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Effect of nitrogen levels and intercropping on yield and economics of finger millet (*Eleusine coracana* G.)

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Abstract
The experiment was laid out in split-plot design with three replications. The main plot treatment comprised of intercropping system in 1:1, 2:1, 3:1, 1:2 and 1:3 row ratio along with sole finger millet and groundnut and sub plot treatments consisted of three nitrogen levels *viz*. 100% RDN, 75% RDN and 50% RDN + *Azospirillum* / *Rhizobium.* The most of the yield attributes and Finger millet equivalent yield were higher under intercropping of Finger millet + Groundnut in 1:3 row ratio with 100% RDN ha^{-1}. Total biomass yield was higher in sole groundnut than intercropping system. The economic indices *viz*.LER, RCC and ATER showed better performance of intercropping of Finger millet + Groundnut in 1:2 row ratio with 100% RDN ha^{-1}. However, intercropping of Finger millet + Groundnut in 1:3 row ratio with 100% RDN ha^{-1} realized higher net returns (Rs 119796 ha^{-1}) and B: C ratio (1.92).

Keywords: Snail, bovine, porcine, physicochemical properties, mucin, mucoadhesives

Introduction
Finger millet (*Eleusine coracana* G.) is an important food grain crop of semi-arid tropics particularly of India and East Africa. Nutritional status of this crop is quite good as it contain protein 9.2 percent, fat 1.29 percent, carbohydrates 76.32 percent, minerals 2.24 percent, ash 3.90 percent, calcium 0.33 percent and vit. A, B and phosphorus in smaller quantity. Beneficial effect of Finger millet + Groundnut intercropping in plains of semi-arid dryland areas are reported by CRIDA (2002) and found intercropping legumes with finger millet distinctly advantageous over sole cropping. As the nutrient needs of intercropping system may be differ from monoculture of their component crops, it is therefore, important to standardize the most profitable level of nitrogen for intercropping system. In any successful intercropping, the pattern of crop geometry should be such that it should offer maximum utilization of all the resources. Hence present investigation was conducted to ensure better interaction of the resources and to improve the profitability of the system.

Materials and Methods
The experiment was laid out in split-plot design with three replications. The main plot treatment comprised intercropping system in 1:1, 2:1, 3:1, 1:2 and 1:3 row ratio along with sole finger millet and groundnut and sub plot treatments consisted of three nitrogen levels *viz*. 100% RDN, 75% RDN and 50% RDN + *Azospirillum/Rhizobium.* The soil of the experimental plot was uniform, level and well drained. It was sandy clay loam in texture, low in available nitrogen (243.00 Kg ha-1), available phosphorus (10.80 Kg ha-1), moderately high in available potassium (231.22 Kg ha-1), medium in organic carbon (12.22 g kg-1) and slightly acidic in reaction (pH 5.49). The sowing was done in the experimental plot on 13th June, 2016 by drilling method at a distance of 30 x 10 cm and by dibbling method at a distance of 30 x 15 cm in respect of finger millet and groundnut, respectively. The other common package of practices was followed time to time and periodical growth observations were recorded. 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.

Results and Discussion
Yield studies
Thus sole finger recorded highest grain and straw yield over rest of the treatments followed by intercropping of Finger millet + Groundnut (3:1) thus two treatments found significantly superior to rest of the treatments because of higher plant population per unit area. Plant intercropped with groundnut were more efficient in production of dry matter.

This clearly indicated that higher photosynthetic efficiency and less competition for nutrient and other resources. These result are in accordance to the results reported Singh and Arya (1999).

Every increase in nitrogen levels significantly increased in grain and straw yield of finger millet. Higher yield attributes under 100% RDN level might be due to fulfillment of crop need with increased nitrogen levels. The higher value of growth and yield attributes under 100% RDN reflected in significantly higher grain and straw yield of finger millet compared to rest of treatments. Application of 100% RDN recorded maximum and significantly higher grain, straw and biological yield over rest of the treatments.

Effect of intercropping on groundnut

Regarding the performance of intercrop *viz*. groundnut grown with finger millet, it was observed that there was marked increase in the growth observations such as height, number of leaves branches and dry matter per plantin 1:3 row ratio. Similarly, yield attributing characters of intercrop were also influenced in similar manner due to intercropping with finger millet in 1:3 row ratio. This has finally resulted in comparatively better yield of this intercrop with their increased proportion with finger millet intercropping systems similar type of findings were also reported by Jakhar *et al*. (2015) [4]

Indices of intercropping system

The land equivalent ratio (LER) values in different intercropping system were greater than unity, indicating the yield advantage tht was achieved from intercropping system. Similar observations were made by Jadhav *et.al.* (1992) [3] Singh and Arya (1999) and Girish (2004) [2]. The higher LER was recorded under finger millet + groundnut intercropping system in 1:2 application of 100% RDN, closely followed by finger millet + groundnut 1:3 row ratio. In finger millet + groundnut 1:2 row ratio, the finger millet yield was increased but there was slightly decrease in groundnut yield as compared to other treatments except in 1:1 row proportion. There was multifold increase in finger millet yield. Therefore, higher LER values were recorded in above referred treatment combination. Higher FEY (54.03 q ha^{-1}) was obtained in finger millet + groundnut 1:3 row ratio with application of 100% RDN. This was closely followed by finger millet + groundnut in 1:2 proportion over sole finger millet. This was due to the higher market price of groundnut that coupled with better utilization of resources of the component crop in intercropping system. Sing and Arya (1997), Jena *et.al*. (2002), Ramamoorthy *et al*. (2003) [8] and Jakhar *et al*. (2015) [4] had reported similar type results. Relative crowding coefficient values of both the crop were found to greater than unity indicating that, each species gave more yield than expected yield. This is due to mutual co-operation as reported by Maitra *et al*. (2000), Ahlawat *et al*. (2005) [1] and Sharma (2006) [9]. The highest RCC value was obtained under intercropping of finger millet + groundnut 1:2 in row proportion with the application of 100% RDN followed by intercropping of finger millet + groundnut 1:3 row proportion. In case of finger millet + groundnut at all the row ratios showed that the aggressivity values of finger millet were positive and for those of groundnut were negative. It was observed that aggressivity index was maximum or positive for finger millet when grown in combination with groundnut. Finger millet + Groundnut (1:3) recorded higher aggressivity index in case of finger millet over all the treatment combinations. Aggressivity index of groundnut was negative indicating the dominance of finger millet in all intercropping combinations. Similar type of findings were also reported by Maitra *et al*. (2000) and Alawat *et al*. (2005) [1].

The competitive ratio of finger millet with groundnut recorded due to different treatment combinations indicated that competitive ratio values for finger millet were less than 1 in treatment Finger millet + Groundnut (2:1) and Finger millet + Groundnut (3:1) proportion and it was lowest under treatment of Finger millet + Groundnut (3:1); while on the other hand it was more than one under treatment T3, T6 and T7. The competitive ratio was maximum under T7. In case of groundnut, competitive ratio was less than one under all the treatments except treatment T4. The competitive ratio value of groundnut was lowest under T7and the highest value recorded under treatment T5. Jakhar *et al*. (2015) [4] reported similar type of finding under strip cropping of finger millet and groundnut. The values of Area-Time Equivalent Ratio (ATER) recorded in relation to different intercrop combinations are given in Table 1-2. Higher area-time equivalent ratio was recorded with the treatment T6 (Finger millet + Groundnut 1:2 row proportion) with 100% RDN and it was lowest under treatment T2 (Sole groundnut). In general, the ATER values increased with increase in proportion of finger millet as well as the level of nitrogen in the intercropping combination.

Economics of treatment combinations

Data from table No 3 revealed that the maximum net profit of Rs/-128157 ha^{-1} was obtained when groundnut crop was sown by as sole crop over remaining treatment combinations. Where Sole finger millet with 50% RDN + *Azo*. reported lowest value of net profit Rs/- 16015 and cost benefit ratio 1.30 over intercropping treatment. Among intercropping treatment T7 with application of (100% RDN) obtained maximum net profit (Rs/- 119796 ha^{-1}) and B: C ratio (1.92).With respect of intercropping treatment T5 with application of 50% RDN obtained minimum net profit (Rs/- 19254 ha^{-1}) and B: C ratio (1.22). It was observed that from this finding the application of (50% RDN) was recorded minimum net profit and cost benefit ratio. These result are in line with that reported by Jakhar*et al*. (2015) [4].

Table 1: Mean grain and straw yield of finger millet (q ha^{-1}) and dry pod yield, haulm yield and kernel yield groundnut (q ha^{-1}) as affected by different treatments.

Treatment	Finger millet (q ha^{-1})		Groundnut (q ha^{-1})		
	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Dry pod yield (q ha^{-1})	Haulm yield (q ha^{-1})	kernel yield (q ha^{-1})
Main Plot Treatments (Intercropping)					
T_1. Sole Finger millet	19.03	54.04	28.96	34.40	19.62
T_3. Finger millet + Groundnut 1:1)	15.54	40.49	13.45	18.04	9.26
T_4. Finger millet+Groundnut (2:1)	15.63	43.60	12.55	16.92	8.67
T_5. Finger millet + Groundnut (3:1)	16.91	47.14	7.16	12.15	4.93
T_6. Finger millet + Groundnut (1:2)	15.74	37.02	19.02	22.20	13.20
T_7. Finger millet + Groundnut (1:3)	11.20	27.84	21.90	25.45	14.80
S.E. ±	0.58	1.22	0.70	0.66	0.50
CD at 5%	1.67	3.51	2.02	1.90	1.44
Sub Plot Treatments (Nitrogen Levels)					
N_1. 100% RDN	17.29	43.94	19.05	23.18	12.93
N_2.75% RDN	15.87	40.88	17.28	21.56	11.81
N_3. 50% RDN + *Rhizo. /Azo*.	14.84	39.43	15.19	19.82	10.48
S.E. ±	0.41	0.85	0.49	0.47	0.36
CD at 5%	1.18	2.45	1.42	1.35	1.03
Interaction					
S.E. ±	1.00	2.08	1.23	1.18	0.88
CD at 5%	NS	NS	NS	NS	NS
General Mean	16.00	41.42	17.17	21.52	11.74

Table 2: Indices as observed in various treatment combinations.

	LER		Total LER	CEY		RYT	Aggressivity		Competitive Ratio		RCC		ATER
	F'millet	G'nut		FEY	G'nut		F'millet	G'nut	F'millet	G'nut	F'millet	G'nut	
T1N2	1.00	0.00	1.00	19.14	-	0.500	-	-	-	-	-	-	1.000
T1N3	1.00	0.00	1.00	18.54	-	0.500	-	-	-	-	-	-	1.000
T2N1	0.00	1.00	1.00	-	31.54	0.500	-	-	-	-	-	-	0.846
T2N2	0.00	1.00	1.00	-	30.46	0.500	-	-	-	-	-	-	0.846
T2N3	0.00	1.00	1.00	-	24.86	0.500	-	-	-	-	-	-	0.846
T3N1	0.87	0.44	1.31	34.34	6.81	0.630	0.854	-0.854	1.968	0.508	6.56	0.79	1.241
T3N2	0.82	0.48	1.30	35.81	6.37	0.619	0.692	-0.692	1.727	0.579	4.63	0.91	1.225
T3N3	0.75	0.48	1.24	29.44	5.69	0.612	0.557	-0.557	1.581	0.633	3.14	0.92	1.164
T4N1	0.91	0.43	1.34	33.48	7.13	0.666	0.052	-0.052	1.040	0.961	4.85	1.53	1.272
T4N2	0.80	0.43	1.23	32.32	6.18	0.632	-0.111	0.111	0.915	1.093	1.95	1.53	1.162
T4N3	0.75	0.44	1.20	27.17	5.66	0.638	-0.216	0.216	0.839	1.192	1.51	1.61	1.129
T5N1	0.91	0.17	1.08	13.30	7.14	0.557	0.529	-0.529	1.775	0.563	3.34	0.62	1.054
T5N2	0.91	0.22	1.13	16.69	7.00	0.569	0.321	-0.321	1.362	0.734	3.24	0.86	1.094
T5N3	0.85	0.38	1.22	23.02	6.37	0.479	-0.368	0.368	0.755	1.325	1.88	1.80	1.166
T6N1	0.87	0.69	1.56	50.52	6.83	0.778	1.602	-1.602	2.546	0.393	13.63	1.12	1.457
T6N2	0.81	0.59	1.40	46.04	6.29	0.723	1.582	-1.582	2.799	0.357	8.77	0.71	1.310
T6N3	0.80	0.69	1.49	44.12	6.00	0.614	1.385	-1.385	2.340	0.427	8.02	1.11	1.384
T7N1	0.79	0.74	1.54	58.00	6.23	0.810	2.181	-2.181	3.484	0.287	11.52	0.97	1.424
T7N2	0.64	0.71	1.35	44.29	5.00	0.662	1.622	-1.622	2.724	0.367	5.35	0.80	1.238
T7N3	0.64	0.83	1.48	44.30	4.83	0.667	1.462	-1.462	2.315	0.432	5.41	1.67	1.348

Table 3: Mean total cost, gross return, net return and B: C ratio as influenced by different treatments.

Treatments	Total cost (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Intercropping				
T1. Sole finger millet	55107	72459	17351	1.31
T2. Sole Groundnut	130440	241505	111065	1.85
T3. Finger millet + Groundnut (1:1)	106763	170546	63783	1.59
T4. Finger millet + Groundnut (2:1)	103239	164007	60769	1.58
T5. Finger millet + Groundnut (3:1)	91505	124514	33009	1.35
T6. Finger millet + Groundnut (1:2)	119928	214339	94411	1.78
T7. Finger millet + Groundnut (1:3)	124938	230529	105591	1.84
Nitrogen levels				
N1. 100% RDN ha-1	109262	190966	81704	1.70
N2. 75% RDN ha-1	104744	174616	69873	1.62
N3. 50% RDN ha-1 + *Rhizo. /Azo*.	99675	156375	56699	1.53

Conclusion

It can be concluded that to obtained higher grain and straw yield ha^{-1}, net returns and higher benefit: cost Finger millet + Groundnut should be grown in 1:3 row ratio with the application of 100% RDN. As groundnut enhanced the growth and yield of finger millet as it is remunerative intercrop.

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