

Review Article

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Finger Millet (*Eleusine coracana* G.) based Intercropping for Food Security in Konkan Region -A Review

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ABSTRACT

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In recent years, there has been increasing recognition of the importance of millets in India, since major cereals which are grown on good soils supplied with large quantity of fertilizer, irrigation and pesticide inputs have attained yield plateau. Millets have potentiality of contributing to increase food production, both in developing and developed countries. In general, millets are rich in many minerals besides their better adaptability to adverse growing conditions. Millets are cultivated mainly as rainfed crop. However, these are especially valued for filling specific niches because they often succeed under stressful situation where other crops fail to produce an acceptable harvest. Among different millets finger millet has capacity to produce consistent yield, even without special care. It is considered as poor man's food and also recommended as the food for person suffering from diabetes due to its medicinal value. For assessment of intercropping (two crops only), different indices have been used to determine advantage of an intercropping system over sole cropping by giving different formulae this paper give the critical review the Finger millet (*Eleusine coracana* G.) based intercropping for food security in konkan region.

Introduction

In recent years, there has been increasing recognition of the importance of millets in India, since major cereals which are grown on good soils supplied with large quantity of fertilizer, irrigation and pesticide inputs have attained yield plateau. Millets have potentiality of contributing to increase food production, both in developing and developed countries (Shau, 1965). In general, millets are rich in many minerals besides their better adaptability to adverse growing conditions.

Millets are cultivated mainly as rainfed crop. However, these are especially valued for filling specific niches because they often succeed under stressful situation where other crops fail to produce an acceptable harvest. Among different millets finger millet has capacity to produce consistent yield, even without special care. It is considered as poor man's food and also recommended as the food for person suffering from diabetes due to its medicinal value. Finger millet has some unique qualities, which make it potentially valuable product. The straw has an immense

utility as fodder for both draught and milch animals. It makes good fodder and contains up to 61% total digestible nutrients (Upadhyaya, 2006). Nutritional value of finger millet implies proteins 7.6g, fats 1.5g, carbohydrates 88g, calcium 370mg, vitamin A 0.48mg, thiamine (B1) 0.33mg, riboflavin (B2) 0.11mg and niacin (B3) 1.2mg per 100g of grains.

In Maharashtra, finger millet occupies an area of about 120 thousand hectares with an annual grain production of 109 thousand tonnes with productivity 908 kg per ha in 2009-10 (Rajendra Prasad, 2012).

It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudurg, Dhule, Jalgaon, Nashik, Pune, Satara and Kolhapur districts of Maharashtra. The largest acreage of ragi is in *Konkan* region. It is also taken as *rabi* crop where irrigation facilities are available. In *Konkan* region, finger millet plays an important role in agriculture with an area of 471 hundred ha with an annual production of 480 hundred tonnes (Deshmukh, 2007).

Intercropping is one of the sure ways of increasing production without much increase in the application of inputs. Intercropping refers to growing of two or more crops simultaneously on the same piece of land. This system gives crop intensification of both time and space. Apart from its advantages like diversification, labors distribution, maintenance of soil fertility, suppression of weeds, two major advantages are higher productivity and greater stability through utilization of solar energy, moisture and nutrients. The practice of intercropping in finger millet will definitely improve the economy of lower class as it will help them in fulfilling their own requirements along with finger millet which they grow on large scale. Intercropping of finger millet with pigeon pea at 4:1 ratio resulted in to higher finger millet equivalent yield compared to sole finger

millet (Ved Prakash *et al.*, 2005). Legumes have assumed much significance in intercropping because of their potential for nitrogen transfer to cereal crop (Giri and De, 1978). Growing groundnut as an intercrop in finger millet is more profitable than sole finger millet in *Konkan* region during *kharif* season (Thorat *et al.*, 1986).

Assessment of intercropping indices

For assessment of intercropping (two crops only), different indices have been used to determine advantage of an intercropping system over sole cropping by giving different formulae.

Descriptions of all such indices along with their formulae, advantage and disadvantage are presented.

The following symbols have been used in the formulae of these indices

Y_{ii} - Sole crop (pure stand) yield of crop A.

Y_{jj} - Sole crop (pure stand) yield of crop B.

Y_{ij} - Intercrop yield of crop A, when grown with crop B as intercrop.

Y_{ji} - Intercrop yield of crop B, when grown with crop A as intercrop.

a_{ij} - Proportion of area allotted to crop A in intercropping.

a_{ji} - Proportion of area allotted to crop B in intercropping.

P_i - Unit price of crop A.

P_j - Unit price of crop B.

Relative Crowding Coefficient (RCC)

This coefficient was proposed by De wilt (1960) and examined by Hall (1974a, 1974b). The RCC is useful for replacement series of intercropping experiment. RCC for each crop gives a measure of whether that crop was produced more or less yield than expected yield, e.g. RCC for crop A is

Intercrop yield of crop A x Proportion of area under crop B in intercropping

$$K_{ij} =$$

(Yield of sole crop A - Intercrop yield of crop A) x (Proportion of area under crop A in intercropping)

$K_{ij} =$	$Y_{ij} \cdot a_{ij}$
	$(Y_{ii} - y_{ij}) \times a_{ij}$

If $k_{ij} > 1$, then there is yield advantage of crop A in intercropping. If there is no effect of intercropping on the yield of crop A, then $k_{ij} = 1$; $k_{ij} < 1$ indicates the yield disadvantages due to intercropping. Similarly, one can compute k_{ji} , RCC for crop B. The component crop with higher relative crowding coefficient is the dominant and is more competitive than the associated crop.

Land Equivalent Ratio (LER)

$A_{ij} =$	Y_{ij}	-	Y_{ji}
	$Y_{ii} \cdot a_{ij}$		$Y_{jj} \cdot a_{ji}$

Willy and Osiru(1972) defined LER as relative area of the some crop that would be required to produce the equivalent yield achieved by intercropping and given by

LER =	Y_{ij}	+	Y_{ji}	= $L_i + L_j$
	Y_{ii}		Y_{jj}	

Where, L_i and L_j are known as component LER or partial LERs.

Crop Equivalent Yield (CEY)

Lal and Ray (1976), Verma and Modgal (1983) proposed economics of crop by converting grain/seed/fodder etc. in terms of gross return for valid comparison and obtained wheat equivalent yield as

Where, $C_i = P_{c_i} / P_w$

P_{c_i} and P_w are per unit prices of i^{th} crop and wheat, respectively.

Aggressivity (A)

Aggressivity was proposed by Mc Gillchrist and Trenbath (1971), who extended the work of William (1962) and Mc Gillchrist (1965). Aggressivity of crop A with crop B gives the simple difference between the expected relative yield only. Aggressivity of crop A with crop B is given by

$$A_{ij} = \frac{\text{Intercrop yield of crop A} - \text{Intercrop yield of crop B}}{\text{Expected yield of crop A} - \text{Expected yield of crop B}}$$

= Expected relative yield of crop A - Expected relative yield of crop B

If the aggressivity value of a component crop with other component crop is zero, then the two component crops are said to be equally competitive. Aggressivity value when greater than zero indicates that one crop is dominating over the other. As it is based on a sample difference, the interpretation of intercropping treatment may become difficult if the values are identical in different treatments.

Area Time Equivalent Ratio (ATER)

Jagannath and Sunderaja (1987) proposed Area Time Equivalent Ratio

$$ATER = (L_i \cdot t_i + L_j \cdot t_j) / T$$

Where, L_i and L_j – Partial LERs
 t_i and t_j duration of crop i and j
 T = Duration of whole intercropping system
 $ATER > 1$ = intercropping system more advantageous than monocropping

Yield advantage in intercropping system

Land Equivalent Ratio (LER)

Pradhan and Ghosh, (1988) at Ranchi (Jharkhand) obtained higher LER (1.51) under finger millet + black gram mixed cropping system as compared to finger millet + green gram (1.14) mixed cropping system and that of sole crop (1.00). The higher LER was recorded under finger millet (cv. EC.42-3-4) + pigeon pea (cv.T-21) paired row system as compared to finger millet (cv. PR-717) + pigeon pea (cv.Kanke-9) paired row system and that of sole crop at Bhubaneswar, Orissa (Parida *et al.*, (1989). Jadhav *et al.*, (1992) from Dapoli reported that finger millet and okra 4:2 intercropping system recorded higher LER as compared to finger millet + urd bean 4:2, finger millet + groundnut 4:2 and finger millet + cowpea 4:2. At Nagamangala (Karnataka), higher LER was recorded under finger millet + pigeon pea 8:2 intercropping as compared to finger millet + field bean 8:2 intercropping system and sole crop of finger millet (Shankaralingappa and Hegde 1992). Shankaralingappa and Rajashekara (1992) from Bangalore reported that intercropping of finger millet with Lucerne 1:1 recorded higher LER as compared to that of finger millet + field bean 1:1 intercropping system and sole crop of finger millet.

Ital *et al.*, (1994) observed that, the LER was highest (1.41) in intercropping of pearl millet + pigeon pea in row proportion of 4:2 with additive series followed by the same plant density series in 3:1 row proportion (1.36). Das and Guha (1996) found that land equivalent ratio in all intercropping treatments were higher than pure crop. The highest land equivalent ratio (1.30) was given by row ratio 2:2 of rape seed + niger. Dubey and Shrivastava (1997) observed that intercropping of kodo millet + pigeon pea (4:1) gave the highest

seed yield of 793 kg ha⁻¹ after sole kodo millet 1226 kg ha⁻¹ during all the years and also the highest kodo millet seed equivalent yield of 2961 kg ha⁻¹ was recorded in kodo millet + pigeon pea 2:1 proportion.

On red sandy loam soil at Koraput (Orissa), Mohapatra and Halder (1998) obtained higher LER under finger millet + soybean 5:2 intercropping system as compared to that of 3:2 row ratio, finger millet + rice bean (5:2 and 3:2 row ratio) intercropping system and sole crop of finger millet. Singh and Arya (1999) at Ranichauri (Uttanchal) observed that finger millet and soybean mixed cropping system (9:1 seed mixture) recorded higher LER (1.35) as compared to finger millet + rice bean (1.21) and finger millet + rajma mixed cropping system and sole crop of finger millet. Finger millet + pigeon pea at 4:1 ratio recorded the highest land equivalent ratio (1.48) for two years indicating 48 per cent more land use efficiency over the sole cropping. Maitra *et al.*, (2001) and Sarangi *et al.*, (2002) from Berhampur recorded higher LER under intercropping of finger millet (medium duration) with pigeon pea (short duration) (8:2) as compared to finger millet (medium duration) + pigeon pea (medium duration) (8:2) intercropping system and sole crop of finger millet. Ramamoorthy *et al.*, (2003a) at Coimbatore (TN) reported that finger millet + determinant type of field bean intercropping recorded higher LER (1.48) as compared to finger millet + field bean (indeterminant type) intercropping system in 8:2 row ratio LER (1.45) and sole crop of finger millet LER (1.00). Finger millet + french bean intercropping recorded higher LER as compared to finger millet + horse gram and was on par with those of finger millet intercropped with peas, soybean, cluster bean (Girish, 2004). Padhi *et al.*, (2010) reported that intercropping system of pigeon pea (UPAS -120) + finger millet (Bhairabi) at 2:4 row ratio recorded higher

LER (1.42) as compared to pigeon pea (UPAS- 120) + finger millet (PR- 202) in 2:4 row ratio. The literature on land equivalent ratio (LER) clearly indicated that finger millet intercropped with pigeon pea or soybean or groundnut recorded higher LER than finger millet intercropped with green gram, rajma, rice bean or field bean. Further, LER value was higher under inter/mixed cropping system than sole cropping of finger millet.

Crop equivalent yield

Experiment conducted at Dapoli showed higher finger millet equivalent yield under finger millet + okra 4:2 intercropping system as compared to finger millet + urd bean 4:2, finger millet + groundnut 4:2 and finger millet + cow pea 4:2 (Jadhav *et al.*, 1992). At Bangalore, highest FMEY was obtained under finger millet + pigeon pea intercropping system in 8:2 row ratio as compared to finger millet + field bean intercropping system in 8:2 row ratio and sole crop of finger millet (Shankaralingappa and Hedge, 1992). Shivkumar and Yadahalli (1995) at Bangalore, reported that intercropping of pigeon pea with finger millet in 5:2 row ratio gave higher FMEY as compared to that of finger millet + field bean 5:2 intercropping system and sole crop of finger millet. Experiment conducted at Ranichauri (Uttaranchal) showed higher finger millet equivalent yield under finger millet + soybean mixed cropping system (9:1 seed mixture) as compared to finger millet + rice bean and finger millet + rajma mixed cropping system (9:1 seed ratio) and sole crop of finger millet (Singh and Arya, 1999). Jena *et al.*, (2000) at Ganjam (Orissa) reported that intercropping of finger millet with pigeon pea in 4:1 row proportion recorded higher FMEY as compared to 5:2 row ratio and sole crop of finger millet. Shashidhara *et al.*, (2000) from Hanumanamatti, Karnataka reported that finger millet + pigeon pea in 4:2 row ratio

recorded the higher FMEY 16.63 q ha⁻¹ as compared to those of 3:1 (14.86 q ha⁻¹) and 5:1 (15.27 q ha⁻¹) row ratio and sole crop of finger millet.

Ramamoorthy *et al.*, (2003) conducted field experiment at Coimbatore and observed that intercropping of finger millet + field bean (determinant type) in 8:2 row ratio recorded higher FMEY of 4516 kg ha⁻¹ as compared to finger millet + field bean (indeterminate type) intercropping system in 8:2 row ratio (3731 kg ha⁻¹) and sole crop of finger millet (2589 kg ha⁻¹).

Padhi *et al.*, (2010) recorded that pigeon pea seed equivalent yield of all intercropping systems was significantly superior to their respective sole crop yields at both the row ratios. 14 per cent increase in grain yield of finger millet was observed at 2:8 row ratio while sowing at 2:4 row ratio recorded 15 per cent higher PSEY than the former row ratio due to 77 per cent increase in seed yield of pigeon pea in this row ratio. Jakhar *et al.*, (2015) studied the strip combination equivalent yield of dominating crop. Among the different ratio of strip cropping, 4:6 row ratio gave higher FMEY along the years (2011-13). Strip ratio 6:4 gave 57, 44 and 59 per cent higher yield than sole finger millet in the year 2011, 2012 and 2013, respectively.

Aggressivity

Aggressivity (-2.44) of finger millet was negative and those of legume (2.44) was positive indicating finger millet a dominated species and legumes as dominant species (Maitra *et al.*, 2002). Sarkar and Pal (2004) at Kolkata recorded Aggressivity (A) factor for rice which was only aggressive under 2:2 row ratio with both groundnut and pigeon pea than the ratio 2:1, 4:1, 6:1, 4:2 and 6:2, respectively. At New Delhi, Ahlawat *et al.*, (2005) reported that aggressivity of chick pea

was negative in all the intercropping systems. The aggressivity (A) of Indian mustard increased with increasing row ratio of chick pea + Indian mustard from 2:1 to 4:1, this increase was noticed in chick pea + barley only up to 3:1 row ratio. In chick pea + linseed intercropping system, linseed aggressivity decreased with increasing row ratio from 2:1 to 4:1. Mahale (2006) at Dapoli recorded that aggressivity (A) index was maximum in sesame + groundnut in 1:3 ratio with 0 kg S ha⁻¹ in case of sesame over all the treatment combinations. Aggressivity index of groundnut was negative indicating the dominance of sesame in intercropping system. Sharma *et al.*, (2006) at Palampur (HP) found that the negative aggressivity (A) of intercrop except rajma with cabbage and cauliflower in all the arrangement indicated poor competitiveness of intercrop than the vegetable which had positive aggressivity (A) in a cabbage + French bean, potato + rajma, potato + French bean, tomato + rajma tomato + French bean. Padhi *et al.*, 2010 at Agriculture Research Station Berhamapur (Orissa) recorded that highest aggressivity (A) in UPAS- 120 sown at 2:4 row ratio than TTB- 7 sown at 2:8 row ratio. Jakhar *et al.*, (2015) studied the performance of finger millet and groundnut based strip cropping in ratio 6:4, 8:4, 10:4 and 12:4. The aggressivity (A) values for the entire strip cropping ratio were negative which indicated that finger millet have shown dominance over groundnut. Dominance was the lowest in 10:4 row ratio.

Relative crowding coefficient

Maitra *et al.*, (2000) worked out Relative crowding coefficient for different intercropping systems and found that intercropping pigeon pea with finger millet had higher yield advantage (49.85) than finger millet + green gram (5.81), finger millet + groundnut (9.16), finger millet + soybean

(6.40). Sarkar and Pal (2004) from Kolkata reported the RCC values of rice which were greater than 1, indicating that rice gave more yield than expected. The crowding coefficient indicated that it was advantageous to grow rice with groundnut at 2:1, 4:1 and 6:1 ratio and pigeon pea at 2:1, 4:1 and 6:1 ratio, which gave higher values than unity. Ahlawat *et al.*, (2005) from New Delhi reported that RCC was higher in 2:1 row ratio of chick pea + barley and 4:1 row ratio of chick pea + linseed than other treatments. Sharma *et al.*, (2006) at Palampur reported the highest relative crowding coefficient that was noticed in cauliflower + French bean ratio showing the highest yield advantage than other treatment.

Competitive Ratio (CR)

Jakhar *et al.*, (2015) in strip combination of finger millet and groundnut 6:4 row proportion recorded that higher value (1.33) of CR for finger millet of its intercropping with groundnut which indicated that it was more competitive to groundnut because it had rapid initial growth rate leading to competition for resources with finger millet.

Intercropping and nutrient uptake

Mahadkar (1983) reported that mixture of finger millet + black gram had significantly higher total uptake of nitrogen *i.e.* 41 kg ha⁻¹ followed by green gram and mothbean combination. Geeta kumari and Shivshankar (1991) studied intercropping of ragi and soybean and observed that available P status of soil was more in intercropping plot and the uptake of N and P was more by pure crop of ragi and soybean due to competition for factors like light, space, moisture etc. in the intercropping system. Tomar *et al.*, (1997) studied the response of wheat based intercropping system to N fertilizer levels. Sole lentil recorded highest N uptake over the

cropping system followed by chickpea. Application of 90 Kg N ha⁻¹ recorded higher N uptake than 0, 30 and 60 kg N ha⁻¹. Intercropping of pulses with cereals and other non-legume companion crops have certain in built advantage over pure cropping. Further they have recorded that, pulses leave 20 - 25kg ha⁻¹ of nitrogen in the soil at the time of harvest, which is utilized by the subsequent crop and tremendous leaf fall will form best source of organic matter (Velayutham and Somasundaram, 2000).

Jha *et al.*, (2000) conducted a field experiment at Agricultural College Farm, Dholi, Bihar and concluded that uptake is a function of yield, naturally higher uptake was recorded where yield was higher due to increased application of fertilizer particularly Nitrogen.

Oberson *et al.*, (2001) from a field experiment conducted at the Carimagua Research Station, Colombia on maize + soybean or rice + cowpea intercropping system observed that legume based cropping systems maintained higher organic and available P levels than non legumes in rotation. Greater turnover of roots and above ground litter in legume-based intercropping could provide steadier organic inputs and therefore, high P cycling and availability.

Intercropping and monetary return

Economics of particular intercropping system is supposed to be the most important aspect from the crop production point of view. Intercropping aims at maximum production and net return per unit of time and space. Though the yield of main crop was reduced due to inclusion of component crop in intercropping systems, higher monetary return was recorded by many research workers in India, which is attributed to the bonus obtained from component crop

Intercropping is a profitable practice under rainfed condition. Growing of two or more crops on the same piece of land having different rooting capacity exploit the available resources from the soil to the fullest extent. Thus, increasing the overall production and monetary returns (Aiyer, 1949).

Intercropping of finger millet with cowpea in 2:1 row ratio recorded higher net return (Rs 2648 ha⁻¹) than the sole crop of finger millet and in ratios of 3:1 and 6:1 row ratio, Reddy *et al.*, (1983). Thorat *et al.*, (1986) reported that sole crop of groundnut gave significantly higher net return of Rs 2617.50 ha⁻¹ over all the treatments except finger millet + groundnut intercropping in 1:1 proportion which recorded the maximum net return of Rs 1948.74 ha⁻¹ which was statistically at par with the net return given by 2:1 proportion of the same crop combination. This accounts additional increase of Rs 1383.50 ha⁻¹ and Rs 1296.13 ha⁻¹, respectively over the net return given by the sole crop of finger millet.

Finger millet + black gram intercropping in 1:1, 2:1, 3:1 proportion on area basis recorded maximum net return of Rs. 1715.96, 1562.11 and 1477.15 ha⁻¹ respectively, Mahadkar and Khanvilkar (1988), Jadhav *et al.*, (1992) reported that intercropping of finger millet with urd bean and okra in 4:2 row proportion gave a maximum net return of Rs. 3,615 and 3,579 ha⁻¹ with a cost: benefit ratio of 2.21 and 1.45, respectively. Higher gross return in finger millet + pigeon pea 8:2 intercropping system as compared to finger millet + field bean 8:2 intercropping system and sole crop of finger millet were reported by Shankarlingappa and Hegde (1992). Singh and Arya (1999) from Ranichauri (Uttaranchal) reported higher net return and B: C ratio under mixed cropping of finger millet + soybean (9:1 seed mixture) as compared to finger millet + rice bean mixed cropping system and sole crop of finger

millet. Maitra *et al.*, (2000) from Shriniketan (West Bengal) reported that intercropping of finger millet + pigeon pea and finger millet + groundnut at 4:1 row proportion recorded higher monetary net returns and benefit : cost ratio than finger millet + green gram, finger millet + soybean and sole finger millet. Chakraborty *et al.*, (2002) conducted experiment to study the efficiency of bio-fertilizer on finger millet raising the level of nitrogen from 0 to 80 kg ha⁻¹. The highest total return was recorded by *Azospirillum* +80 kg N ha⁻¹ (Rs 7893 ha⁻¹) which was more or less same with 80 kg N ha⁻¹ (Rs 7720 ha⁻¹). From Hanumanamatti (Karnataka), Shashidhara (2000) reported higher net return (Rs. 7285 ha⁻¹) and B: C ratio (4.29) due to intercropping of finger millet with pigeon pea in 4:2 row ratio as compared to 3:1 and 5:1 row ratios (Rs. 5625 and 6672 ha⁻¹ of net returns and 3.24 and 3.99 B:C ratio, respectively)

Net returns of Rs. 23277 ha⁻¹ and benefit: cost ratio 5.90 were recorded under strip cropping of finger millet + pigeon pea as compared to sole crop of finger millet Rs 14854 ha⁻¹ net return and 4.30 B:C ratio, Ramamoorthy *et al.*, (2003). Ved Prakash *et al.*, (2005) at Almora (Uttaranchal) reported relay cropping of wheat in finger millet (transplanted) + pigeon pea (4:1) registered higher gross return (Rs. 58799 ha⁻¹), net return (Rs 23149 ha⁻¹) and benefit: cost ratio (1.65) compared to relay cropping of wheat in finger millet (drilled) + pigeon pea (4:1) was found to be the next best in terms of gross return (Rs 56274 ha⁻¹), net return (Rs 20274 ha⁻¹) and benefit: cost ratio (1.56). In intercropping system of pigeon pea (UPAS. 120) + finger millet (Bhairabi) was found to be the most economic followed by UPAS. 120 + PR 202 with comparable net returns at 2:4 ratio (Padhi *et al.*, 2010).

Murali *et al.*, (2014) reported that intercropping of finger millet + pigeon pea (transplanted) with 4 week old seedling gave maximum net returns Rs 26,218 ha⁻¹ with B:C ratio 2.49 compared to finger millet + direct sown pigeon pea (Rs 4,974 to Rs 13,899 ha⁻¹ with B:C ratio of 1.37 to 2.02). Jakhar *et al.*, (2015) from Odisha reported that strip cropping of finger millet + groundnut in different ratio resulted in to maximum net returns from 6:4 row ratio. B:C ratio (2.87) was highest as compared to all the treatments.

The literature on economics of intercropping system clearly indicated that finger millet based intercropping system accounted for higher economic returns than sole cropping. Among the intercropping systems, finger millet + pigeon pea / soybean / urd / bean / okra accounted for higher economic returns than other system of finger millet with field bean / cowpea / green gram.

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