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Effect of groundnut (*Arachis hypogaea* L.)-based intercropping systems on yield and economics under rainfed condition

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ABSTRACT

A field experiment was conducted during the *kharif* season of 2010-11 to 2012-13 at Nana Kandhasar, Surendranagar, Gujarat to study the yield, economics and post harvest soil nutrient status of groundnut (*Arachis hypogeae* L) - based intercropping systems under rainfed condition. Results of experiment indicated that intercropping of groundnut and sesame in the row proportion of 1:1 recorded significantly higher groundnut pod equivalent yield (1106 kg/ha), land equivalent ratio (1.18), net returns (Rs 30691/ha) as well as B:C ratio (1.82) over other planting pattern. Further, the data revealed that the highest nutrient use productivity (27.88 kg/ha/kg) was recorded under sole groundnut, while maximum available N (220.2 kg/ha) and K (310.4 kg/ha) was recorded with groundnut + greengram (1:1) and highest available P (29.2 kg/ha) with sole mothbean. Thus, groundnut + sesame (1:1) is a biologically and economically sustainable intercropping system for rainfed conditions of Gujarat.

Key words: Equivalent yield, Groundnut, Intercropping, Land equivalent ratio, Sesame.

INTRODUCTION

Intercropping is an advanced agro-technique and is considered to be an effective and potential means of increasing crop productivity, particularly in marginal and small holdings under rainfed situation thus it provides an efficient utilization of natural resources, decreases the cost of production, provides financial stability, decreases the pest and disease incidence, intercropping system smothers weeds growth, improves soil fertility and increases crop yield along with improves quality of produce (Francis *et al.*, 1976; Willey, 1979). Substantial increase in total production over space and time by means of simple expedient of growing crops together are the unique advantages associated with intercropping as mainly micro-climatic manipulation is possible in intercropping when compared to sole cropping system.

Groundnut (*Arachis hypogaea* L.) is the major oil seed crop of Gujarat mostly grown in *kharif* season and most of the area is confined to Saurashtra region. In India, it is cultivated on an area of 5.53 m ha with production of 9.67 million tonnes and productivity of 1750 kg/ha (AICRPG,2015). Groundnut contains 45-50% edible oil,is short stature crop, being a leguminous crop fixes atmospheric nitrogen and adds enormous organic matter through leaf litter, root and root nodules there by increases the soil fertility status after groundnut.The features of this crop offer a potential scope for intercropping to exploit the land and resources more efficiently.

In Gujarat, groundnut with sesame intercropping is an old and important cropping system under rainfed situation. Growing groundnut with sesame endowed with varying rooting depth and growth pattern help better extraction of soil moisture and nutrients from different soil profile. It is also known to intercept more solar energy and give comparatively higher yield stability and insurance during aberrant weather conditions than sole crops.Intercropping groundnut with sesame was most beneficial as compared to sole stand of groundnut (Abdel and Abdel, 2014). Honnali and Chittapur (2014) stated that groundnut with sesame intercropping recorded the highest groundnut equivalent yield with net returns than that with other groundnut-based intercropping.However, for growing sesame and pulse crop as intercrop in groundnut particularly under semi-arid, erratic and uneven rainfall conditions of Saurashtra region of Gujarat, it is necessary to evaluate the compatibility verses the competitive effects with different row ratios. Realizing the importance of these facts, the present experiment was conducted to assess the possibility of increasing crop production per unit area by introducing intercrops with groundnut under rainfed situation.

MATERIALS AND METHODS

A field experiment was conducted at Dry Farming Research Station, Junagadh Agricultural University, Nana Kandhasar (22º45' N, 71º25' E, 86.67 m above the mean sea level), Surendranagar, Gujarat during *kharif* season of 2010-11, 2011-12 and 2012-13. The site is situated in the

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North Saurashtra agro-climatic region of Gujarat under Gujarat plains and hills zone of India. The climate of this region is semi-arid and sub-tropical with fairly dry and hot summer. The rainy season commences in the second fortnight of June and ends in September with an average annual rainfall of 600 mm. July and August are the peak months of rainfall. The total rainfall received during growing seasons was 878.5 mm in 2010-11, 637 mm in 2011-12 and 425 in 2012-13. The experimental soil was sandy loam (76.46% sand, 9.24% silt and 14.30% clay) in texture and slightly alkaline in reaction with pH 7.90 and EC 0.41 dS/m. The soils are medium in fertility and low in organic carbon (4.8 g/kg), available nitrogen (189.5 kg/ha) and available phosphorus (23.0 kg/ha) and high in available potassium (300.5 kg/ha).

The experiment consists of tentreatments of sole cropping of groundnut, greengram (*Vigna radiata* L.), sesame (*Sesame indicum* L.), mothbean (*Vigna aconitifolia* L.) and intrcropping of groundnut with greengram, sesame, mothbean in 1:1 and 3:1 row proportion were evaluated using randomized block design with three replications. The groundnut 'GG-2', greengram' K-851', sesame'Guj-2' and mothbean 'Guj-1' were sown at 45 cm spacing on 14July, 12 July and 15August,during 2010-11, 2011-12 and 2012-13, respectively. The plant to plant distance of sesame, greengram and mothbean was maintained 10 cm by a thinning at 15 days after sowing. Seed rate of 100, 25, 3 and 20 kg/ha was used for groundnut, greengram, sesame and mothbean, respectively.Seed rate for each intercropping system was calculated on the basis of ratio indicating the number of rows of each component crop. The recommended fertilizer doses used for groundnut, greengram, sesame and mothbean were, 12.5 -25-00, 20-40-00, 25-50-00 and 20-40-00 kg N-P_2O_5-K_2O/ha, respectively.The fertilizers were applied as per row ratio of component crops in the intercropping systems. Full dose of N and P as basal in form of urea and DAP was applied in groundnut, greengram and moth bean, while half dose of N and full dose of P as basal in form of urea and DAP and remaining half dose of N was top-dressed in form of urea at 30 DAS in sesame crop. The required cultural practices and plant protection measures were followed as per recommended package of practices for particular crop. Weeds were managed by two hand weeding at 20 and 40 DAS and two intercultural operations with hand hoe at 20 and 40 DAS. The groundnut crop was harvested on 30, 17 and 3 October during 2010-11, 2011-12 and 2012- 2013, respectively. Inter crops also harvested as per physiological maturity of the respective crops.

Groundnut equivalent yield and land equivalent ratio were calculated by standard methods. Nutrient use productivity (NUP) was calculated dividing the equivalent yield of the system by the total quantity of nutrients used. Net returns were calculated by subtracting cost of cultivation from gross returns. The benefit: cost ratio was calculated by dividing the net returns with cost of cultivation. Soil samples were drawn from 0-30 cm depth in each treatment after harvest of the crop. Treatment wise available nitrogen, phosphorus and potassium was analysed by using the internationally accepted methods referring the methods of Jackson (1973).Economics of the systems were calculated on the basis of the prevailing market prices of the commodities during the study. All data were subjected to the analysis of variance (ANOVA) appropriate to the design using the windows based statistical package for the social science. Test of significance of the treatment difference was done on the basis of the *f*- test (Gomez and Gomez, 1984). The least significant differences between the treatments were compared at 5% level of probability.

RESULTS AND DISCUSSION

Effect on yield: Significantly higher pod and haulm yields (Table-1)were recorded by sole groundnut than rest of the intercropping treatments, which could be attributed to higher and optimum plant densities in sole cropping system. The lower significant pod and haulm yields were noticed under groundnut with green gram, sesame and moth bean at 1:3

Table 1: Effect of groundnut based- intercropping system on yield of main crop, inter crop and groundnut equivalent yield under rainfed condition (Pooled data of three years)

Treatment	Yield of base crop (kg/ha)		Yield of inter crop (kg/ha)		Groundnut equivalent yield (kg/ha)	
	Pod	Haulm	Seed	Stalk	Pod	Haulm
Sole groundnut	1046	1710	-	-	1046	1710
Sole greengram	-	-	908	1511	939	294
Sole sesamum	-	-	517	941	849	53
Sole Mothbean	-	-	866	1475	873	287
Groundnut + greengram (1:1)	528	903	515	853	1059	1069
Groundnut + sesame (1:1)	568	967	329	514	1106	995
Groundnut + mothbean (1:1)	471	846	458	772	932	997
Groundnut + greengram (3:1)	653	1086	277	471	942	1178
Groundnut + sesame (3:1)	672	1170	184	285	972	1186
Groundnut + mothbean (3:1)	615	1027	237	400	852	1105
SEm±	22	77	23	86	49	67
CD (P=0.05)	63	230	65	255	146	200

row ratio intercropping system. This might be due to lower plant densities of groundnut and also higher competition offered by intercrops for natural resources like space, plant nutrient, moisture and incoming sun radiation. The results are corroborating with the findings of Solaiappan *et al.* (1994) and Prasad*et al.* (2007).

In case of seed and stalk yields of greengram, sesame and mothbean were reduced in intercropping systems in comparison to their respective sole cropping systems. Such variation could be ascribed due to decrease in plant densities when grown as intercrops with groundnut and higher competition among groundnut and intercrops for natural resources like soil moisture, plant nutrients, space and sunlight responsible for higher photosynthesis rate resulting lower accumulation of dry matter per plant in comparison of sole crop(Chandrika *et al.,*2001; Ghosh *et al,.*2016).

Data from Table-1 revealed that, groundnut pod equivalent yield was significantly higher in groundnut + sesame (1:1) intercropping (1106kg/ha) followed bygroundnut + greengram in 1:1 row proportion (1059kg/ha).This increase was mainly owing to additional yield advantage of sesame intercropping as well as higher market price of sesame seed than that of groundnut pod as well as greengram and mothbean seed. The improvement of yield could be owing to differential spatial arrangement of both the crops. Sarkar*et et al.* (2003) also reported highest sesame equivalent yield under sesame + groundnut among the intercropping system. Mahale *et al.* (2008) recorded higher groundnut equivalent yield under intercropping of groundnut with sesame in 2:1 row ratio. Significantly higher groundnut haulm equivalent yield recorded with sole groundnut (1710kg/ha) than the other sole crop as well as intercropped system. This is owing to higher plant population of groundnut in sole crop.

Effect on land equivalent ratio: Land equivalent ratio (LER) calculated from combined intercrop yield was higher with 1:1 row ratio than 3:1 row ratio irrespective of the component crops. The LER with all1:1 intercropping system was higher than either of the sole crops except mothbean (Table-2). This clearly indicated greater biological efficiency of the intercropping treatments. The significantly highest LER (1.18) was recorded in intercropping of groundnut and sesame in the row ratio of 1:1, followed by groundnut + greengram (1.08) in same row ratio. Similar results were also obtained by Sarkar and Chakraborty (2000) and Sarkar *et al.* (2001).This was due to extra yield obtained from intercrop and makes the combination higher advantageous over sole crops. This might be due to development of better complementary relationship. It showed that to produce combined mixture yield by growing sole stand would require 18% more land. The LER for intercropping where it is more than 1, indicating suitability of practice in quantitative term. Abdel and Abdel (2014) also reported maximum LER in groundnut + sesame sown with 2:2 row ratio than 3:1 row proportion.

Effect on economics: Sole groundnut recorded the highest cost of cultivation and gross returns/ha over other sole as well as groundnut-based intercropped systems. However, the highest net returns was recorded in groundnut + sesame (1:1) intercropping system, closely followed by sole groundnut. This could be attributed to higher seed rate of groundnut, which increased cost of cultivation of sole groundnut over other sole crops as well as intercropped systems. Significantly higher B:C ratio was recorded with intercropping of groundnut with sesame in 1:1 row ratio (1.82), followed by groundnut + greengram (1.72) intercropping system in same row proportion. Higher economic returns were recorded in intercropping of groundnut with sesame, owing to additional yield advantage as well as higher market price of sesame compared to mothbean and greengram. Oyeogbe *et al.* (2015) reported higher net returns, when sesame intercropped with groundnut compared to greengram and cotton. In general, intercropping of groundnut in 1:1 row ratio accrued higher net returns and B: C ratio as compared to 3:1 row ratio. Almost similar findings were recorded by Sarkar *et al.* (2003)

Table 2: Effect of groundnut based- intercropping system on land equivalent ratio and economics under rainfed condition (Pooled data of three years)

Treatment	LER	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B: C ratio
Sole groundnut	1.00	19045	48562	29517	1.55
Sole greengram	1.00	14624	37010	22386	1.53
Sole sesamum	1.00	14717	33569	18852	1.28
Sole Mothbean	1.00	14024	34158	20134	1.44
Groundnut + greengram (1:1)	1.08	16835	45804	28969	1.72
Groundnut + sesame (1:1)	1.18	16881	47572	30691	1.82
Groundnut + mothbean (1:1)	0.99	16535	40276	23741	1.44
Groundnut + greengram (3:1)	0.94	17940	42119	24179	1.35
Groundnut + sesame (3:1)	1.00	17963	43494	25531	1.42
Groundnut + mothbean (3:1)	0.87	17790	38545	20755	1.17
SEm±	0.03	-	2238	2238	0.10
CD (P=0.05)	0.10	-	6649	6649	0.29

Table 3: Effect of groundnut based- intercropping system on nutrient use productivity and soil nutrient status under rainfed condition (Pooled data of three years)

Treatment	Nutrient use productivity (kg/ha/kg)	Nutrient present in soil after crop harvest		
		Nitrogen	Phosphorus	Potassium
Sole groundnut	27.88	210.9	26.5	292.2
Sole greengram	15.65	220.2	28.7	310.4
Sole sesamum	11.32	178.3	23.9	272.8
Sole Mothbean	14.56	214.0	29.2	302.8
Groundnut + greengram (1:1)	21.72	195.1	27.5	298.6
Groundnut + sesame (1:1)	19.66	186.1	24.9	285.5
Groundnut + mothbean (1:1)	19.12	193.1	26.1	299.1
Groundnut + greengram (3:1)	21.84	203.2	27.3	295.2
Groundnut + sesame (3:1)	20.73	194.3	26.3	290.3
Groundnut + mothbean (3:1)	19.76	204.8	26.8	293.4
Initial value	-	189.5	23.0	300.5
SEm±	0.73	4.83	0.96	6.22
CD (P=0.05)	2.06	14.35	2.86	18.49

in groundnut + sesame and Jadav *et al.,*(2007) in groundnut + castor intercropping system.

Effect on nutrient use productivity: Nutrient use productivity (NUP) varied from 11.32 to 27.88 kg/ha/kg nutrient applied and significantly higher NUP was recorded in sole groundnut (Table-3). This could be attributed to lower fertilizer requirement of groundnut over greengram, mothbean and sesame crops. Among all the groundnut-based intercropping system, groundnut + greengram (3:1) recorded highest NUP (21.89 kg/ha/kg), being at par with remaining all the tested intercropping systems. The lowest NUP was found in sole sesame (11.32 kg/ha/kg), followed by sole mothbean and greengram.

Effect on available soil nutrient status: All the available primary nutrients in soil were significantly affected by different groundnut-based intercropping systems. This might be due to inclusion of different crops including pulses in the intercropping systems. The available nitrogen in soil varied from 178.3 to 220.2 kg/ha (Table 3). Sole greengram showed the maximum 16.2% increase in available N in soil over initial. Pulse crops with their characteristic promotion of free living microorganisms (*Rhizobium* spp.) release N in soil. Release of N helps narrowing down of C: N ratio and thus, increased mineralization resulted in rapid conversion of organically bound N to inorganic forms (Kumar *et al.*, 2010). The highest available phosphorus in soil was in sole mothbean, which was 26.96% higher than the amount recorded at initial stage. The favourable effect in enhancing the P availability may be attributed to the reduction in fixation of water soluble P and increase in mineralization of P due to microbial action which enhanced the availability of P. The organic anions and hydroxyl acids liberated during the crop growth period may complex or chelate Fe, Al, Mg and Ca and prevent them from reacting with phosphate (Gogoi, 2011). Available potassium after harvesting of different groundnut-based intercropping systems indicated change over initial status. The maximum K availability was recorded from sole greengram, followed by sole mothbean. Intercropping of groundnut with either of the tested crops, lower down the K availability in soil over initial status. Similar results were also reported by Gogoi (2011).

It was concluded that intercropping of groundnut with sesame in 1:1 row ratio is a biologically and economically sustainable intercropping system for rainfed conditions of Gujarat.

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