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Production potential of intercropping of groundnut *(Arachis hypogaea)* with pigeonpea *(Cajanus cajan)* and maize *(Zea mays)* under various row proportions in rainfed Alfisols of West Bengal

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ABSTRACT

A field experiment was conducted during the rainy *(kharif)* seasons of 2002 and 2003 at Jhargram, West Bengal, to evaluate the production potential and economic feasibility of intercropping of groundnut *(Arachis hypogaea* L.) with pigeonpea [*Cajanus cajan* (L.) Millsp.] and maize (*Zea mays* L.) under 6 row proportions (3:1, 4:1, 5:1, 3:2, 4:2 and 5:2). Groundnut yield was reduced by 8-35% due to intercropping and yields of pigeonpea and maize were inversely proportional to groundnut row number. Yield components of main and intercrops were also decreased in intercropping systems. Among the intercropping systems, groundnut with pigeonpea in 5:2 row proportion or with maize in 4:2 row proportion was most remunerative in respect of net return and benefit : cost ratio. These 2 intercropping systems showed high competitive ratios, land-equivalent ratio and monetary advantage among all intercropping systems.

Key words : Intercropping, Groundnut, Maize, Pigeonpea, LER, Yield

The traditional practice of growing two or more crops together without any definite spatial arrangement is being followed in rainfed uplands. Intercropping has long been recognized as a kind of biological insurance against risks under aberrant rainfall behaviour in dry land environment. Stability of crop yield can be achieved in upland with crops substitution and intercropping (Rao *et al.,* 1982). When crops of different growth habits are put together in an intercropping system, it provides greater opportunity to secure higher yield from the same piece of land. The upland (Alfisols) in Red and Laterite Zone of West Bengal is suitable for growing rainy season *(kharif)* groundnut. Instead of growing sole groundnut, intercropping of any suitable crops like pigeonpea or maize can be more profitable in the dry tracts of this zone. Their deep root system helps in tapping plant nutrients and water from deeper layers allowing the base crop (groundnut) to feed at top layers of the soil. Moreover, spatial arrangement and plant population in an intercropping have important effects of the balance of competition between component crops and their productivity (Sarkar and Pal, 2004). Hence present experiment was undertaken to evaluate the comparative performance of intercropping groundnut with pigeonpea and maize at different row proportions under rainfed lateritic uplands (Alfisols) of West Bengal.

MATERIALS AND METHODS

The field experiment was conducted during the rainy seasons of 2002 and 2003 at the Regional Research Station of Bidhan Chandra Krishi Viswavidyalaya, Jhargram (West Bengal), on lateritic upland soil (Alfisol-Haplustalf), having sandy-clay loam texture, pH 5.7, organic carbon 0.38%, available P 10.93 kg/ha and available K 200.16 kg/ha. The treatments consisted of sole crops of groundnut cv. 'JL 24', pigeonpea cv. 'UPAS 120' and maize cv. 'Navjot' and 12 additive intercropping systems of groundnut with each pigeonpea and maize in row ratios of 3:1, 4:1, 5:1, 3:2, 4:2 and 5:2 (Table 1).

Fifteen treatments were laid out in randomized complete-block design with 3 replications. The additive rows of pigeonpea and maize were adjusted according to row ratio of treatments. The fertilizers in sole stands of groundnut, pigeonpea and maize were applied as 20:60:40, 20:50:20 and 100:60:40 kg N, P_2O_5 and K_2O/ha respectively. The row spacing for groundnut, pigeonpea and maize was 30, 60 and 60 cm respectively. Crops were sown in middle of July in both the years of experimentation. The total rainfall during the crop period was 1,090 and 1,150 mm in 2002 and 2003 respectively. The results of both the years were more or less similar and hence 2 years data were pooled and statistically

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analysed. Different competition indices were calculated as described by Willey (1979). Area-time equivalent ratio was calculated as proposed by Heibsch (1978). Groundnut-equivalent yield was worked out by converting the yields of intercrops to the yield of groundnut on the basis of prevailing market price of each crop. The economics of different crops and crop combinations were computed on the basis of prevailing market rates of produce and agro-inputs.

RESULTS AND DISCUSSION

Productivity of main crop

Sole crop of groundnut always showed higher yield attributes over intercropped groundnut (Table 1). Pods/plant, kernels/pod and shelling (%) of groundnut decreased significantly in intercropping system, depending on nature of intercrops and their spatial arrangement. Groundnut in association with each pigeonpea and maize in 5:1 row proportion recorded more pods/plant, kernels/pod, shelling (%) and test weight of kernels owing to wider spacing of intercrops compared to other row arrangements. Maximum reduction in yield attributes were recorded in groundnut intercropped with either pigeonpea or maize in 3:2 row proportion due to more shading and competition effects by intercrops on groundnut.

Intercropping significantly reduced the pod yield of groundnut compared with sole groundnut due to competition effect. The average reduction in pod yield of groundnut varied from 8.2 to 34.88%, depending on nature of intercrops and planting pattern. Rao and Mittra (1994) reported 7–50% yield reduction in groundnut by intercropping with pigeonpea. Jana and Saren (1998) reported that row ratio of 3:2 in groundnut + maize intercropping system reduced pod yield 36.2% due to depressing effect of maize on groundnut. Intercroping system of groundnut with either pigeonpea or maize in 5:1 row proportion recorded higher pod yield of groundnut on account of improvement in yield attributes of groundnut under this row ratio because the depressing effect of intercrops on groundnut was minimized due to lesser number of intercrops rows and more space occupied by groundnut.

Productivity of intercrops

Sole crops of pigeonpea and maize recorded higher yield attributes and seed yield over their respective intercropped stands (Table 1). Magnitude of reduction in yield and yield attributes of pigeonpea and maize due to intercropping with groundnut varied with plant population and spatial arrangement of component species. Maximum reduction in yield attributes and yield of pigonpea and maize was recorded in intercropping with groundnut under 5:1 row proportion due to intense competition effect because of greater population pressure of groundnut on lesser population of intercrop. However, minimum reduction in yield of pigeonpea and maize was found in intercropping with groundnut in 3:2 row proportion.

Table 1. Yield components and yield of sole and intercrops as influenced by intercropping system (pooled data of 2 years)

Treatment	Groundnut					Intercrop			
	Pods/ plant	Kernels/ pod	Shelling (%)	100-kernel weight (g)	Pod yield (q/ha)	Pods or cobs/plant	Seeds/pod or seeds/cob	100-seed weight (g)	Seed yield (q/ha)
Sole cropping									
Groundnut	21.00	1.88	66.14	36.33	12.87				
Pigeonpea						247.80	5.42	82.30	10.52
Maize						0.89	235.16	183.14	24.48
Intercropping									
Groundnut : pigeonpea									
3:1	14.10	1.65	60.52	35.26	9.25	211.69	4.61	78.80	3.69
4:1	16.92	1.74	62.73	35.78	10.84	198.36	4.35	76.56	3.09
5:1	19.31	1.81	64.71	36.33	11.82	190.75	4.27	74.79	2.51
3:2	12.51	1.59	59.24	34.94	8.38	225.57	4.84	81.28	4.59
4:2	15.17	1.70	61.31	35.52	9.98	217.64	4.68	79.95	3.71
5:2	18.38	1.79	63.65	36.18	11.44	205.83	4.56	76.85	3.31
Groundnut : maize									
3:1	14.87	1.68	60.92	35.36	9.80	0.71	200.46	174.87	8.76
4:1	17.42	1.75	62.96	35.92	10.90	0.69	190.37	170.24	7.50
5:1	18.83	1.80	64.25	36.31	11.25	0.67	182.14	167.51	6.25
3:2	13.16	1.63	58.54	34.96	8.50	0.75	210.15	179.69	10.80
4:2	16.82	1.72	62.37	35.45	10.60	0.72	203.33	176.13	9.10
5:2	18.11	1.77	63.50	36.15	11.00	0.69	193.49	172.78	7.75
CD (P=0.05)	1.51	0.03	1.32	NS	0.87				

Total productivity

All the intercropping systems showed superiority to sole groundnut in terms of groundnut-equivalent yield, expect 3:1 or 3:2 row proportion in intercropping irrespective of intercrop (Table 2). The higher groundnut-equivalent yields were obainied with groundnut intercropping with pigeonpea in 5:2 row ratio and with maize in 4:2 row ratio; however, both the intercropping systems were statistically at par to each other. Higher groundnut-equivalent yield under intercropping of groundnut with pigeonpea in 5:2 row proportion or with maize in 4:2 row proportion might be due to efficient utilization of resources and less competition between component crop species. Intercropping groundnut with each pigeonpea and maize either in 3:1 or 3:2 or 3:2 row associations gave lower groundnut-equivalent yields compared with sole crop of groundnut as well as other intercropping system owing to more inter-specific competition of component crops, resulting in reduction of groundnut yield.

Biological feasibility

The land-equivalent ratio (LER) more than 1 indicates greater biological efficiency of intercropping system (Rafey and Prasad, 1992). Intercropping system of groundnut with pigeonpea and maize resulted in LER more than 1, indicating intercropping advantages (Table 3). Intercropping system of groundnut with pigeonpea in 5:2 row proportion and with maize in 4:2 row proportion showed the greater biological efficiency of the system (LER 1.20 and 1.19 respectively). This yield advantage owing to intercropping might be attributed to combined effect of better utilization of natural resources than sole cropping of companion crops, resulting in higher productivity per unit area. The association of groundnut with pigeonpea in 3:1 and 3:2 row ratios gave lower LER (1.06

Table 2. Groundnut-equivalent yield and economics of groundnut, pigeonpea and maize intercropping system (pooled data of 2 years)

Treatment	Groundnut-equivalent yield (q/ha)	Net return (kg/ha)	Benefit : cost ratio
Sole cropping			
Groundnut	12.87	15,200	1.44
Pigeonpea	9.47	10,824	1.33
Maize	7.95	8,612	1.18
Intercropping			
Groundnut : pigeonpea			
3:1	12.56	14,762	1.42
4:1	13.62	16,557	1.54
5:1	13.10	15,183	1.38
3:2	12.51	14,980	1.49
4:2	13.32	16,186	1.55
5:2	14.42	17,986	1.66
Groundnut : maize			
3:1	12.65	15,335	1.54
4:1	13.34	16,289	1.57
5:1	13.28	15,896	1.49
3:2	12.01	14,400	1.50
4:2	13.56	17,075	1.70
5:2	13.52	16,572	1.58
CD (P=0.05)	1.05		

Prevailing market prices of groundnut, pigeonpea and maize @ Rs 20.0 18.0 and 6.50/kg respectively

Table 3. Competition function and monetary advantages of groundnut, pigeonpea and maize intercropping system (pooled data of 2 years)

Treatment	Land-equivalent Ratio (LER)	Competitive ratio		Relative crowding co-efficient		Products of relative crowding co efficient (K)	Area-time equivalent ratio (ATER)	Monetary advantage (Rs/ha)
		CR_g	CR_i	K_g	K_i			
Intercropping								
Groundnut : pigeonpea								
3:1	1.06	0.68	1.46	0.84	1.62	1.36	0.96	1,422
4:1	1.13	0.71	1.39	1.33	1.66	2.20	1.01	3,141
5:1	1.15	0.77	1.29	2.25	1.56	3.51	1.02	3,673
3:2	1.08	0.99	1.00	1.24	1.16	1.43	0.99	1,853
4:2	1.12	1.10	0.91	1.72	1.09	1.87	1.02	2,854
5:2	1.20	1.13	0.88	3.20	1.14	3.65	1.08	4,806
Groundnut : maize								
3:1	1.11	0.71	1.40	1.06	1.67	1.77	1.09	2,507
4:1	1.15	0.69	1.45	1.38	1.77	2.44	1.12	3,479
5:1	1.13	0.68	1.46	1.39	1.71	2.38	1.10	3,311
3:2	1.10	0.99	1.00	1.29	1.18	1.52	1.06	2,184
4:2	1.19	1.11	0.90	2.33	1.18	2.75	1.16	4,329
5:2	1.17	1.08	0.92	2.35	1.16	2.72	1.14	3,928

CG_g and CR_i, Competitive ratio of groundnut on intercrops and of intercrops on groundnut respectively; K_g and K_i, crowding coefficient of groundnut on intercrops and of intercrops on groundnut respectively

and 1.08), indicating inefficient systems. The companion crop either pigeonpea or maize appeared more competitive than groundnut giving higher values for competitive ratio (Table 3), expect 4:2 or 5:2 row proportion in intercropping system. The relative crowing coefficient values of groundnut was always greater than 1 indicated that groundnut gave more yield than expected, expect groundnut + pigeonpea intercropping in 3:1 row proportion. The product of relative crowding coefficient indicated definite yield advantage to grow groundnut with pigeonpea and maize (K>1.00). Highest area-time equivalent ratio (1.16) was recorded for groundnut intercropping with maize in 4:2 row ratio, indicating a more efficient use of area time by intercrop over other systems. Thus the biological parameters indicated that intercropping groundnut with pigeonpea or maize could be biologically sustainable.

Economic viability

The monetary advantage (MA) based on LER indicated superior economic viability of groundnut + pigeonpea intercropping in 5:2 row ratio, followed by groundnut + maize in 4:2 row ratio (Table 3). The intercropping of groundnut with pigeonpea in 5:2 ratio gave the maximum net return of Rs 17,986/ha (Table 2), followed by groundnut + maize intercropping in 4:2 ratio (Rs 17,075/ha). The benefit : cost ratio values (Table 2) were higher under groundnut + maize intercropping in 4:2 ratio (1.70) and groundnut + pigeonpea intercropping in 5:2 ratio (1.66) mainly owing to higher economic production in these system.

Hence it was concluded that intercropping of groundnut either with pigeonpea in 5:2 row ratio or with maize in 4:2 row ratio is biologically and economically sustainable intercropping system for rainfed lateritic upland (Alfisols) of West Bengal.

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