimated from the green and dry fodder yields/plot. From selected 5 plants, leaf was separated carefully and the leaf and canes (stem) were weighed and their ratio was worked out.

The nitrogen (N) concentration of fodder on dry weight basis was estimated by Micro-Kjeldhal method (Jackson, 1973) and crude protein concentration was calculated by multiplying N concentration of the plant with 6.25. Crude protein yield was arrived as product of crude protein concentration (%) and dry fodder yield (t/ha) /100. Land Equivalent Ratio (LER) was worked out for intercropping systems as a product of ratio of yield of cereal/legume fodder in intercropping to that of its yield in sole stands. Income Equivalent Ratio (IER) was also worked out similar to LER by multiplying the fodder yield with price of dry fodder (Rs./tonne). Per day productivity (kg/ha/day) was worked as ratio of fodder yield (t/ha) to crop duration (days). In the calculation of economics, a price of Rs. 3,000 and 5, 000/ tonne of dry matter of cereal and legume fodder were used. All input prices were taken as per the prevailing prices of market. Benefit Cost Ratio was worked out as ratio of gross income (net income + cost of cultivation) to the cost of cultivation. Legume yield was converted into cereal fodder equivalent yield by multiplying dry matter yield with its price (Rs./t) and divided by price of cereal fodder. The analysis of variance was done for all the information generated in RBD. The significance of treatment differences was compared by critical difference at 5% level of significance (P=0.05) and statistical interpretation of treatments was done as per Gomez and Gomez (1988).

RESULTS AND DISCUSSION

Growth and fodder production

Growth (plant height at harvest) and fodder (green and dry) production of crops in sole and intercropping stands were given in Table 2. The plant height (cm) data reveals that sorghum (191.6 cm mean) and maize (185.0 cm mean) have recorded statistically at par plant heights during both the years. Their intercropping with cowpea did not alter plant heights significantly, though sweet sorghum has recorded slightly lower plant heights in intercropping (181.2

TABLE 2

Growth and fodder production of crops in sole and intercropping system in Andaman and Nicobar islands

Crop and cropping system	Plant height (cm)		Fodder yield (t/ha)			
	2015	2016	Green		Dry	
			2015	2016	2015	2016
Maize sole	181.3	188.0	38.3	46.0	11.95	14.80
Sweet sorghum sole	190.5	192.6	42.2	48.5	14.18	15.27
Cowpea sole	145.0	149.7	24.6	22.0	6.01	6.33
Maize+cowpea	184.7 (153.2)	189.5 (150.8)	34.0 (10.5)	45.8 (9.7)	10.75 (2.52)	14.72 (2.55)
Sorghum+cowpea	179.9 (148.2)	182.5 (147.0)	38.4 (9.6)	48.0 (9.3)	12.83(2.30)	14.98 (2.44)
Perennial sorghum sole*	245.0	238.0	64.5	82.8	20.46	26.26
C. D. (P=0.05)	19.09	18.48	5.00	6.18	1.680	1.270

Figures in parenthesis are intercrop cowpea yields; * Fodder yield from 2/3 cuts in 2015/2016.

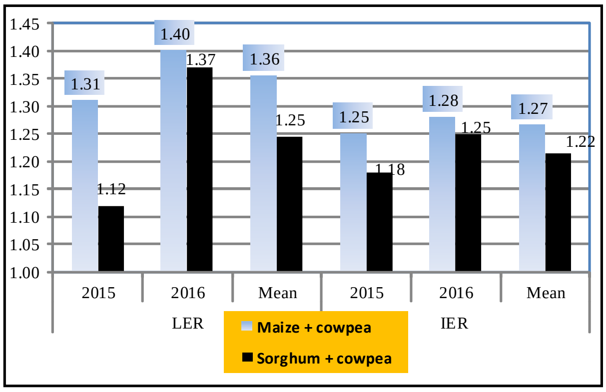

Fig. 1. Land Equivalent Ratio (LER) and Income Equivalent Ratio (IER) of intercropping systems.

cm) as compared to its sole crop (191.6 cm). Perennial sorghum has produced the tallest plants at first harvest with a mean value of 241.5 cm while cowpea has produced the shortest plants (147.4 cm). There was no tillers production in all crops except multicut sorghum, hence statistical analysis not done. However, the mean number of tillers/hill at first harvest (5) has increased to 10 after first cut and then decreased to 7 after second cut.

The fodder yield data shows that single cut fodder crops of sweet sorghum and maize in sole and intercropping stands have statistically similar green fodder production during both the years and dry fodder production during 2016. During 2015, dry fodder production of sweet sorghum was significantly higher (2.23 and 2.1 t/ha) than that of the maize in both sole and intercropping stands. The differences in plant height among these crops (6.6 cm) have contributed to the more dry fodder production of sorghum. Sole cowpea remained the lowest fodder producer among all the fodder crops with a mean green (dry) fodder yield of 23.3 (6.17) t/ha. Cowpea performance in intercropping did not vary with the base crop i.e. maize /sweet sorghum. In intercropping, cowpea has produced 42% (39.7%) of green (dry) fodder yields of its sole stand from 27.5% plant population indicating enhanced performance of crop. Cereal crops on an average have 90.6 (2015) and 98.7% (2016) production in intercropping as compared to their sole crops. Similar results were reported by Gangaiah (2004) from a rain fed situation study at Dharwad, Karnataka with sweet sorghum, maize and their intercropping with cowpea. The higher yields of sweet sorghum in the current study were also supported by the findings of Mishra *et al* (2017). Multicut sorghum (CoFS-29) from two cuts in 2015 and 3 cuts in 2016 has produced 20.46 and 26.26 t/ha of dry fodder yields. However, it's per cut yields were statistically at par with that of sweet sorghum and maize when two cuts were taken in 2015 (10.23 t/ha) and were significantly lower when 3 cuts were taken during 2016 (8.75 t/ha).

Per day productivity of fodder (Table 3) of sweet sorghum was the highest (mean: 158.5 kg/ha) among the sole crops and were least in cowpea (66.5 kg/ha; mean). Multicut sorghum has significantly lower per day productivity than sweet sorghum and maize in 2015 and at par values with maize during 2016. Intercropping of sweet sorghum / maize with cowpea has increased their per day productivity on an average by 17.1 kg/ha over sole sweet sorghum and maize. Cereal equivalent yield (CEY) of system data indicates that intercropping of sweet sorghum and maize with cowpea has significantly increased in CEY i.e. on an average by 5.13 and 5.69 t/ha over sole sweet sorghum and maize (Table 3). Sole annual fodder crops have at par CEY during both the years. The CEY of multicut sorghum was at par with sweet sorghum during 2015 and was significantly higher than all crops during 2016. The mean CEY of multicut sorghum

TABLE 3

Per day productivity and cereal equivalent yield of system of fodder crops and systems in Andaman and Nicobar islands

Crops/Cropping system	Productivity (kg/ha-day) by system			Cereal equivalent yield (t/ha) of system		
	2015	2016	Mean	2015	2016	Mean
Maize sole	142.3	143.7	143.0	11.95	14.80	13.38
Sweet sorghum sole	168.8	148.3	158.5	14.18	15.27	14.73
Cowpea sole	71.5	61.5	66.5	15.03	15.83	15.43
Maize+cowpea	128.0 (30.0)	142.9 (24.8)	132.7 (27.4)	17.05	21.10	19.07
Sweet sorghum+cowpea	152.7 (27.4)	145.4 (23.7)	149.1 (25.5)	18.58	21.08	19.83
Perennial sorghum	142.1	123.3	135.4	20.46	26.26	23.36
C. D. (P=0.05)	10.3	9.8	-	2.35	2.57	-

Figures in the parenthesis are cowpea per day productivity values.

(23.36 t/ha) though higher, they are produced over long duration and 2-3 cuts and thus are inferior to annual intercropped fodder crops.

Fodder quality and crude protein yield

Fodder quality (leaf stem ratio and crude protein content) and crude protein yield data was presented in Table 4. Crude protein content was highest in legume crop of cowpea (17.7% mean) that was almost over two times that of cereal fodder crops. Sweet sorghum has the lowest crude protein content (7.6%) while maize and multicut sorghum have slightly higher crude protein contents (8.75 and 8.55%). Intercropping of maize/ sweet sorghum with cowpea did not alter the crude protein concentration of either of the component crops, significantly.

Leaf : stem (L/S) ratio varied significantly among the fodder crops. Maize (0.62), cowpea and sweet sorghum (0.575) have higher leaf stem ratio (L/S) values while multicut sorghum has the lowest L/S values (0.28). Intercropping of sweet sorghum and maize with cowpea has increased the L/S values of cowpea by 0.04 and 0.05 as compared to sole cowpea (0.58 in 2015 and 0.57 in 2016), while that of maize / sweet sorghum remained unaffected (slightly declined).

Crude protein yield (t/ha) was statistically similar in sole sweet sorghum, cowpea and maize and ranged from the lowest of 1.05 t/ha (2015) to 1.29 t/ha (2016). Additive series intercropping of sweet sorghum and maize with cowpea (1:1) has significantly increased the crude protein yields than their sole crops. The mean increase in crude protein yield of intercropping was 0.43 t/ha over the mean of sole crops (1.13 t/ha). Total crude protein yield was highest in multicut sorghum (2.00 t/ha, mean), however, their per cut crude protein production (0.81 t/ha) was significantly lower than the annual fodder crops in sole (1.13 t/ha) and intercropping system (1.55 t/ha).

Intercropping evaluation

Intercropping of maize and sweet sorghum with cowpea in additive series has enhanced the overall dry fodder production of component crops on account of additional fodder production from cowpea without adversely affecting base crop dry matter production. Thus the enhanced dry matter production of cowpea in intercropping has resulted in increased land equivalent ratio (LER) on an average by 0.36 (maize + cowpea) and 0.25 (sweet sorghum + cowpea) as compared to their sole crops (Fig 1). LER values in general were higher in 2016 than 2015 on account of higher dry matter production in the former year. Similarly the Income Equivalent Ratio (IER) of intercropped maize with cowpea (1.37) was slightly better to cowpea intercropped sweet sorghum (1.32). Enhanced LER values of the current study were corroborated by the findings of Kumar *et al.* (2014) for maize and Pal *et al*. (2014) for sorghum intercropped cowpea.

ECONOMICS

Economics (Table 5) of fodder crops reveal their highly remunerativeness that was evident from gross income exceeding cost of cultivation in all crops and B: C ratio values (1.53-3.06). Based on gross income and B:C ratio, multicut sorghum was most

TABLE 4

Fodder quality (crude protein, leaf/ stem ratio) and crude protein yield of different crops cropping systems in Andaman and Nicobar islands

Crop and cropping system	Crude protein content (%)		Leaf : Stem ratio		Crude protein yield (t/ha)	
	2015	2016	2015	2016	2015	2016
Maize sole	8.8	8.7	0.61	0.63	1.05	1.29
Sweet sorghum sole	7.5	7.7	0.57	0.58	1.06	1.18
Cowpea sole	17.9	17.6	0.58	0.57	1.08	1.11
Maize+cowpea	8.9 (17.5)	8.7 (17.4)	0.60 (0.63)	0.61 (0.61)	1.40	1.72
Sorghum+cowpea	7.6 (17.3)	7.7 (17.2)	0.56 (0.62)	0.57 (0.62)	1.37	1.72
Perennial sorghum sole*	8.5	8.6	0.28	0.28	1.74	2.26
C. D. (P=0.05)	1.4	1.3	0.05	0.09	0.10	0.13

*From 2/3 cuts in 2015/2016. Figures in parenthesis are cow pea data.

TABLE 5
Economics of fodder cultivation in Andaman & Nicobar Islands

Crop and cropping system	Gross income (Rs./ha)		Cost of cultivation (Rs./ha)		Benefit : Cost ratio	
	2015	2016	2015	2016	2015	2016
Maize sole	35850	44400	21342	22009	1.68	2.02
Sweet sorghum sole	42540	45810	21680	22225	1.96	2.06
Cowpea sole	30050	31650	19611	19386	1.53	1.63
Maize+cowpea	44850	56910	21879	22831	2.05	2.49
Sorghum+cowpea	49990	57140	22182	22986	2.25	2.49
Perennial sorghum sole*	61380	78780	23883	25739	2.57	3.06
C. D. (P=0.05)	3525	3816			0.25	0.21

*From 2/3 cuts in 2015/2016

promising option. This was due to more fodder production from 2-3 cuts with same or little additional investment in the form of top dressing of nitrogen. However, as fodder is produced from 2-3 cuts over 200 days, when we workout per cut gross income and B: C ratio, it fares poorly. Hence intercropping of sweet sorghum with cowpea with a mean gross income of Rs. 53,565 and BC ratio of 2.37 was best combination. This was closely followed by maize intercropping system with cowpea with a mean gross income and B: C ratio of Rs. 50,880 and 2.27. Sole cowpea has the least gross income and B: C ratio (Rs. 30,850 and 1.58). Intercropping of sweet sorghum / maize with cowpea on an average has increased the gross income by Rs. 13,839 as compared to sole crops of sweet sorghum / maize / cowpea (Rs. 38,383). This increase in gross income in intercropping has resulted in increasing B : C ratio by 0.51 as compared sole crops (1.81).

CONCLUSION AND FUTURE WORK

The study identifies maize and sweet sorghum as the potential fodder crops whose additive series intercropping with cowpea (1:1) would produce highest quantity of quality fodder besides ensuring higher monetary returns. Further, there was need to work on silage production technology for continued supply of green fodder that could augment fodder shortages of Islands even during post rainy seasons (January-April).

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