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Radiation interception and rain water utilization efficiency of legume based intercropping in rainfed upland rice area of eastern India

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ABSTRACT

An on-farm research was conducted on crop diversification and rice substitution with legumes (through sole and intercropping) during *kharif* 2000 and 2001 in a representative area (Dhenkanal) of Orissa state of India.The highest rice equivalent yield was obtained from groundnut + pigeonpea intercropping (6656 and 7023 kg ha^{-1} in first and second years, respectively). The rainwater utilization efficiency (in terms of rice equivalent yield) for that combination was 7.04 and 4.81 kg ha^{-1} mm^{-1} in two respective years. Substitution of rice with other sole or intercrops found more beneficial.

Key words: Radiation interception, legume, intercropping, rainwater utilization efficiency, rainfed upland.

Inspite of low and unstable yield of upland rice due to erratic southwest monsoon, moisture stress during crop growth period, light textured soils with low water retention and fertility status, existence of biological constraints like weeds, diseases (blast, brown spot) and pests (gundhi bug, termite), traditional farmers of eastern India (Assam, West Bengal, Orissa, Jharkhand, eastern U.P and Chhattisgarh) grow rice on such land. Under this situation crop diversification and rice substitution with low water requiring legumes like groundnut, pigeonpea, cowpea, blackgram, greengram (through sole or intercropping) may be one of the best options to the hands of farmers for mitigating drought and increased productivity (Kar *et al.*, 2004). Rice substitution with legumes in rainfed upland not only provides food security but also nutritional and environmental security as well. Idea of crop diversification with legumes in upland rice area is to emphasize that these crops can provide an assured income in light textured soils with low water retention and low rainfall because water requirements of legumes are less than that of rice. Besides legumes sustain soil fertility by fixing atmospheric nitrogen.

So a detailed study of radiation interception and its utilization efficiency as influenced by substituted sole and

intercropping forms an important supplementary component to improve the productivity of upland of upland rice area of eastern India..

MATERIALS AND METHODS

On- farm trials on crop diversification were conducted in rainfed upland rice area during *kharif* 2000 and 2001 at Dhenkanal district, Orissa. The climate of the experimental site was hot and sub-humid and southwest monsoon generally sets on 10th June in the region. The soil of the experimental site was light textured and taxonomically belonged to category of the fine, loamy, mixed iso-hypothermic Typic Haplaustlaf. The clay content of the soils varied from 21.5 to 28.7 % and silt content from 18.4 to 31.2 %. The pH ranged between 5.1 to 6.2, which was moderately acidic. The organic carbon varied from 0.23 to 0.52 %, indicated low fertility status. At field capacity (0.033 MPa), the highest amount of water retained by soils was at 0.60-0.90 m depth (0.227 m^3m^{-3}) and the lowest was at 0.0-0.15 m depth (0.171 m^3m^{-3}). Available water holding capacity of the soils varied from 0.110 to 0.145 m^3m^{-3} in different depths. In this investigation productivity, radiations and rain-water use efficiency of groundnut based inter-cropping consisted of groundnut + pigeonpea (4:1), groundnut + greengram (4:1), groundnut + blackgram (4:1), groundnut + cowpea (4:1), were compared with that of sole groundnut and sole rice. The varieties 'Smriti' 'UPAS-120' 'T-9' 'K-851' and 'Pusa Kamal' were used as test variety for groundnut, pigeonpea, blackgram, greengram and cowpea respectively. The experimental design was randomized block design with the plot size being 8 m x 5 m.

For measurement of biometric observations, one square meter sampling area was selected randomly from each experimental unit and observations were recorded at 10 days interval. Dry weight of the plant materials was measured after drying the samples for 48 hours in a hot air oven at 80 °C temperatures. The intercepted photosynthetically active radiation (IPAR) was measured using light transmission meter (EMS-7). The yield of all the crops was collected at final harvest.

The mean daily values of solar radiation received above the crop canopy during different weeks of the crop growth were estimated using Penman (1948) formula and the photosynthetically active radiation was calculated by multiplying it with 0.48 following Monteith (1972) and Kailasanathan and Sinha (1984). Reflection coefficient of 0.25 has been used for green crops.

The weather parameters during the

crop growth period were collected from nearby meteorological observatory of Central Rubber Board, Regional Centre, Dhenkanal.

RESULTS AND DISCUSSION

Intercepted photosynthetically active radiation (IPAR)

The intercepted photosycnthetically active radiation (IPAR %) of sole groundnut and groundnut based intercropping was computed (Fig. 1). The inter-crops intercepted more PAR than sole crop. Maximum interception of 85 to 87 % was observed when groundnut was grown as sole crop. The radiation interception was found more (90 to 94 %) when the crop was grown with pigeonpea, that occurred at 110 DAS. At 70 DAS maximum radiation interception was observed in groundnut + greengram (84-87 %) and groundnut + blackgram (82-89%). In case of groundnut + cowpea intercropping, peak IPAR was 83-87 % that occurred at 60 DAS. After 70 DAS, radiation interception started to decrease in cowpea, blackgram and greengram because of reduction of canopy vigour. From the study, it was revealed that radiation interception was higher in inter-cropping than that of sole crops.

Rainwater use efficiency

The yield of all the crops/crop combinations was converted into rice equivalent yield and rainwater use efficiency in terms of rice equivalent yield [rice equivalent yield (kg ha^{-1}) produced per mm of rainwater received during the growth period] was computed (Table 1). From the study it was found that in first year among different inter-cropping combinations, water use efficiency was the highest in groundnut + pigeonpea (7.04 kg ha^{-1} mm^{-1}) followed by groundnut + greengram (6.08 kg ha^{-1} mm^{-1}) and groundnut + blackgram (5.5 kg ha^{-1} mm^{-1}). Among sole crops, groundnut recorded the highest rainwater use efficiency. Sole blackgram and greengram recorded more rainwater use efficiency than pigeonpea because of their short duration Within crop growth period blackgram and greengram received less rainfall as compared to pigeonpea. Whereas, sole rice achieved the lowest rainwater use efficiency (1.6 and 2.6 kg ha^{-1} mm^{-1}) among the crops or crop combinations. Though in second year due to well distributed rainfall upland rice recorded higher rainwater use efficiency but rice substituted legumes achieved much higher rainwater use efficiency in both the years.

So from rainwater utilization point of view, groundnut + pigeonpea intercropping and sole groundnut were more efficient which could be grown in upland successfully to increase and stabilize the productivity of rainfed

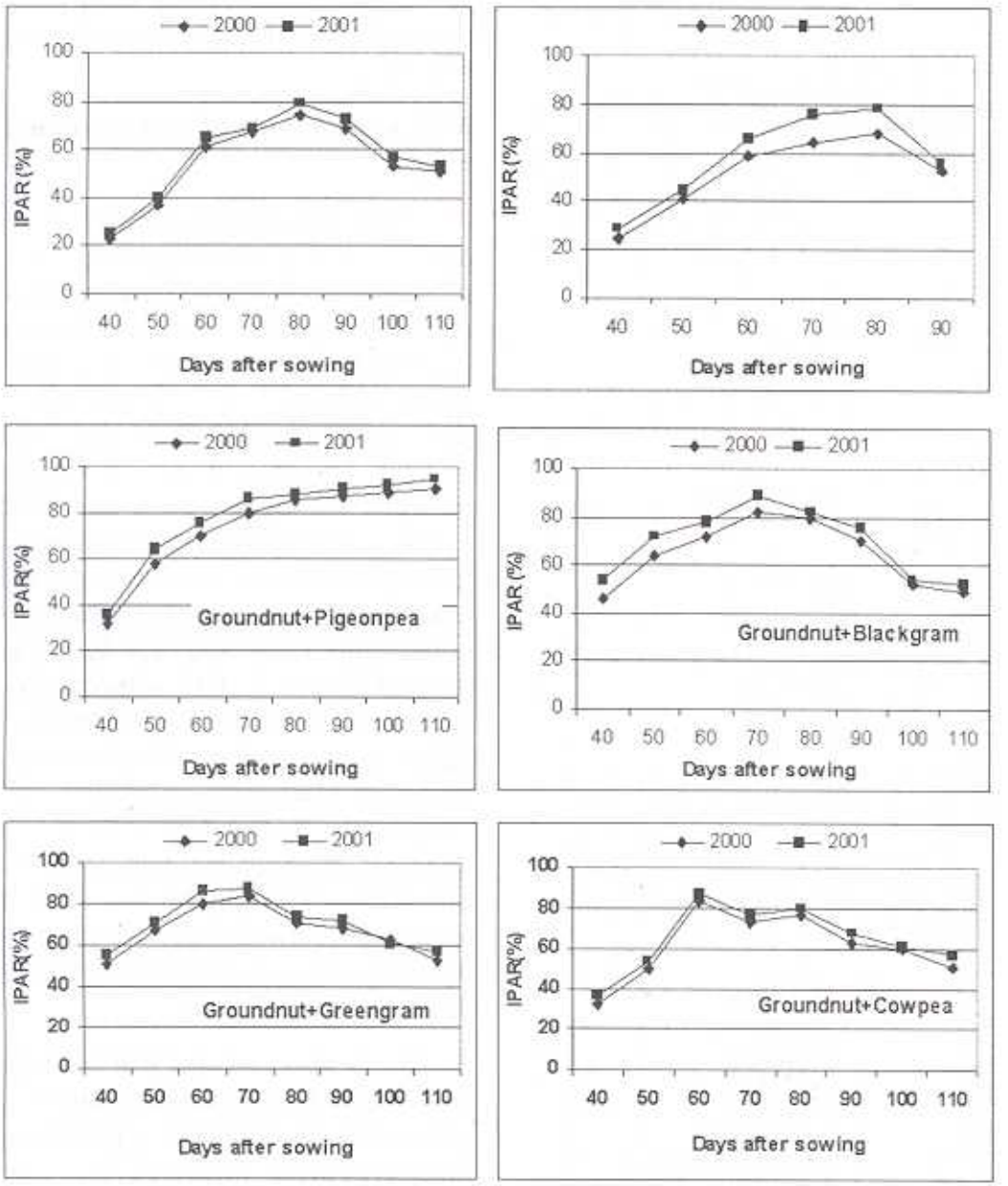

Fig. 1 : Intercepted photosynthetically active radition (IPAR) by different sole and intercrops

Table 1: Rice equivalent yield, net return and rainwater use efficiency of rice substituted crops in upland

Treatments	Yield of (kg ha^{-1}) of main crop(groundnut)		Yield of intercrops (kg ha^{-1})		Rice equivalent yield (kg ha^{-1})		Net return (Rs. ha^{-1})		Rainwater utilization efficiency (kg ha^{-1} mm^{-1})	
	2000	2001	2000	2001	2000	2001	2000	2001	2000	2001
Groundnut+pigeonpea(4:1)	1105	1295	670	578	6656	7023	20124	20704	7.04	4.81
Groundnut+blackgram(4:1)	920	965	370	420	4930	5298	14692	13768	5.5	4.4
Groundnut+greengram(4:1)	1015	1090	360	498	5410	6267	15140	18408	6.08	5.3
Groundnut+cowpea(4:1)	875	920	340	482	4180	4644	10220	12076	4.7	4.01
Groundnut	1410	1560	-	-	5640	6240	16060	18960	6.3	5.3
Pigeonpea	1480	1355	-	-	5550	5081	16200	13325	5.8	3.4
Blackgram	1050	1225	-	-	4200	4900	13300	11650	6.8	5.1
Greengram	1080	1120	-	-	3780	3920	9620	10180	6.1	4.16
Cowpea	1400	1800	-	-	2800	3600	6200	9400	4.4	3.2
Rice(Farmer's practice)	1010	2810	-	-	1010	2850	Nil	5400	1.6	2.6
S.E.m(±)					513.95	411.14			0.5	0.29

upland rice area of eastern India where present productivity is very low (<1 t ha^{-1}).

Rice equivalent and net economic return

For better comparison, productivity of different rice substituted crops (sole or intercrops) was converted into rice equivalent yield (Table 1). Among intercropping, groundnut+pigeonpea intercropping (4:1) recorded the highest rice equivalent yield (6656 and 7023 kg ha^{-1}). Among sole crops groundnut recorded the highest 5640 and 6240 kg ha^{-1} yield in two respective years. On the other hand sole rice produced the lowest-yield as compared to other crops or intercrops (1010 and 2850 kg ha^{-1} in the year 2000 and 2001, respectively). Rice equivalent yield of groundnut was higher in association with pigeonpea, than with blackgram, greengram and cowpea as in the case of growth attributes, radiation and rain water use efficiency. It might be due to less competition between these two crops for light, nutrient, and space owing to their different growth habits.

Study also revealed that for both years, highest net economic return was obtained from groundnut + pigeonpea inter-cropping followed by sole groundnut (Table 1). Among sole crops groundnut was more profitable with net economic return of Rs. 16,060 ha^{-1} and

Rs. 18,960 ha^{-1} in first and second years respectively. Among inter-cropping combinations, lowest net return was obtained from groundnut + cowpea. On the other hand, sole rice produced net return of only Rs. 5240 in good rainfall year (2001) and in the year 2000 it was nil due to occurrence of dry spells during tillering stage of rice. From the study it is revealed that productivity of rice fluctuated significantly between rainfall deficit or rainfall excess years but rice substituted legumes or legume based intercrops performed well both in rainfall deficit and rainfall excess years and productivity did not differ significantly between two study years. It might be due to the fact that water requirements of these crops are less and pulses had inherent capacity to draw soil moisture from lower strata, therefore, fit well under rainfed condition.

CONCLUSION

From the crop diversification research in rainfed upland rice area, it can be concluded that rice substitution with low water requiring or deep rooted crops like pigeonpea, groundnut, blackgram, greengram, cowpea (sole or intercrops) were more efficient to utilize rainwater or photosynthetically active radiation.

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