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EVALUATION OF RAINFED GROUNDNUT UNDER INTEGRATED NUTRIENT MANAGEMENT PRACTICES IN HARDWIKIA BASED AGRI-SILVI SYSTEM

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ABSTRACT
A field experiments was conducted to study the economical performance of ground nut in hardwickia plantation under different integrated nutrient management at Students' Farm on red sandy loam soil. The results showed that the pod yield of groundnut was significantly higher (948.2 kg ha^{-1}) in solecropping than the intercropping of groundnut in unpollarded hardwickia. But the groundnut pod yields under pollarded hardwickia were atpar to that of solecropped groundnut. Maximum pod yield was obtained by application of recommended dose of NPK + vermicompost (896.2 kg ha^{-1}) and enriched FYM with recommended dose of NPK (877.8 kg ha^{-1}) during both the years. The total gross, net monetary returns and Profit per rupee investment from the system (tree + crop) were increased under intercropping situation where trees were pollarded. Intercropping of groundnut in pollarded hardwickia trees with recommended dose of NPK with combination of vermicompost gave the maximum total gross monetary returns (28157 Rs ha^{-1}) and followed by enriched FYM (27949 Rs ha^{-1}). Whereas, total net monetary returns (20359 & 18711 Rs ha^{-1}) and profit per rupee investment (2.63 & 2.53) from the system increased to the maximum extent when groundnut was applied with recommended dose of NPK along with enriched FYM.

INTRODUCTION

Traditional resource management adaptations such as agro-forestry systems may potentially provide options for improvement in livelihoods through simultaneous production of food, fodder and firewood as well as mitigation of the impact of climate change. Suitable alternate land use systems involving agriculture, horticulture, forestry and agroforestry has been designed with the support of local natural resources for almost identical hydrological behaviour as under the natural system. Sequestering carbon in tree biomass by way of integrating trees into landscapes as agroforestry, forestry and plantations is a cost-effective climate change mitigation strategy (Josep G. Canadell, *et al.,* 2008 and Prasad, *et al.,* 2012). Suitably selected trees in an agroforestry system enhance the system productivity and act as sink for atmospheric carbon. The system as a whole contributes to mitigate climate change with secondary benefits of food security, increased farm income, restored biodiversity, maintained watershed hydrology and improved soil health and people livelihood (Roy and Tewari, 2012 and Singh G *et al.,* 2007). Escalating cost of inorganic fertilizers, their undesirable impact on the physical condition of soil, erratic rainfall and poverty call for immediate inclusion of organic sources in any rainfed cropping system. The combined use of organic with inorganic fertilizers not only helps to improve the yield of crop but also helps in improving the soil health and soil fertility (Anand *et al*., 2016 and Zahida *et al.,* 2016). Hence, Keeping in view of importance of agroforestry, an experiment was carried out to evaluate the effects of different integrated nutrient management on yield and economics of agroforestry system in dry lands.

MATERIALS AND METHODS

A field experiment was conducted during two *kharif* seasons at Students' Farm, College of Agriculture, Rajendranagar and Hyderabad. The experimental site was under ten years old hardwickia plantation spaced at 4m x 4m. The soil in hardwickia plantation was red sandy loam, medium in organic carbon ranges (0.66 - 0.67 %), available N (314.5 - 319 kg ha^{-1}), available P (37.4 - 38.2 kg ha^{-1}) and available K (236 - 237 kg ha^{-1}) during two years, whereas the open area was low in organic carbon (0.28 - 0.30 %) and available N (189.8 -190.3 kg ha^{-1}), medium in available P (26.4 - 26.8 kg ha^{-1}) and available K (216.5 - 217.4 kg ha^{-1}) during two years. The treatments comprised of 3 cropping situations *viz.,* intercropping of groundnut in pollarded hardwickia, intercropping of groundnut in unpollarded hardwickia and solecropping of groundnut as main plots and seven integrated nutrient management practices as sub plots *viz.,* recommended dose of NPK (20:40:40), recommended dose of NPK + FYM (10 t ha^{-1}), recommended dose of NPK + vermicompost (2 t ha^{-1}), enriched FYM (750 kg ha^{-1}) with recommended dose of NPK, 50 % recommended dose of NPK + FYM (10 t ha^{-1}), 50 % RDF + vermicompost (2 t ha^{-1}) and enriched FYM (750 kg ha^{-1}) with 50 % RDF. The experiment was laid out in split plot design with three replications. The plot sizes were 4m x 4m in

intercropping and solecropping as well. Hardwickia trees were cut above 3 m height under the treatment of intercropping of groundnut in pollarded hardwickia during both the years of study. The groundnut variety TMV - 2 was selected as intercrop and sown at recommended spacing both in intercropping and solecropping situations. Groundnut was grown as rainfed crop in the system. The total rainfall was received in the cropping season was 800 mm rainfall distributed in 41 rainy days during first year and 498 mm rainfall distributed in 35 rainy days during second year. The data recorded on various parameters were subjected to Fisher's method of analysis of variance (Fisher, 1948) and interpretation of data as given by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Pod yield

It was clearly noticed from the yield data that the pod yields increased to the maximum extent when groundnut was grown as solecrop in comparison with intercropping of groundnut in pollarded hardwickia trees by 20.7 % and 140.9 %, respectively during first year and by 28.0 % and 127.8 % respectively during second year. Whereas, there was drastic decrease in both pod yields under intercropping situation when groundnut grown in unpollarded trees. Similar trend was observed in harvest index also. Greater yields were recorded in solecropped groundnut as well as intercropped groundnut in pollarded trees and this could be attributed to resultant effects of favourable plant growth and better yield attributes obtained in these situations where there was no competition absolutely on natural resources available. These results are in agreement with the findings of Bheemaiah and Subramanyaman (2002) and Madhukar Rao (2005).

The perusal of yield data clearly revealed that among the integrated nutrient management practices studied, application of recommended dose of NPK with combination of vermicompost as well as enrichment of FYM recorded the maximum pod yields. However application of FYM along with recommended dose of NPK also was found effective in enhancement of pod yields when compared to application of 50 % recommended dose of NPK with the combination of different organic manures. Higher pod yields obtained with recommended dose of NPK could be due to adequate supply of essential nutrients and also application of vermicompost and enrichment of FYM might have helped steady supply of nutrients because of favourable soil properties maintained throughout the crop growth period. Sagare *et al*. (1992) stated that an increase in pod yield of groundnut due to recommended dose of fertilizer application with combination of organic manures which might be attributed to enhanced synthesis of carbohydrates and proteins. Similar results were obtained by Singh *et al*. (2001) and Das (2002).

Monetary returns from groundnut crop under different cropping situations and integrated nutrient management practices in hardwickia based agrisilvicultural system

Under the combination of cropping situations and integrated nutrient management practices, groundnut grown as solecrop gave maximum gross and net monetary returns at all the levels of integrated nutrient management practices when compared to the respective integrated nutrient management practices under intercropping situations. Similar results were obtained by Joseph *et al*. (1999). Maximum gross monetary returns from the crop were obtained with the application of vermicompost as well as enriched FYM along with recommended dose of NPK under solecropping situation which was followed by recommended dose of NPK + FYM under the same cropping situation. However, intercropped groundnut in pollarded hardwickia trees also proved effective in obtaining higher gross monetary returns from the crop with the application of vermicompost and enriched FYM along with recommended dose of NPK followed by recommended dose of NPK + FYM. Whereas the net monetary returns from the crop were found maximum in enrichment of FYM with recommended dose of NPK as well as recommended dose of NPK + FYM followed by recommended dose of NPK + vermicompost under solecropping situation. Intercropped groundnut also showed better returns under same set of integrated nutrient management practices. Both gross and net monetary returns were badly affected under intercropping situation in unpollarded hardwickia trees. Negative values were

Table 1: Pod yield (kg ha^{-1}) of groundnut as influenced by cropping situations and integrated nutrient management practices in agrisilvicultural system

Treatments	I year				I lyear			
	Cropping Situations (CS)				Cropping Situations (CS)			
Integrated Nutrient Management (INM)	IPH	IUPH	SC	Mean	IPH	IUPH	SC	Mean
RDF (20: 40: 40 kg ha^{-1})	786.9	402.7	914.8	701.5	669.8	396.2	866.5	644.1
RDF + FYM (10 t ha^{-1})	924.5	470.7	1047.8	814.3	755.2	464.8	966.4	728.8
RDF + Vermicompost (2 t ha^{-1})	1027.1	528.7	1132.8	896.2	925.8	508.8	1079.8	838.2
Enriched FYM (750 kg ha^{-1}) with RDF	1017.1	494.0	1122.4	877.8	929.1	518.8	1083.0	843.6
50 % RDF + FYM (10 t ha^{-1})	536.3	257.0	771.1	521.5	453.3	256.1	659.5	456.3
50 % RDF + Vermicompost (2 t ha^{-1})	607.9	297.2	827.9	577.7	527.1	269.1	733.1	509.8
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	597.3	304.7	820.7	574.2	524.8	275.5	737.5	512.6
Mean	785.3	393.6	948.2		683.6	384.2	875.1	
	SEm ±		CD (P = 0.05)		SEm ±		CD (P = 0.05)	
CS	32.73		90.87		23.29		64.64	
INM	19.51		39.58		23.87		48.43	
CS x INM at main	33.79		68.56		41.34		83.89	
CS x INM at sub	81.19		196.43		59.13		131.93	

IPH - Intercropping in pollarded hardwickia; IUPH - Intercropping in unpollarded hardwickia; SC - Solecropping; NS- Non Significant ; RDF (recommended dose of NPK)

Table 2: Gross and net monetary returns (Rs ha^{-1}) and profit per rupee investment from groundnut crop as influenced by cropping situations and integrated nutrient management practices in agrisilvicultural system

Treatments	I year Gross returns	Net returns	Profit per rupee investment	II year Gross returns	Net returns	Profit per rupee investment
Intercropping in pollarded hardwickia						
RDF (20: 40: 40 kg ha^{-1})	16525	9875	1.48	14065	7615	1.18
RDF + FYM (10 t ha^{-1})	19415	11415	1.43	15859	8059	1.03
RDF + Vermicompost (2 t ha^{-1})	21567	10767	0.99	19442	8842	0.83
Enriched FYM (750 kg ha^{-1}) with RDF	21359	14269	2.00	19511	12621	1.82
50 % RDF + FYM (10 t ha^{-1})	11263	3993	0.55	9520	2445	0.35
50 % RDF + Vermicompost(2 t ha^{-1})	12766	2691	0.27	11069	1194	0.12
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	12544	6179	0.97	11020	4855	0.79
Mean	16491	8455	1.10	14355	6519	0.87
Intercropping in unpollarded hardwickia						
RDF (20: 40: 40 kg ha^{-1})	8456	1806	0.27	8320	1870	0.29
RDF + FYM (10 t ha^{-1})	9884	1884	0.24	9760	1960	0.25
RDF + Vermicompost (2 t ha^{-1})	11102	302	0.03	10685	85	0.01
Enriched FYM (750 kg ha^{-1}) with RDF	10374	3099	0.44	10894	4004	0.58
50 % RDF + FYM (10 t ha^{-1})	5398	-1877	- 0.26	5378	-1697	- 0.24
50 % RDF + Vermicompost(2 t ha^{-1})	6241	-3834	- 0.38	5651	- 4224	- 0.43
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	6398	-33	- 0.01	5786	- 379	0.06
Mean	8265	1344	0.33	8068	1619	0.40
Solecropping						
RDF (20: 40: 40 kg ha^{-1})	19211	12561	1.89	18197	11747	1.82
RDF + FYM (10 t ha^{-1})	22005	14005	1.75	20295	12495	1.60
RDF + Vermicompost (2 t ha^{-1})	23789	12989	1.20	22678	12077	1.12
Enriched FYM (750 kg ha^{-1}) with RDF	23571	16481	2.32	22743	15853	2.30
50 % RDF + FYM (10 t ha^{-1})	16193	8918	1.23	13850	6775	0.96
50 % RDF + Vermicompost(2 t ha^{-1})	17386	7311	0.73	15395	5520	0.56
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	17234	10869	1.71	15488	9323	1.51
Mean	19913	11876	1.55	18378	10541	1.41

also recorded in net monetary returns with the application of 50 % recommended dose of NPK + FYM 50 % recommended dose of NPK + vermicompost and enrichment of FYM with 50 % recommended dose of NPK. The increased gross and net monetary returns with the application of enriched FYM, vermicompost and FYM either in solecropping or intercropping of groundnut was mainly due to improvement in soil physical properties which might have resulted in efficient nutrient uptake by the plant with application of recommended dose of NPK to the crop. The addition of these organic manures especially enriched FYM and vermicompost helped the crop throughout its growth period by adequate and fast supply of nutrients and moisture which ultimately resultant in higher pod yields of groundnut. These results are in agreement with the findings of Pooranchand *et al*. (2004).

Similar trend was observed in profit per rupee investment under combination of cropping situations and integrated nutrient management practices. The highest profit per rupee investment was obtained in enrichment of FYM with recommended dose of NPK under solecropping situation followed by enrichment of FYM with recommended dose of NPK under intercropping of groundnut in pollarded hardwickia. Profit per rupee investment was found to be very low under intercropping situation in unpollarded hardwickia trees at all levels of integrated nutrient management practices.

Total monetary returns from the hardwickia based agrisilvicultural system under different cropping situations and integrated nutrient management practices

From the economic evaluation of cropping situations in hardwickia based agrisilvicultural system revealed that the total monetary returns increased substantially when tree and crop components were taken into account in the system. Thus, it was clearly evident that intercropping of groundnut in pollarded hardwickia trees showed maximum gross and net monetary returns when compared to those solecropping groundnut. There was considerable reduction in monetary returns under intercropping situations in unpollarded hardwickia trees. The improved monetary returns from the system (tree crop) when groundnut crop was grown in pollarded trees was mainly due to additional advantage of value added products from the hardwickia trees in the form of poles, fuel, wood and fodder coupled with better performance of growth and yield of groundnut crop whereas reduction in monetary returns in intercropped groundnut in unpollarded trees even when compared to solecropped groundnut was mainly due to severe competition specially for light, because of spreading crown of uncut trees in this cropping situation. Hence, the presence of trees in this cropping situation could not compensate the monetary returns to the returns obtained by solecropped groundnut which was found better. This shows clearly that arable crop like groundnut when grown as an intercrop in the trees should have compatibility with the trees in mutual sharing of natural resources available. Profit per rupee investment was also found to be maximum under

Table 3: Total Gross and Total net monetary returns (Rs ha^{-1}) and profit per rupee investment from the system (tree + crop) as influenced by cropping situations and integrated nutrient management practices in agrisilvicultural system

Treatments	I year Total gross returns	Total net returns	Profit per rupee investment	II year Total gross returns	Total net returns	Profit per rupee investment
Intercropping in pollarded hardwickia						
RDF (20: 40: 40 kg ha^{-1})	23115	15965	2.23	20655	13705	1.97
RDF + FYM (10 t ha^{-1})	26005	17505	2.06	22449	14149	1.71
RDF + Vermicompost (2 t ha^{-1})	28157	16857	1.49	26032	14932	1.35
Enriched FYM (750 kg ha^{-1}) with RDF	27949	20359	2.68	26101	18711	2.53
50 % RDF + FYM (10 t ha^{-1})	17853	10078	1.30	16110	8535	1.13
50 % RDF + Vermicompost (2 t ha^{-1})	19356	8781	0.83	17659	7284	0.70
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	19134	12269	1.92	17610	10945	1.64
Mean	23081	14544	1.76	20945	12609	1.57
Intercropping in unpollarded hardwickia						
RDF (20: 40: 40 kg ha^{-1})	15046	8396	1.26	14910	8460	1.31
RDF + FYM (10 t ha^{-1})	16474	8474	1.06	16350	8550	1.10
RDF + Vermicompost (2 t ha^{-1})	17692	6892	0.64	17275	6675	0.63
Enriched FYM (750 kg ha^{-1}) with RDF	16964	9874	1.39	17485	10595	1.54
50 % RDF + FYM (10 t ha^{-1})	11988	4713	0.65	11968	4893	0.69
50 % RDF + Vermicompost (2 t ha^{-1})	12831	2756	0.27	12241	2366	0.24
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	12988	6623	1.04	12376	6211	1.01
Mean	14855	6818	0.89	14658	6821	0.93
Solecropping						
RDF (20: 40: 40 kg ha^{-1})	19211	12561	1.89	18197	11747	1.82
RDF + FYM (10 t ha^{-1})	22005	14005	1.75	20295	12495	1.60
RDF + Vermicompost (2 t ha^{-1})	23789	12989	1.20	22678	12077	1.12
Enriched FYM (750 kg ha^{-1}) with RDF	23571	16481	2.32	22743	15853	2.30
50 % RDF + FYM (10 t ha^{-1})	16193	8918	1.23	13850	6775	0.96
50 % RDF + Vermicompost (2 t ha^{-1})	17386	7311	0.73	15395	5520	0.56
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	17234	10869	1.71	15488	9323	1.51
Mean	19913	11876	1.55	18378	10541	1.41

Table 4: LER / IER of system (tree + crop) as influenced by cropping situations and integrated nutrient management practices in agrisilvicultural system

Treatments	I year	II year
Intercropping in pollarded hardwickia		
RDF (20: 40: 40 kg ha^{-1})	1.86	1.77
RDF + FYM (10 t ha^{-1})	1.88	1.78
RDF + Vermicompost (2 t ha^{-1})	1.91	1.86
Enriched FYM (750 kg ha^{-1}) with RDF	1.91	1.86
50 % RDF + FYM (10 t ha^{-1})	1.70	1.69
50 % RDF + Vermicompost (2 t ha^{-1})	1.73	1.72
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	1.73	1.71
Mean	1.82	1.77
Intercropping in unpollarded hardwickia		
RDF (20: 40: 40 kg ha^{-1})	1.44	1.46
RDF + FYM (10 t ha^{-1})	1.45	1.48
RDF + Vermicompost (2 t ha^{-1})	1.47	1.47
Enriched FYM (750 kg ha^{-1}) with RDF	1.44	1.48
50 % RDF + FYM (10 t ha^{-1})	1.33	1.39
50 % RDF + Vermicompost (2 t ha^{-1})	1.36	1.37
Enriched FYM (750 kg ha^{-1}) with 50 % RDF	1.37	1.37
Mean	1.41	1.43

intercropping of groundnut in pollarded hardwickia followed by solecropping of groundnut. Whereas, profit per rupee investment was found to be very low under intercropping of groundnut in unpollarded trees.

Among the integrated nutrient management practices applied in different cropping situations, enrichment of FYM as well as vermicompost with recommended dose of NPK under intercropping situation in pollarded hardwickia trees enhanced the gross monetary returns from the system to the maximum, followed by application of FYM with recommended dose of NPK. Whereas, the solecropped groundnut showed better performance in obtaining higher gross monetary returns from the system at the same integrated nutrient management practices than intercropped groundnut in unpollarded hardwickia trees. Whereas, the net monetary returns from the system were found highest under enrichment of FYM with recommended dose of NPK under intercropping of groundnut in pollarded hardwickia trees which was followed by recommended dose of NPK + FYM and recommended dose of NPK + vermicompost. Total net monetary returns from the system was found better in solecropping with the application of organic manures along with recommended dose of NPK than that of intercropping situation in unpollarded hardwickia trees. Profit per rupee investment also increased with the application of organic manures except vermicompost at recommended dose of NPK under intercropping of groundnut in pollarded hardwickia trees. However, the profit per rupee investment was found better with enrichment of FYM with recommended dose of NPK under solecropping of groundnut also. But 50 % recommended dose of NPK with vermicompost reduced the profit per rupee investment to the lowest under intercropping of groundnut in unpollarded hardwickia trees. Similar results were reported in tree crop combination studies (Padmavathi Devi 2004 and

Devaranavadgi *et al*., 2005).

Land Equivalent Ratio (LER)/ Income Equivalent Ratio (IER)

Higher values of LER / IER (>1) were recorded in groundnut under intercropping situation either in pollarded hardwickia or unpollarded hardwickia than those solecropping of either hardwickia or groundnut. Indicating the advantage of intercropping of groundnut with hardwickia over its solecropping due to better competitive ability of component crop involved in the system. The interspaces between the tree rows could be better utilized for growing arable crops which ultimately help in increasing monetary returns. These results are in agreement with those reported by Syed Ismail and Narayana Reddy (2004) and Sunanda Rani *et al*. (2006).

Among the integrated nutrient management practices studied under different cropping situations, it was clearly observed that application of organic manures (vermicompost, enrichment of FYM and FYM) along with recommended dose of NPK under intercropping situation either groundnut crop grown in pollarded or unpollarded hardwickia enhanced the values of LER or IER markedly when compared to 50 % recommended dose of NPK with organic manures. However all integrated nutrient management practices under intercropping situation either pollarded or unpollarded hardwickia proved to be effective in increasing the values of LER or IER when compared to solecropping of groundnut crop. These results are in agreement with the findings of Padamavathi Devi (2004).

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