An Analytical Assessment of the Performance of Peanut Crop under the Traditional Rainfed Navadhanya Cropping System

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ABSTRACT

Traditional mixed/poly cropping systems such as Navadhanya are the characteristic of rainfed agriculture. Such crop systems are perceived to reduce vulnerability and increase resilience against the vagaries of climate change, crop failures and market fluctuations and contributes to the increase in soil organic matter. However, studies on the socio-economic, agro-ecological, resilience, and yield potential of traditional mixed cropping systems like Navadhanya remains limited. In this background, an analytical study was conducted to assess the productivity (yield) of peanut crop and the composite returns from all crops cultivated in Navadhanya cropping system under rainfed conditions in Ananthapuram and Chittoor districts of AP. The study adopts the Land Equivalent Ratio (LER) for interpretation and analytic generalization of results.

Peanut was found to be the main crop in the study area and subsidiary/secondary crops include different pulses, nutri-cereals (millets) and oil seeds. Besides, peanut (the main crop), other crops of pigeon pea, filed bean and castor were found to be common across Navadhnaya farms of the study site. However, green gram was missing from fields of farmers practicing 6 crops and sorghum and green gram were missing from fields of farmers practicing 5 crops under Navadhanya crop system. The average yield of peanut (bunch variety) was suggested to be between 324 – 405 kg/acre for Andhra Pradesh. In comparison with the average peanut yield suggested for AP, the results of the study suggests that yield of peanuts was best in farms with 7 crop species (42.67% higher), followed by farms with 6 crop species (27.87 % higher) and farms with 5 crop species (4.94 % higher). The yield in all three models was found to be better than the average yield (kg/acre) suggested for Andhra Pradesh. The results of the study are aligned with results of LER studies, therefore, it may be safe to say that productivity of Navadhanya cropping system is relatively higher than monocultures.

Keywords: Traditional cropping system; Navadhanya; Multiple cropping system; Land Equivalent Ratio (LER); Ananthapur; Peanut; Groundnut; Rainfed agriculture.

1. INTRODUCTION

Traditional mixed/poly cropping systems such as Navadhanya (Narayanasway, 2000), of the semi-arid and drylands of Rayalaseema region of the Indian state of Andhra Pradesh (AP), *Dongar chasa* (cultivation over hillocks) of Odisha, and *podu* (shifting cultivation) systems and (Dash, 2006; Deb, 2021) of high hill tribal dominated areas of the North Coastal AP, are perceived to reduce vulnerability and increase resilience against the vagaries of climate change, crop failures and market fluctuations and contributes to the increase in soil organic matter. Picasso, et al (2008) points out that species diversity can increase productivity of natural grasslands (Hector et al., 1999; Tilman et al., 2006), however, the effect of crop species diversity in agricultural systems is not well understood. However, studies on the socio-economic, agro-ecological, resilience, and yield potential of traditional mixed cropping systems like Navadhanya hitherto remains limited (Runkulatile, et al., 1998; Morales-Rosales & Franco-Mora, 2009; Hamzei & Seyedi, 2015; Deb, 2021). Studies on the different dimensions of traditional cropping systems should be amplified to further the scientific understanding and mainstreaming of such crop systems. In the above context, an analytical study was conducted to assess the productivity (yield) of peanut crop and the composite returns from all crops cultivated in the traditional Navadhanya cropping system under rainfed conditions in Ananthapuram and Chittoor districts of AP. However, many important variables such as the impact of Navadhanya cropping system on soil biomass and fertility, labour, food and nutrition are beyond the purview of the present study.

2. MATERIALS AND METHODS

2.1. The Study Area: Ananthapuram and Chittoor districts of are designated as the study area of the present study. Both the districts are geographically located in the Rayalaseema region of Andhra Pradesh. Ananthapuram is geographically located at 14.6824° N, 77.6017° E, and it is the only arid region of the Indian state of AP, located in the rain shadow region of the country. Chittoor district is geographically located at 13.4788° N, 78.8383° E, in AP. The study area has a tropical wet and dry or savanna climate. Over 60% of the population is rural and about 75% of agriculture is rainfed in the study area. Peanut (*Arachis hypogaea*) is the major crop in the study area and the acreage under traditional poly-crop systems such as Navadhanya has dwindled considerably in the study area for the past few decades.

2.2. Sampling: The Watershed Support Services and Activities Network (WASSAN), a NGO based out of Hyderabad, has encouraged a total 1200 farmers, covering 1200 acres (*percapita area of an acre*) and 450 farmers, covering 726 acres (*percapita area of an acre*) to adopt Navadhanya cropping system for Kharif season in the year 2018, in Ananthapuram and Chittoor districts respectively. For the purpose of the present study, a total of 175 (10%) famers have been randomly selected from the total 1750 farmers practicing Navadhanya cropping in Ananthapuram and Chittoor districts of Andhra Pradesh. However, only 40 (22.8%) farmers have responded and participated in the present study. The participant farmers accounts to 2.2% of the total farmers practicing Navadhanya in the study area (Rukmani and Manjula, 2009; IOPEPC, 2017).

2.3. Data Collection and Analysis: Data was collected from 40 practicing Navadhanya farmers through personal interviews and on farm observations at the end of Karif season. A specially designed questionnaire was used for data collection. The predominantly quantitative data was analysed adopting tabular analysis and visualized in histograms and pie -charts. The results were interpreted adopting analytic generalization method. Analytic generalization occurs most keenly at the point of analysis and interpretation. Through rigorous inductive analysis, together with the use of confirmatory strategies, researchers would arrive at insightful, inductive generalizations regarding the phenomenon under study (Polit and Beck, 2010). Analytic generalization is suitable for case study research method. If a case or more cases validate the same theory, replication can be claimed and researchers are concerned with replication logic and theory rather than the sampling logic (Yin, 2009). The present study adopts the Land Equivalent Ratio (LER) for interpretation and analytic generalization of results.

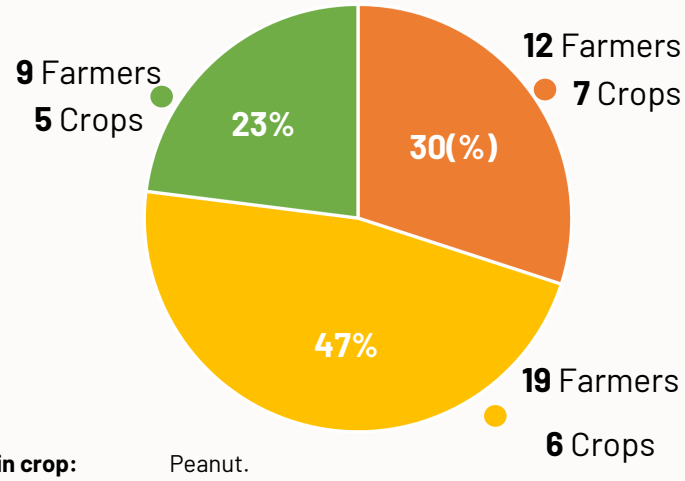
2.4. The Land Equivalent Ratio (LER)

"The Land Equivalent Ratio (LER) is the sum of the fractions of the intercropped yields divided by the sole-crop yield" (Morales-Rosales and Franco-Mora, 2009). The equation LER = S (Ypi/Ymi), is used for calculation of LER, where Yp is the yield of each crop or variety in a mixture, intercrop or a poly-crop, and Ym is the yield of each crop or variety in a single crop or monoculture. A ratio is calculated for each crop (i) to determine its partial LER and all the partial LERs are summed to give the total LER for an intercrop (Darish et al., 2006). A LER value of 1.0, indicates no difference in yield between an intercrop and a collection of single crops (Mazaheri and Oveysi, 2004). Any value greater than 1.0, indicates a yield advantage for an intercrop over a single crop. A total LER of higher than 1.0, indicates a positive interference among the components of a mixture crop or varieties, which also mean that any potentially negative interferences existing in a mixture may be alleviated (Morales-Rosales and Franco-Mora, 2009). Perhaps, the competition for resources is avoided and partitioning of resources occur in a mixture, intercropping or a poly-crop arrangement (Willey and Osiru, 1981).

3. RESULTS

All farmers participated in the study are small-size farmers and has an average area of one acre under Navadhanya cropping at their respective farms. Navadhanya cropping system is predominantly practiced under rainfed conditions in the study area. Depending on the local weather conditions critical/protective irrigation is provided only once or twice for Navadhanya crops in the study area. The participant farmers of the study were found to cultivate 5-7 crop species under Navadhaya cropping system. Peanut is cultivated as the main crop in the study area and subsidiary/secondary crops include different pulses (pigeon pea (*Cajanus cajan*), cow pea (*Vigna unguiculata*), green gram (*Vigna radiata*), and field bean (*Vicia faba*), nutri (coarse) cereals (sorghum, *Sorghum bicolor*) and oil seeds (castor, *Ricinus communis*) in the study area (*Figure-1*).

Fig - 1: Details of farmers and different Crop Species Cultivated under Navadhanya Cropping System



Main crop: Peanut
Subsidiary crops: Sorghum, Pigeon pea, Cowpea, Green gram, Field bean and Castor

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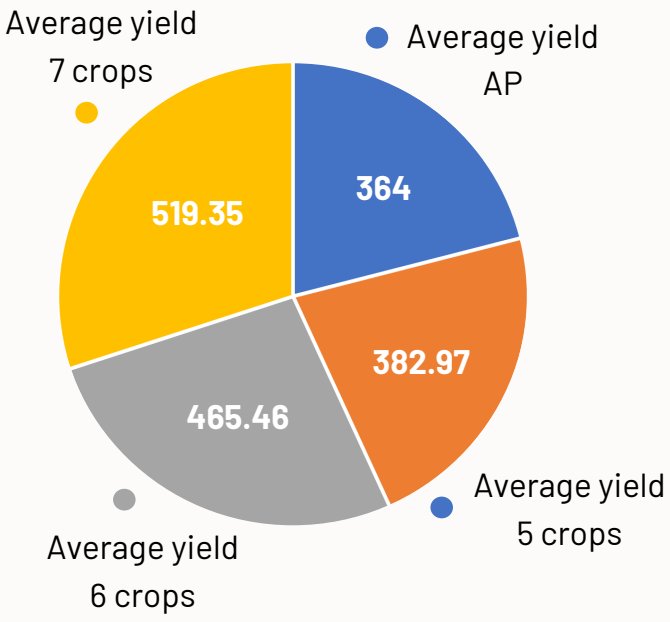
Besides, peanut (the main crop), other crops of pigeon pea, filed bean and castor were found to be common across Navadhnaya farms of the study site. However, green gram was missing from fields of farmers practicing 6 crops and both sorghum and green gram were missing from fields of farmers practicing 5 crops under Navadhanya cropping system. However, the choice of participant farmers for opting out of sorghum and green gram needs further investigation.

Results show that about 30 percent of participant farmers have sown 7 crops, 47 percent of farmers have sown 6 crops and 23 percent of farmers have sown 5 crops under Navadhanya cropping system in the study area (Figure - 2).

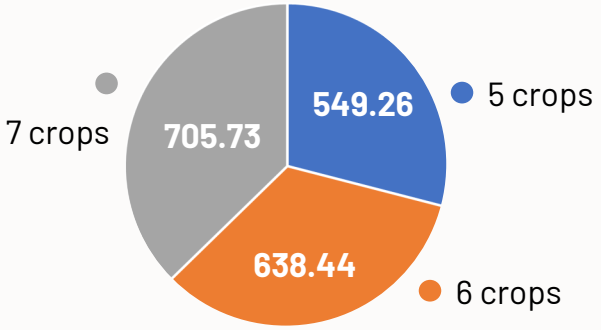
Fig-2: Yield (kg/ac) of Peanut under different Numbers of Crop Species



Yield performance of the main crop, peanut/ groundnut as well as the overall yield performance under the different numbers of crops cultivated in the same farm was examined to assess the performance of Navadhanya cropping system.

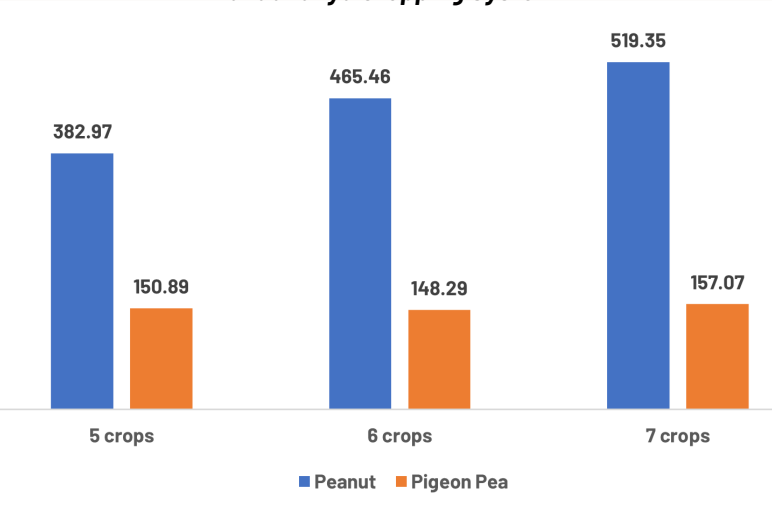
The average yield of peanut (bunch variety) was suggested to be between 324 – 405 kg/ acre for Andhra Pradesh (GOI, 2017; IOPEPC, 2017; Jasani, 2009). However, results of the present study suggests that the yield of peanut in all three models with varying number of crop species cultivated together in the same farm (7, 6 and 5 different crop species) was found to be better than the average yield of peanuts (predominantly cultivated under mono-cropping and irrigated conditions) suggested for AP. Contrary to the belief that performance of peanut is negatively affected by the increase in number and density of other crop species, results of the present study shows that the yield was best in farms with 7 crop species (42.67% higher), followed by farms with 6 crop species (27.87 % higher) and farms with 5 crop species (4.94 % higher). The yield in all three models was found to be better than the average yield (kg/acre) suggested for AP (*Figure–3*).

Fig - 3: The Total Food Grains Yield (kg/ac) of Navadhanya Cropping System under Different Numbers of Crop Species



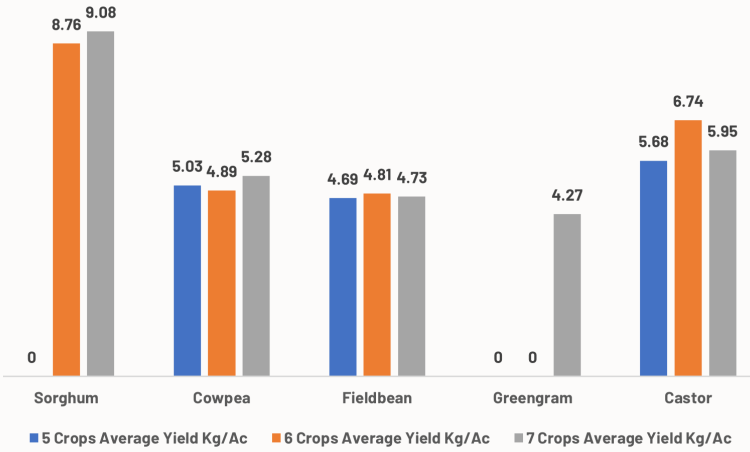
The performance of the main crop (peanut), and pigeon pea (an economically important subsidiary crop) under different numbers of crop species, 5, 6 and 7, as illustrated in the figure (5). The results suggests a positive correlation between the increase in number of crop species and the yield of peanuts. However, performance of pigeon pea on the other hand shows a slight dip in yield in farms with 6 numbers of crop species. It performed relatively well in farms with 5 and 7 numbers of crop species. It was noticed that performance of pigeon pea was best in farms with 7 number of crop species (*Figure - 4*).

Fig - 4: Yield Performance (Kg/Ac) of Peanut and Pigeon Pea under Different Numbers of Crop Species in Navadhanya Cropping System



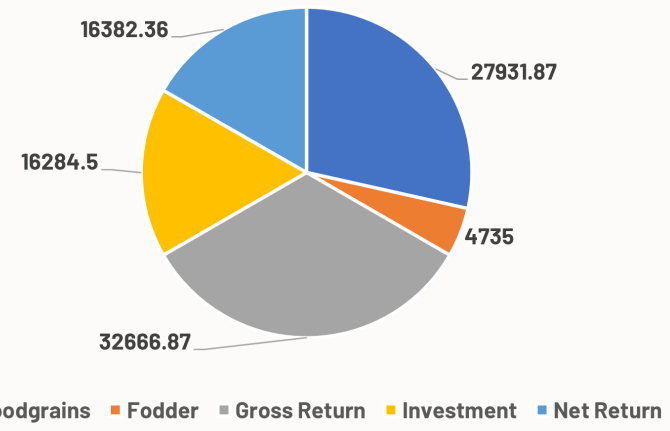
The yield of field bean remains uniform under all the three models and the performance of castor was found to be better in farms with 6 crop species and shows a slight dip in yield in farms with 5 and 7 crops. However, both the main and subsidiary crops (except castor) have performed relatively better in farms with 7 crop species (*Figure - 5*).

Fig - 5: Yield Performance (in kg/ac) of the Subsidiary Crops Under Different Numbers of Crop Species



Results of the present study suggest that the average value of food grains and fodder produced from an acre under Navadhanya cropping system was INR 27931.87 and INR 4735 respectively. The average investment for the same area for Navadhanya crop system was INR 16284.5. The gross returns was found to be INR 32666.87/acre and the net return was INR 16382.36/acre, (*Figure - 6*). The net returns of Navadhanya cropping system is equivalent of the investment.

Fig - 6: Economics of Navadhanya Cropping System for an Acre



4. DISCUSSION

The participant farmers of the study were found to cultivate 5-7 crops under Navadhaya cropping system in the study area. Traditionally, there were about 250 double cropping systems practiced in the Indian sub-continent, out of which 35 cropping systems were very prominent and prevalent (Ray, 2021; Das, 2006). However, the popularity of double and triple cropping of rice and wheat has disrupted both the agrobiodiversity as well as the diverse traditional cropping systems of the country (Pingali, 2012; Kataki, 2002). Similarly, the Three Sisters also known as the Holy Trinity are traditionally cultivated by some of the indigenous communities of the American continent. The Three Sisters are represented by corn, beans and squash, which are not only an integral part for the traditional agriculture but also an important facet of the indigenous culture and traditions (Murphy, 2018). The diversity and the different crop numbers and densities found in traditional cropping systems around the world is a product of years of experimentation and observations of nature—crop—human—systems, which was passed down the generations primarily through traditional knowledge and practices.

Results of the present study suggests that yield performance of peanut in all three crop densities was better than the average yield suggested for AP. The performance of peanut was best in farms with 7 crops than farms with 6 and 5 crops and mono-cropping farms cultivated under rainfed conditions. Picasso, et al (2008) suggests that mixtures of species in intercrops/polycultures may improve the overall performance of a cropping system with regards to yield, nutrient cycling, weed suppression, pest control, conserve soil moisture, reduce soil erosion, and sequester more carbon, and among others (Primentel et al., 1987; Holland and Brummer, 1999; Runkulatile et al. 1997; Liebman, 1995; Entz et al., 2002; Dinnes et al., 2002; Jackson, 2002; Vandermeer et al., 2002; Freibauer et al., 2004).

***The LER value of 1.73 suggests that "the sum of the yields of a mixture/ poly crop can only be equalled to a monoculture planted 1.73 times the area divided proportionally among the crops of a mixture/ poly-crop"* (Morales-Rosales and Franco-Mora 2009; Darish, *et al* 2006).**

Runkulatile, et al. (1997) in their study on the impact of different ratios of peanut-finger millet intercrops on LER found that all three ratios of peanut-finger millet intercropping have produced more grains and total above-ground biomass than expected from sole crops. The three major processes in the yield advantage observed in the study are: (1) the

vigorous growth of peanut, after the harvesting of finger millet. (2) The relatively higher accumulation of N due to larger leaf area produced due to "shading effect". And (3) the efficient use of water in the intercropping system.

Studies show that plants acclimated to a shaded environment for a long period exhibits higher dry matter production than the unshaded plants after the shade was removed. Runkulatile, et al. (1997) observed a higher leaf photosynthetic and transpiration rates in the intercropped peanut than in its sole grown counterpart, when the leaves were exposed to full sunlight at a later growth stage. In this case, the peanut crop shaded by the companion finger millet crop maintained a higher photosynthetic ability until a later stage, after the finger millet was harvested. The phenomenon of exhibiting high photosynthetic and transpiration rates when the shade is removed and leaves are exposed to full sunlight at a later growth stage is known as "shading effect" (Ibid, 1997). Shading effect is known to significant increase of LER of peanut after finger millet is harvested, which in turn results in production of higher dry matter in peanut. Dry matter of peanut crop cultivated in intercropping are found to be higher than peanuts cultivated as a sole crop. Similar results were observed in rice (Nagata et al. 1994) Sunflower (Osmond et al. 1988) and legumes (Matthews et al. 1991).

The yield performance of pigeon pea, however remains uniform under all the three crop densities in the study area.

Results of the study shows that both the main and subsidiary crops (except castor) have performed relatively better in farms with 7 crop species than farms with 5 and 6 crops species. Picasso, et al (2008) found that polycultures out yielded monocultures on average by 73%. Similarly, Deb (2021) applied LER for measuring productivity and found that multiple cropping systems are more productive than single cropping farms. Loreau and Hector, (2001) elucidates that the diversity–productivity relationship can be explained by complementarity among species or by selection effects. Positive interactions among species increases the performance of the community through a process called facilitation (Deb, 2021). In a community, different species with complementary traits (e.g., rooting depth, shoot height) can use different resources or niches, providing access to more resources and making it more productive as the community as a whole than its constituent species individually (Ibid, 2021). However, (Ibid, 2021) suggest that not all multiple cropping farms are equally productive; rather, their relative productivity depends on the specific crop combination and planting design.

5. CONCLUSION

Adopting an analytical generalization method the present study attempts to analyse the results using the LER method. LER based studies have amply demonstrated that increase in species richness in multiple crops/polycultures has measurable benefits in terms of yield, biomass, pest, and weed suppression. Well-adapted, companion species are found to complement each other and have a major effect on the ecosystem function. The results of the study are aligned with results of LER studies, therefore, it may be safe to say that productivity of Navadhanya cropping system is relatively higher than monocultures. Traditional diverse cropping systems should be promoted as diverse multispecies agroecosystems have been proposed as a viable alternative to low diversity mono-cultural systems to sustain agriculture productivity into the future. Further, studies suggest that agricultural community should inform more ecological theory and adopt it in both theory and practice for building sustainable food systems of the future.

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