TEMPORAL AND PLANT DENSITY EFFECTS OF INTERCROP COMPETITION ON SUNFLOWER

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SUMMARY

Investigations on intercropping of sunflower was made for two consecutive rainy seasons in Alfisols at Bangalore with staggered (45 days in 120 cm rows) and simultaneous (in 60 cm row) sowings in pigeonpea *(Cajanus cajan (L) Millsp.)* at two plant densities of both crops in additive and replacement series in 1:1 ratio, with respective sole crops.

Sole cropping produced higher leaf area, dry weight and stalk yields of both crops. In staggered planting, sole sunflower yielded 676 and 710 kg and intercropped sunflower yielded 470 and 628 kg/ha at 50 and 100 % plant densities respectively. Under simultaneous planting, sole sunflower yielded 1840 and 2326 kg and intercropped sunflower yielded 1544 and 1970 kg/ha at 50 and 100 % plant densities respectively.

Intercropping systems removed higher amounts of nutrients and yielded higher pigeonpea and sunflower equivalent yields, monetary returns, proteins and energy compared to either of sole crops. The Land Equivalent Ratio (LER) of all the intercropping systems were greater than unity with positive monetary advantages. Highest LER of 1.50 and monetary advantage (1766 Rs./ha) was in pigeonpea (50%) + sunflower (100%) system in staggered planting and pigeonpea (100%) + sunflower (50%) system in simultaneous planting (LER 1.33 & MA = 2748 Rs./ha). The former had higher Area Time Equivalency Ratio (ATER) (1.02) where pigeonpea was dominant with higher Competitive Ratio (CR) values (1.41 and 1.69 for seed and biological yields), while, sunflower was totally dominant (CR values of 1.33 to 4.04 and 0.96 to 3.34 for seed and biological yields of sunflower and pigeonpea respectively) in simultaneous intercropping. Nutrient Supplementation Indices (NSI) in general, were all positive and high for all intercropping systems.

Intercropping of pigeonpea and sunflower at pigeonpea (100%) + sunflower (50%) population in simultaneous planting, and pigeonpea (50%) + sunflower (100%) population in staggered planting resulted in highest LER and higher yields of both the crops with better ATER and optimum competitive ratios. The nutrient requirement of intercropping system was higher compared to the individual sole cropping.

INTRODUCTION

Crop production in drylands will continue to be a main stay of Indian agriculture and crop mixtures are traditional feature of subsistance agriculture where the farming conditions do not guarantee for profitable crop production. Recently, there has been a rapidly growing interest in intercropping as a potentially beneficial system of crop production due to its implied physico-technical and socio-economic principles (Beets, 1982). They may also be especially important because they are achieved not by means of costly inputs but by the simple expedient of growing crops together. Providing optimum conditions for achieving maximum complementarity between the crops is the ultimate goal of scientific intercropping.

More than 80 % of areas under pulses and oilseeds in India is under dryland agriculture and their productivity is one of the lowest. The bimodal rainfall distribution of 700 mm rain covering a period of 150-180 days on a soil of 45-60 cm depth with a water holding capacity of 150-200 mm, does not guarantee for definite double cropping in sequence but safely permits intercropping with crops varying in their duration to exploit the moisture availability period effectively. Pigeonpea (*Cajanus cajan* (L) Millsp.) and sunflower (*Helianthus annuus* L.) are the important rainfed pulse and oilseed crops of India and especially for the state of Karnataka. Pigeonpea is a long duration crop with slow and non-responsive initial growth but branches off profusely at later stages. Thus the sowing of the crop has to be necessarily done in wider rows varying from 60 to 120 cm. Until the crop attains grand growth stage, the growth factors will be under-utilized by the crop and wastfully lost by weeds. Early-sown pigeonpea with pre-monsoon rains in May at Bangalore resulted in higher productivity with least pest incidence. Sowing sunflower at the onset of monsoon in 2nd fortnight of June to 1st fortnight of July is optimum. While these two crops have wide temporal differences in their maturity with distinctly differing growth habits and rate of growth, both have high plasticity for variations in the plant population.

Growing together the two crops in intercropping system will benefit in increasing the cropping intensity and production. Any mixed cropping system will experience either competition or complementation or compensation of various degrees between the species grown together as detailed by Trenbath (1976). Provision of competition free period to the susceptible crop at its critical period is a newer dimension in the management of scientific intercropping system to achieve maximum complementarity (Singh *et al*. 1979). The potential advantage of growing species in associations therefore depends primarily on the degree of intercrop versus intracrop competition.The competition between these two contrasting crops and their adjustments in terms of variation in plant population and time of establishment was assessed in the present study, for achieving maximum complementarity and optimal harnessing of the growth factors.

MATERIAL AND METHODS

Two intercropping experiments consisting of (1) staggered planting of sunflower (SF) 45 to 48 days after sowing of pigeonpea (PP) spaced at 120 cm rows and (2) simultaneous sowing of pigeonpea and sunflower with 60 cm row spacing in 1:1 row proportion were conducted at Gandhi Krishi Vignana Kendra campus in Bangalore, India, during 1985-86 and 1986-87 under rainfed conditions. Both experiments had identical treatment combinations with 50 and 100 % of the recommended plant populations of pigonpea (Hy 3C) and sunflower

(hybrid KBSH-1) in sole and intercropping as PP 100 % + SF 100 %, PP 100 % + SF 50 %, PP 50 % + SF 100 %, PP 50% + SF 50 % in 1:1 ratio and SF 100 % sole, SF 50 % sole, PP 100 % sole and PP 50 % sole as main plots. Fertilization was arranged as sub plots: land based (without regard to crop species or plant population, a common fertilizer dose of 50:50:25 kg $N:P_2O_5:K_2O$/ha for the system) and crop based (as per the crop and its population, 25:50:25 and 50:50:25 kg $N:P_2O_5:K_2O$/ha for 100% population of pigeonpea and sunflower respectively) The desired plant population of individual crops as per the treatment combination was achieved by adjusting the intra row spacing in 60 and 120 cm row spacings in experiment 1 and 2 respectively. The nutrients were supplied through urea (46 % N) for nitrogen, super phosphate (16% P_2O_5) for phosphorus and muriate of potash (60% K_2O) for potassium. All the P and K fertilizers were applied as basal at the time of sowing in rows while nitrogen was applied in two splits The gross plot size of each sub-plot was 6 m x 4.8 m for experiment 1 and 5.4 m x 4.8 m for experiment 2. The soil of the experimental site was Alfisol of medium deep, well drained and lateritic sandy clay loam texture with slightly acidic soil reaction (pH = 5.6). The field capacity and permanent wilting point values of 0-30 cm soil depth were 15.2 % and 7.9 % respectively. The soil fertility was medium in available nitrogen (306 kg/ha), phosphorus (37 kg/ha) and potassium (212 kg/ha) with low organic carbon (0.40%). Normal crop management practices were followed in raising both sunflower and pigeonpea crops in terms of interculture, plant protection and post-harvest operations.

The total rainfall received during 1985 and 1986 was 699 and 777 mm respectively, against a normal annual rainfall of 888 mm. During the crop growth period, pigeonpea received 498 and 526 mm of rain in 1985 and 1986 respectively, While sunflower received 403mm of rain when sown simultaneously with pigeonpea and only 239 mm when sowing was staggered by 45 days in 1985. During 1986, simultaneous sown sunflower received 460 mm of rain while staggered sown sunflower received 427 mm.

Periodic observations were recorded on both crops to assess their performance in terms of growth (height, branching, leaf area, dry matter production, flowering) and yield (seed, pod & its components, stalk, etc.). The intercropping systems were assessedfrom many angles of efficiency in terms of apportioning of Leaf Area Index (LAI) of individual crops and the system, land utilization, through Land Equivalent Ratio (LER = *the ratio of the area needed under sole cropping to one of the intercropping at the same management level to give an equal amount of yield*) (Andrews and Kassam, 1976), land utilization in terms of per day productivity per unit land, through Area Time Equivalency Ratio (ATER = *the area time (ha days) required by monoculture to area time (ha days) used by the intercrop in producing the same quantities of all component crops in producing the same quantities of all component crops*) (Hiebsh and Mc Collum, 1987), economic gain, through Monetary Advantage (MA = *the monetary benefit from intercropping compared to either sole cropping*) (Willey, 1979) and relative magnitude of competition between the crops, through Competitive Ratio (CR = *number of times by which one component crop is more competitive than other*) (Willey and Rao, 1980) besides the nutrient requirement and demand of individual crops in the intercropping system, through Nutrient Supplementation Indices (NSI = the percentage of the uptake for a element by sole crop «A» that should be added in mixture to meet the combined needs of intercropped «A» and «B» (Wahua, 1983) for N, P and K.

RESULTS AND DISCUSSION

Under simultaneous intercropping of sunflower and pigeonpea in 60 cm row spacing, leaf area of sunflower got marginally reduced in all less-than-double total populations of intercropping with pigeonpea, compared to the highest leaf area of sunflower recorded in sole cropping at 100 and 50 % population (Table 1). When 100 % plant population of both crops were involved, the leaf area of sunflower was significantly reduced. The system LAI was higher in all the intercropping combinations with more than 100 % total population density from both the crops. When the total population in intercropping system was only 100 % (PP 50 % + SF 50 %), the system LAI was marginally less (2.64) than the sole crop LAI of sunflower with 100 % population (2.76) due to the slow rate of development of pigeonpea, but it was higher than sole crop LAI of sunflower with 50 % population (1.49) due to the contribution from pigeonpea. Sunflower crop contributed largely to the system LAI to the tune of 80 % by virtue of its fast growth and dominating effect.

Under staggered intercropping, when sunflower was introduced after 45 days after establishment of pigeonpea in 120 cm row spacing, the system LAI at 60 days after sowing of sunflower (pigeonpea at its grand growth stage at 105 days after sowing) was significantly high in all the intercropping systems (3.76 to 7.44) than sole cropping (1.69 and 0.98) whereas the leaf area of sunflower in intercropping system was significantly lower (1620 to 1758 cm^2/plant) compared to sole cropping (200 to 2500 cm^2/plant). The contribution of sunflower for the system LAI was around 30 %. This was due to the competition from well grown pigeonpea as well as significantly low amount of rainfall for sunflower (239 mm) received by staggering the sowing compared to simultaneous sowing which received higher rainfall of 403 mm during 1985 while there was not much variation during 1986.

The seed yield of sunflower was higher in simultaneous inercropping compared to staggered intercropping (Table 1). This was due to the high amount of rainfall received in 1985 for simultaneous sown sunflower as well as dominance of sunflower over slow growing pigeonpea. Under simultaneous intercropping, 100 % population of sunflower had given higher seed yields at all combinations of pigeonpea and was at par with 50% population of sole sunflower Whereas, under staggered intercropping of sunflower, 100 % population of sunflower with 50 % population of pigeonpea recorded higher sunflower yield. Similar trend was noticed for dry matter production per plant and stalk yield of sunflower both under simultaneous and staggered intercropping systems.

All the combinations of sunflower and pigeonpea intercropping systems recorded higher LER of more than 1.0 indicating the inherent advantage in growing together these two crops (Table 2). The magnitude of LER was higher in staggered intercropping than simultaneous intercropping. Under simultaneous intercropping, 100 % population of pigeonpea with 50 % population of sunflower recorded highest LER of 1.33 while under staggered intercropping system, 100 % population of sunflower with 50 % population of pigeonpea recorded highest LER of 1.50 followed by LER of 1.40 in PP 50 % + SF 50 % and LER of 1.32 in PP 100 % + SF 50 %. Lowest LER of 1.22 and 1.26 was recorded in PP 100 % + SF 100% in both simultaneous and staggered intercropping systems. Monetary Advantage followed similar trend as that of LER with simultaneous intercropping recording higher MA compared to staggered intercropping by virtue of higher returns from sunflower. When time factor of land occupation by different crops was incorporated into the evaluation of intercropping systems it was found that none of the intercropping systems were efficient (ATER < 1.0) except for the staggered intercropping system of PP 50 % + SF 100 %, where

ATER was marginally higher at 1.02. Sunflower crop was dominating in all the combinations of simultaneous and staggered intercropping systems with pigeonpea except in staggered intercropping of PP 50 % + SF 100 % wherein the pigeonpea was dominant. The competitive ratio of sunflower in simultaneous intercropping with pigeonpea varied from 1.30 to 4.04 and that in staggered intercropping varied from 0.71 to 2.18.

The nutrient demand of individual crops in intercropping system as measured through nutrient supplementation indices were in general positive and high for N, P and K for both crops with few exceptions of sunflower in simultaneous intercropping at 100 % population for P and K where the values were low and negative (Table 3). This indicates there is higher requirement of nutrients in intercropping system than their sole cropping in tune with their advantages of better efficiency.

CONCLUSION

Pigeonpea and sunflower forms compatible crops for intercropping by virtue of their differences in growth habits in terms of plant structure and duration. Sunflower was dominant crop in the system. When simultaneous intercropping is to be followed, a combination of 100 % population of pigeonpea with 50 % population of sunflower is optimum. When pigeonpea was provided with an opportunity to establish and compete with sunflower in staggered intercropping, 100 % population of sunflower with 50 % population of pigeonpea was optimum.

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Table 1. Growth and yield of sunflower in intercropping with pigeonpea under simultaneous and staggered sowings (mean of 2 years).

Cropping system	Leaf area (cm^2/plant)[1], system LAI[2] & LAI of SF[3] at 60 DAS						Total Dry weight (g/plant)		Seed yield (kg/ha)		Stalk yield (kg/ha)	
	Simultaneous			Staggered			Simultaneous	Staggered	Simultaneous	Staggered	Simultaneous	Staggered
	1	2	3	1	2	3						
PP 100% + SF 100%	2820	4.95	3.91	1620	7.44	2.32	65.93	39.76	1962	541	1865	1230
PP 100% + SF 50%	3296	3.94	3.20	1778	5.37	1.63	78.53	44.78	1631	470	1668	995
PP 50% + SF 100%	3034	4.15	3.37	1758	5.95	1.74	67.28	45.59	1970	628	2016	1307
PP 50% + SF 50%	3063	2.64	2.12	1684	3.76	1.17	82.10	47.34	1544	557	1659	1150
SF 100% sole	3313	2.76	2.76	2047	1.69	1.69	78.50	50.51	2326	710	2354	1415
SF 50% sole	3599	1.49	1.49	2496	0.98	0.98	92.09	63.21	1840	676	1748	1443
SE mean ±	144.0	0.08	0.07	49.2	0.16	0.04	2.34	1.37	59.57	18.4	57.57	36.8
CD (P=0.05)	425	0.21	0.18	145	0.41	0.11	6.91	4.06	176	54	170	108

SF = Sunflower; PP= Pigeonpea ; 1= Leaf area of SF (cm^2)/plant; 2= System Leaf Area Index; 3= LAI of SF

Table 2. Evaluation of intercropping system of sunflower and pigeonpea under simultaneous and staggered sowings (mean of 2 years).

Cropping system	LER		MA (Rs/ha)		ATER		CR	
	Simultaneous	Staggered	Simultaneous	Staggered	Simultaneous	Staggered	Simultaneous	Staggered
PP 100% + SF 100%	1.22	1.26	2276	1056	0.76	0.84	2.21	1.52
PP 100% + SF 50%	1.33	1.32	2748	1289	0.84	0.94	4.04	2.18
PP 50% + SF 100%	1.17	1.50	1574	1766	0.70	1.02	1.33	0.71
PP 50% + SF 50%	1.25	1.40	2021	1373	0.79	0.95	2.00	1.41
SF 100% sole	1.00	1.00						
SF 50% sole	1.00	1.00						

SF = Sunflower; PP= Pigeonpea ; LER= Land Equivalent Ratio; MA= Monetary Advantage;
ATER= Area Time Equivalency Ratio; CR= Competitive Ratio;

Table 3. Nutrient Supplementation Indices of pigeonpea and sunflower in intercropping system under simultaneous and staggered sowings of sunflower (mean of 2 years).

Cropping system	Method of SF establishment	Nutrient Supplementation Index					
		N %		P %		K %	
		Pigeonpea	Sunflower	Pigeonpea	Sunflower	Pigeonpea	Sunflower
PP (100%) + SF (100%)	Simultaneous	36.48	3.19	123.44	-6.97	-98.29	7.96
	Staggered	14.67	56.59	44.94	31.90	109.75	28.51
PP (100%) + SF (50%)	Simultaneous	61.88	86.33	206.47	91.49	127.47	83.81
	Staggered	27.32	83.17	55.28	55.28	103.74	13.41
PP (50%) + SF (100%)	Simultaneous	19.92	2.61	51.11	-30.20	31.61	-16.60
	Staggered	35.88	68.34	76.53	35.38	131.24	25.03
PP (50%) + SF (50%)	Simultaneous	40.32	41.53	120.52	52.86	75.59	42.36
	Staggered	23.14	60.72	62.93	37.30	123.22	9.66

SF= Sunflower; PP= Pigeonpea