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SUSTAINABILITY OF SUNFLOWER-BASED CROP SEQUENCES IN RAINFED ALFISOLS

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SUMMARY

A field experiment was conducted at Hyderabad, India, for six years (1992 to 1997) to study the performance of rainy season sunflower at 50% (37.5:45:15kg $N:P_2O_5:K_2O$/ha), 100% (75:90:30kg $N:P_2O_5:K_2O$/ha) and 150% (112.5:135:45kg $N:P_2O_5:K_2O$/ha) recommended NPK in annual rotation with rainy season crops viz. sorghum (*Sorghum bicolor* (L) Moench), pigeonpea (*Cajanus cajan* (L) Millsp), groundnut (*Arachis hypogaea*. L.), sunflower (*Helianthus annuus* L.) and castor (*Ricinus cummunis* L.). The study also dealt with the productivity, economic returns and sustainability of the crop rotations. The fertilizer levels did not vary the seed yield of KBSH-1 sunflower over the years. Application of recommended dose of fertilizer to base crop resulted in higher yield of succeeding sorghum, pigeonpea, sunflower and castor, while 50% reduction in recommended dose of NPK to base crop recorded higher yields of groundnut compared with the others. The higher sunflower seed equivalent yield was obtained with groundnut and sorghum as sequence crops. Sunflower-groundnut rotation gave the highest net returns (Rs.17,987/ha) followed by sunflower-sorghum system (Rs.15,457/ha). The study revealed that the sunflower-groundnut cropping system was more sustainable (44.24% SYI) followed by sunflower-sorghum system (37.52%) under rainfed alfisols.

Key words: **castor, groundnut, pigeonpea, sorghum, sunflower, sustainability**

INTRODUCTION

Sunflower (*Helianthus annuus* L.), by virtue of short duration, wide adaptability, photo period insensitivity and availability of promising hybrids and varieties, has stabilized its area and production in India. However, the average productivity of sunflower is very low (550 kg/ha) from an area of 1.71 milion ha (Damodaran and Hegde,1999) largely due to poor nutritional management and lack of scientific-based crop rotation. Deleterious effects of continuous cropping of sunflower on its productivity have been documented (Wang and Fan, 1987; AICORPO Hyderabad,

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1990; Sudhakara Babu *et al.*, 1999). Yield advantages of sunflower were reported when succeeded by groundnut (Reddy and Sudhakara Babu, 1996). Hig sunflower seed equivalent yields and returns were recorded in rainy season sunflower-summer irrigated groundnut sequential cropping system (Reddy and Sudhakara Babu, 1997). Since the bulk of the area under sunflower is rainfed and subject to varying cropping systems, the present study was undertaken to establish a sustainable crop sequence with sunflower raised under varying fertilizer levels under rainfed conditions in alfisols.

MATERIALS AND METHODS

Field experiments were conducted during six rainy seasons (June-December) from 1992-1997 on red sandy loam soils of Hyderabad. Base crop of rainy season sunflower was raised with 50% (37.5:45:15 kg $N:P_20_5:K_20$/ha), 100% (75:90:30 kg $N:P_20_5:K_20$/ha) and 150% (112.5:135:45 kg $N:P_20_5:K_20$/ha) fertilizer levels. The soil was low in nitrogen (organic carbon-0.38%), medium in available phosphorus (16.8 kg/ha), high in available potassium (396 kg/ha) and with slightly acidic pH (6.2). The recommended fertilizer dose to rainfed sunflower was 75:90:30 kg $N:P_20_5:K_20$/ha. The succeeding rainy season crops viz."CSH.6" sorghum, "ICPL.87" pigeonpea, "ICGS.11" groundnut, "KBSH.1" sunflower and "DCS.9" castor were grown in alternate years on the same plots with the following fertilizer levels (sorghum 40:40:30 kg $N:P_20_5:K_20$/ha, pigeonpea 20:40:30 kg $N:P_20_5:K_20$/ha, groundnut 20:40:30 kg $N:P_20_5:K_20$/ha, sunflower 75:90:30 kg $N:P_20_5:K_20$/ha and castor 40:40:30 kg $N:P_20_5:K_20$/ha). The base crop of rainy season sunflower was raised with 3 fertilizer levels and 15 replications during 1992,1994 and 1996. Randomized complete block design was followed for the base crop. The succeeding rainy season crops formed the main plots and 3 residual fertility levels the sub plots in split plot design with 3 replications. The base crop and rainy season crops were sown at onset of monsoon in June-July. The plot size of the sub plot was 4.8 x 5.4 m. In all the seasons same plots were maintained as fixed without disturbance. The distribution of rainfall during crop season of 1992-1997 is presented in Table 1.

Table 1: Montly rainfall (mm) distribution during the crop season

Month	1992	1993	1994	1995	1996	1997
June	111.8 (2)	13.8 (1)	68.7 (5)	73.3 (5)	127.2 (4)	4.8
July	69.3 (2)	79.6 (3)	89.5 (4)	152.2 (9)	70.0 (3)	78.6 (7)
August	215.8 (9)	151.8 (7)	142.5 (7)	57.0 (4)	75.0 (3)	93.5 (4)
September	21.9 (1)	93.8 (6)	30.2 (3)	158.3 (5)	18.0 (1)	124.2 (6)
October	37.4 (4)	49.6 (3)	303.0 (6)	316.4 (11)	18.0 (1)	45.7 (2)
November	65.4 (2)	30.6 (2)	10.4 (1)	31.6 (1)	-	7.9
December	-	-	-	-	-	30.1(1)
Total	521.6 (20)	419.2 (22)	644.3 (26)	788.8 (35)	308.2 (12)	384.8 (21)

* Figures in parenthesis indicate the number of rainy days

Rainfall was adequate during 1992, 1994 and 1995; it was moderate during 1993 and low during 1996 and 1997, which caused year to year variation in the productivity of sunflower and succeeding rainy season crops. On an average the season 1992-1997 was normal for the region. Recommended agronomic practices were followed for all the crops in terms of land preparation, sowing, thinning, plant protection, harvesting and processing. The wholesale market prices of the crops that prevailed during crop harvest period were used for calculating gross returns. Seed equivalent yield of sunflower was computed by using the market prices of the crops. Pooled analysis was made of the yield data for 3 years, for both base crop and rainy season crops. Based on this, sustainable yield index (SYI) was worked out by the formula:

$$SYI = \frac{\overline{A} - \overline{Y}}{Y_{max}} \times 100$$ where,

$\overline{A}$=mean of particular treatment,

$\overline{Y}$=standard deviation of a particular treatment,

Y_{max}=potential yield in different years and treatments.

Pooled data are presented and discussed.

RESULTS AND DISCUSSION

Yield

Base crop. Sunflower yield, as base crop in rainy season, did not vary significantly due to fertilizer levels (Table 2). The mean seed yield of sunflower was 1014 kg/ha varying from 958 to 1051 kg/ha across fertilizer levels over three years.

Table 2: Seed yield (kg/ha) of sunflower and suceeding crops as influenced by fertilizer levels (pooled data)*

Crop	Fertilizer level (kg/ha) for base crop of sunflower			Mean
	50% RDF	100% RDF	150% RDF	
Sunflower (base crop)	958	1051	1034	1014
Sorghum	3300	3569	3595	3488
Pigeonpea	689	841	886	805
Groundnut	2320	2255	2248	2274
Sunflower	711	738	628	692
Castor	508	508	543	520

	SEm+	CD(P=0.05)
Base crop	33.04	NS
Sequence crops		
Fertilizer	31.89	62.50
Crops x fertilizer	71.31	140.00

100% RDF = 75:90:30 kg N:P_2O_5:K_2O/ha

*Mean of 3 years (1992, 1994 and 1996) of base crop sunflower.

Mean of 3 years (1993, 1995 and 1997) of suceeding rainy season crops.

Succeeding crops. The performance of different succeeding crops alternating with sunflower grown at their recommended fertilizer levels showed significant variation from base crop for the varying residual fertility levels. Sorghum yield was higher by 269 and 295 kg/ha at 100% and 150% fertility, respectively over 50% of recommended fertilization to preceding sunflower. This is due to the higher demand and response of sorghum, which was adequately met when the previous season sunflower was grown at its recommended (100%) level of fertilization. Similar trend was noticed in pigeonpea seed yields with 152 to 197 kg/ha higher yields obtained at 100 and 150% level of fertilizers applied to preceding sunflower, respectively. The pod yield of groundnut at 50% residual fertility was highest indicating its optimum requirement. Superiority of groundnut in utilizing the residual fertility from preceding wheat crop has been reported by Pasricha *et al.* (1987) in groundnut wheat cropping system and in groundnut-summer sunflower sequence by Reddy and Sudhakara Babu (1996). Higher nutrient requirement of sorghum for growth and yield may be attributed for its response up to 150% recommended dose applied to preceding rainy season sunflower. Castor and sunflower crops could utilize residual fertility only up to 100% recommended dose to preceding sunflower. The mean yield of sunflower succeeding sunflower was lower (692 kg/ha) compared with base crop yield (1014 kg/ha) and was not responsive to residual fertility. Thus there is variation among the rainy season crops in utilizing the residual fertility left by preceding rainy season sunflower.

Table 3: Sunflower seed equivalent yield (kg/ha) of sequence crops as influenced by fertilizer levels *(Pooled data of 1993,1995 and 1997)

Crop	Fertilizer level (kg/ha) for base crop of sunflower			Mean
	50% RDF	100% RDF	150% RDF	
Sorghum	1036	1118	1129	1094
Pigeonpea	637	740	780	719
Groundnut	1958	1906	1898	1921
Sunflower	711	738	628	692
Castor	369	427	392	396

	SEm+	CD (P=0.05)
Fertilizer levels	19.91	55.18
Cropping system	41.39	120.81
Interaction	44.54	123.46

Sunflower seed equivalent yield. The mean sunflower equivalent yield computed for the succeeding crops (Table 3) revealed that groundnut (1921 kg/ha) and sorghum (1094 kg/ha) sequence crops produced significantly higher sunflower equivalent yield than the other rainy season crops. Sunflower equivalent yield at residual fertility from the 100% recommended dose to preceding sunflower crop was optimum to get higher sunflower seed equivalent yield from sorghum, pigeonpea, groundnut and castor. Whereas the fertilizer levels did not influence significantly the seed yield of sunflower although residual fertility of 50% recommended dose has resulted in the highest sunflower seed equivalent yield from groundnut, there was no significant difference between 50% and 100% recommended dose applied to sunflower. The higher sunflower seed equivalent in groundnut may be attributed to its efficiency to utilize the nutrient resources in the sequence with advantage. Wang and Fan (1987) also reported similar effect of legumes in the sunflower-based cropping system. Yield advantage in the rainy season sunflower with irrigated groundnut as preceding sequence crop during winter was reported by Reddy and Sudhakara Babu (1998).

Economics. Sunflower-groundnut rotation registered the highest mean returns of Rs.17,987/ha (Table 4) due to higher production of both crops coupled with better market prices. The next best remunerative system was sunflower-sorghum following sunflower-pigeonpea. The sunflower-sunflower system recorded the lowest net returns due to relatively low productivity and higher cost of cultivation as compared with sorghum.

Table 4: Economics and sustainable yield index as influenced by fertilizer levels to rainy season sunflower-based cropping systems (mean of 3 cycles)

Cropping system	Net Returns (Rs./ha)				Sustainable Yield Index (SYI) (%)
	50% RDF	100% RDF	150% RDF	Mean	
Sunflower-Sorghum	14054 (7755)*	16152 (10859)	16165 (9665)	15457 (9426)	37.5
Sunflower-Pigeonpea	8621 (9110)	9518 (11307)	8370 (12257)	8836 (10891)	23.1
Sunflower-Groundnut	17756 (10267)	18373 (12886)	17832 (12882)	17987 (12012)	44.2
Sunflower-Sunflower	6705 (12945)	6975 (12118)	5615 (11271)	6432 (12111)	26.1
Sunflower-Castor	7260 (5357)	7508 (4075)	5386 (5651)	6718 (5028)	22.8

*Figures in parentheses indicate the cost of cultivation (Rs./ha)

Sustainability. The sustainable yield index values as a measure of sustainability of the system were high in the sunflower-groundnut cropping system (44.2%) irrespective of variations in weather conditions in the six years (Table 4). This was followed by sunflower-sorghum system (37.5%). These two cropping systems are therefore more stable than the others.

CONCLUSION

The results indicate that in the red sandy loam soils of Andhra Pradesh sunflower-groundnut system gives higher sunflower seed equivalent yield and net returns in addition to providing fodder and improving soil fertility through optimum utilization of resources. This was followed by sunflower-sorghum sequence, that provides fairly high income as well as staple food for humans and fodder for livestock. These two systems with their high sustainability and multiple benefits can be readily accepted by the farming community. Also, they effectively mitigate the threat of downy mildew disease in sunflower (Sudhakara Babu *et al.*,1999), which to the sustainability of the system.

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MANTENIBILIDAD DE ROTACIÓN DE PLANTACIONES, BASADA EN GIRASOL CULTIVADO EN EL CULTIVO SECO EN EL SUELO TIPO ALFISOL

RESUMEN

El ensayo de campo fue realizado en la ciudad de Hiderabad, La India, en un período de seis años (1992-1997) con el fin de investigar las performances de girasol cultivado durante la temporada de lluvias en 50% (37.5:45:15 kg $N:P_20_5:K_20$/ha), 100% (75:90:30 kg $N:P_20_5:K_20$/ha) y 150% (112.5:135:45 kg $N:P_20_5:K_20$/ha) de la dosis de NPK recomendada. La plantación de girasol fue incluida en la rotación de un año con otras plantaciones que se cultivan en la temporada de lluvias, popote (*Sorghum bicolor* (L) Moench), gandul (*Cajanus cajan* (L) Millsp), maní (*Arachis hypogaea*. L.), girasol (*Helianthus annuus* L.) y ricino (*Ricinus cummunis* L.) con el objetivo de determinar el rendimiento, los resultados económicos y la mantenibilidad de dichas rotaciones. El nivel de abono no influyó en el rendimiento de la semilla de la variedad KBSH-1 durante seis años de investigaciones. La aplicación de la dosis del abono recomendada en el cultivo básico, aumentaba el rendimiento de popote, gandul, girasol y ricino, cultivados después de él, mientras que la reducción de 50% de la dosis recomendada, llevó hasta el rendimiento aumentado de maní en relación con otros cultivos. El aumentado rendimiento de la semilla de girasol, fue obtenido en rotaciones con maní y popote. La rotación girasol-maní ha traído el mayor ingreso neto (17,987 riales/ha), y luego siguió la rotación girasol-popote (15,457 riales/ha). Con este estudio se ha determinado que las rotaciones girasol- maní (44.24% SYI) y girasol-popote (37.52%) han sido los sistemas más mantenibles de cultivo en las condiciones de cultivo seco en el suelo tipo alfisol.

PERTINENCE DE LA ROTATION DE LA CULTURE DU TOURNESOL DANS DES ALFISOLS ALIMENTÉS PAR LA PLUIE

RÉSUMÉ

Une expérience a été faite dans les champs à Hyderabad, en Inde sur une période de six ans (1992 à 1997) pour étudier la performance du tournesol en saison des pluies à 50% (37.5:45:15 kg $N:P_2O_5:K_2O$/ha), 100% (75:90:30 kg $N:P_2O_5:K_2O$/ha) et 150% (112.5:135:45 kg $N:P_2O_5:K_2O$/ha) de la dose recommandée NPK. La culture de tournesol a été incluse dans une rotation annuelle avec d'autres cultures cultivées en saison des pluies: le sorgho (*Sorghum bicolor* (L) Moench), le pois d'angole (*Cajanus Cajan* (L) Millsp), l'arachide (*Arachis hypogaea.* L.)l le tournesol (*Helianthus annuus* L.) et le ricin (*Ricinus communis* L.) dans le but d'établir la productivité, les résultats économiques et le bien-fondé ou non de ces rotations. Les niveaux d'engrais n'ont pas eu d'effet sur le rendement en graines de tournesol KBSH-1 au cours des six années d'expérimentation. L'application des doses d'engrais recommandées à la culture de base a augmenté le rendement du sorgho, du pois d'angole, du tournesol et du ricin cultivés ultérieurement tandis qu'une réduction de 50% de la dose recommandée a augmenté le rendement de l'arachide par rapport aux autres cultures. Un rendement augmenté de tournesol a été obtenu par les rotations avec l'arachide et le sorgho. La rotation tournesol-arachide a donné le plus grand rendement net (Rs. 17,987/ha), puis la rotation tournesol-sorgho (Rs. 15,457/ha). Cette expérience a démontré que les rotations tournesol-arachide (44.24% SYI) et tournesol-sorgho (37.52%) étaient les systèmes de culture les mieux fondés dans les alfisols alimentés par la pluie.