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Conservation and production ability of maize (*Zea mays*) – legume intercropping systems under varying dates of sowing

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ABSTRACT

A field experiment was conducted during rainy (*kharif*) season of 1993 and 1994 on 2% sloping field at the Central Soil Conservation Research Farm, Selakui, Dehra Dun, on intercropping of maize (*Zea mays* L.) with cowpea [*Vigna unguiculata* (L.) Walp.], blackgram (*Phaseolus mungo* L.) and soybean [*Glycine max* (L.) Merr.] and their sole stands under early (10 June), normal (25 June) and late (10 July) dates of sowing. Intercropping of cowpea and blackgram with maize gave higher maize-equivalent yields (35.28 and 33.50 q/ha respectively) than sole maize (28.00 q/ha). Intercropping also resulted in higher maize-equivalent yields than respective sole legume stands by 125.86, 128.05 and 265.00% under maize + cowpea, maize + blackgram and maize + soybean respectively. Normal sowing gave higher maize-equivalent yield (30.10 q/ha) than early sowing (22.66 q/ha) and late sowing (18.45 q/ha). Cowpea and blackgram in sole stands had higher canopy, followed by their intercropping with maize, and normal sowing developed canopy faster than early or late sowing. Maximum net return (Rs 9,433/ha) was obtained under normal time of sowing of maize + cowpea.

Key words: Intercropping, Maize, Legumes, Sowing dates

Maize is a principal rainy (*kharif*) - season crop of Western Himalayan region of India and mainly sown with the onset of monsoon, hence its sowing time assumes great importance for higher sustained production and efficient resource conservation. Wider spacing and less initial canopy cover that coincides with higher rainfall intensities and duration induce a high grade of erosion on rolling topography. Canopy cover is considered to be the first line of defence against water erosion with direct reduction in splash effect, reduced soil sealing and more soil infiltrability. Legumes are considered to be the best soil conservators after grasses (Tejwani and Mathur, 1972) and legumes as intercrops impart sustainability in the system (Sharma and Chaubey, 1991). However, no information is presently available on extent of contribution in canopy cover and yield by various *kharif* pulses to maize in intercropping in comparison to sole crops in this region. Therefore a study was undertaken to evaluate the protection and production worth of various *kharif*

legumes, viz. cowpea, blackgram and soybean, with or without maize at different sowing dates.

MATERIALS AND METHODS

The experiment was conducted at Dehra Dun (683 m altitude, 77°51' to 77°58'E and 30° 20' to 30°26'N) during monsoon season of 1993 and 1994 on a 2% sloping field having silty clay-loam soil (35% sand, 40% silt and 25% clay), with pH 6.5. The soil belongs to the Dhulkot series and low in available N (120 kg/ha) and medium in available (16 kg/ha) and (180 kg/ha). The rainfall received during crop seasons (June to September) of 1993 and 1994 was 1,342.6 and 1,435.4 mm, which constituted 88.94 and 86.27% of annual rainfall in the respective years.

The treatments comprised 4 sole crops (maize, cowpea, blackgram and soybean) and 3 intercrop combinations (maize + cowpea, maize + blackgram and maize + soybean) sown at 3 different sowing dates (early, 10 June; normal, 25 June and late, 10 July) were replicated thrice in randomized block design. Two rows of legume intercrops were adjusted between 2 rows of maize sown at 90 cm x 20 cm spacing. The normal recommended cultural practices were used for different sole and intercropping systems.

Regular observations on canopy cover were recorded at 15, 30 and 45 day after sowing (DAS). Since the economical products under various systems were different, maize equivalents were calculated on the basis of prevailing market prices of respective economical products under different crops in Dehra Dun during both the years. Net return, cost of production of maize equivalents and profitability of maize equivalents from various cropping systems (crops/combinations) at different sowing dates were also computed to work out the economical feasibility. The data were statistically analysed.

RESULTS AND DISCUSSION

Though data of 1993 and1994 are given in tables, we interpreted and discussed only the pooled data.

Grain and maize-equivalent yields

Significant variations in mean maize equivalent of intercropping systems than their respective sole stands of intercrops were recorded over all sowing dates (Table 1), being 125.86, 128.05 and 265.00% higher under maize + cowpea, maize + blackgram and maize + soybean respectively. Besides, maize + cowpea and maize + blackgram produced statistically higher mean maize equivalents than sole maize over different sowing dates by 26.00 and 19.64% respectively. Higher maize-equivalent yields under intercropping than sole cropping of maize and/or legumes were also reported by Balasubramanium *et al.* (1989), Balyan and Seth (1989) and Sharma *et al.* (1998). These were attributed to better resource utilization and complementary nutrient use (Willey, 1979). Intercropping of legumes reduced the grain yield of maize over different sowing dates, being maximum under maize + blackgram (12.79%), followed by maize + soybean (7.94%) and maize + cowpea (6.44%). This indicated that interspecific competition or allelopathic effects of legumes on maize was more than intraspecific competition or autotoxic effect of maize on maize that was in order of blackgram > soybean > cowpea. The higher grain yield under maize + cowpea may thus be attributed to minimum adverse effects of growing cowpea on maize. Maize also had adverse effects on grain yields of legumes in intercropping over different sowing dates which was 54.58% in maize + cowpea, 54.20% in maize + soybean and 48.87% in maize + blackgram. Thus reduction in the grain yields of legumes due to maize was almost same with cowpea and soy-

Table 1. Effect of cropping system and sowing date on grain yield, maize equivalent and land-equivalent ratio of maize and *kharif* legumes

Treatment	Grain yield (q/ha)						Maize equivalent (q/ha)			LER		
	1993		1994		Pooled		1993	1994	Pooled	1993	1994	Pooled
	M	I	M	I	M	I						
Cropping system												
T_1 Sole maize	21.42		21.28		21.35		28.28	27.72	28.00			
T_2 Sole cowpea		5.79		5.75		5.77	15.66	15.58	15.62			
T_3 Sole blackgram		4.42		4.95		4.69	15.24	14.14	14.69			
T_4 Sole soybean		4.17		3.08		3.63	9.41	7.39	8.40			
T_5 Maize + cowpea	20.04	2.63	19.05	2.54	19.55	2.59	37.26	33.30	35.28	1.46	1.26	1.36
T_6 Maize + blackgram	18.68	2.26	19.26	2.32	18.97	2.29	33.36	33.63	33.50	1.32	1.41	1.37
T_7 Maize + soybean	19.72	1.91	17.99	1.83	18.86	1.87	31.57	29.75	30.66	1.37	1.44	1.41
CD (P = 0.05)							3.39	6.65	4.30	NS	NS	NS
Sowing time												
Early (1)	18.21	3.62	17.13	3.25	17.67	3.43	24.39	20.92	22.66	1.39	1.35	1.37
Normal (2)	24.17	4.84	24.97	4.68	24.57	4.76	30.04	30.16	30.10	1.44	1.37	1.41
Late (3)	17.51	2.13	16.08	2.30	16.80	2.22	18.76	18.14	18.45	1.33	1.39	1.36
CD (P = 0.05)							3.39	6.65	4.30	NS	NS	NS
Cropping system x Sowing time												
T_1 x 1	19.63		19.17		19.40		26.08	24.95	25.52			
T_1 x 2	26.00		27.60		26.80		34.20	35.70	34.95			
T_1 x 3	18.64		17.06		17.85		24.58	22.51	23.55			
T_2 x 1		5.10		5.28		5.19	13.69	14.13	13.91			
T_2 x 2		7.92		8.88		8.40	21.26	23.67	22.47			
T_2 x 3		4.35		3.09		3.72	12.02	8.95	10.49			
T_3 x 1		3.68		4.00		3.84	17.26	11.36	14.31			
T_3 x 2		6.74		7.32		7.03	20.03	20.93	20.48			
T_3 x 3		2.83		3.53		3.18	8.44	10.12	9.28			
T_4 x 1		5.18		4.56		4.87	11.64	10.49	11.07			
T_4 x 2		5.98		2.74		4.36	13.47	6.32	9.90			
T_4 x 3		1.35		1.95		1.65	3.11	5.35	4.23			
T_5 x 1	18.26	2.26	14.34	1.84	17.30	2.05	37.73	27.60	32.67	1.37	1.20	1.29
T_5 x 2	24.50	3.50	24.54	4.02	24.52	3.76	43.86	45.14	44.50	1.52	1.26	1.39
T_5 x 3	17.35	2.15	16.27	1.76	16.81	1.95	30.18	27.16	28.67	1.50	1.33	1.41
T_6 x 1	17.12	2.40	18.40	1.20	17.76	1.80	31.86	28.33	30.10	1.38	1.34	1.36
T_6 x 2	22.11	2.62	24.03	3.08	23.07	2.85	39.20	42.65	40.93	1.29	1.29	1.29
T_6 x 3	16.80	1.75	15.34	2.67	16.07	2.21	29.02	29.90	29.46	1.31	1.61	1.46
T_7 x 1	17.84	3.09	14.62	2.63	16.23	2.86	32.48	29.55	31.02	1.42	1.52	1.47
T_7 x 2	24.07	2.30	23.71	2.06	23.89	2.18	38.25	36.73	37.49	1.52	1.56	1.54
T_7 x 3	17.26	0.35	15.64	0.81	16.45	0.58	23.97	22.98	23.48	1.19	1.24	1.22
CD (P = 0.05)							2.48	2.71	2.45	0.06	0.06	0.04

M, Maize; I, Intercrop

Price of grain (Rs/q) : maize 425 and 450, Blackgram 1,175 and 1,200, soybean 900 and 975 and cowpea 1,100 and 1,175 during 1993 and 1994 respectively

Price of straw (Rs/q) : maize 50 and legumes 25 for both the years

bean which revealed that interspecific competition in intercropping was more than intraspecific competition in different legumes.

Normal sowing resulted in 32.83 and 63.14% higher mean maize-equivalent yields than early (22.66 q/ha) and late (18.45 q/ha)

sowing respectively; however, latter were at par with each other. Higher mean maize equivalents under normal sowing may be due to favourable growing conditions, whereas lower under early sowing may be due to dry soil conditions at the time of sowing, attack of insects, diseases, birds etc. on seed or seedlings. Under late sowing, seedling and subsequent growth could have been hampered due to high rainfall, subsequent high soil-moisture regimes and smaller growing period leading to low yield especially from legumes.

Significant interaction between maize and intercrops and between sowing dates indicated that normal sown maize + cowpea gave maximum (44.50 q/ha) and statistically highest maize-equivalent yield than all other crop species combinations evaluated at different sowing dates.This may be attributed to the better yields under normal sowing time due to favourable climate and minimum competition between maize and cowpea.

Biological feasibility

Effect of crop species combinations over all sowing dates and effects of sowing dates over all crop species combinations on LER were non-significant (Table 1). Interactions recorded maximum and statistically highest LER under timely sown maize + soybean, while minimum LER was found under late maize + soybean. Although, normal sown maize + soybean produced maximum LER, it could neither gave maximum maize-equivalent yield nor maximum net return. This was simply because LER does not take into account the relative monetary value of products (Willey, 1979) and also LER is independent of yield levels (Chetty and Rao, 1979).

Biological sustainability of intercropping over sole cropping of maize and legumes were indicated by higher LER values (1.22–1.54) under different crop species combinations at all sowing dates.

Canopy development

Variations in canopy cover due to crop species combinations over sowing dates at 15 DAS were non-significant (Table 2). At 30 and 45 DAS, sole cowpea and blackgram produced statistically identical canopy cover, but these were statistically higher than rest of crop species combinations over different sowing dates. Intercropping of maize + cowpea and maize + blackgram recorded statistically second highest canopy cover at 30 and 45 DAS over various sowing dates. These were significantly higher than sole soybean, maize + soybean and sole maize.

Canopy cover under normal sowing was at par with the early sowing at 30 DAS. However, these were statistically superior to late sowing. At 45 DAS, normal sowing recorded statistically higher canopy cover than early or late sowing over different crop species combinations.

Interaction data indicated maximum canopy under late-sown sole cowpea at 15 DAS that was statistically at par with timely sown sole cowpea and sole blackgram. At 30 DAS, normal sown sole cowpea recorded maximum canopy cover that was statistically identical to early cowpea and early and timely sown sole blackgram. Again, normal sown sole cowpea recorded maximum canopy cover at 45 DAS but this was statistically at par with early and late sole cowpea, early, normal or late sole blackgram or maize + cowpea and early and timely sown maize + soybean.

Economical feasibility

Data (Table 3) indicated maximum but statistically identical net return under maize + cowpea, followed by maize + blackgram and sole maize over sowing dates and these were statistically higher than rest of crop species combinations. Variations in cost of production and profitability of maize equivalents due to crop species combinations over sowing

Table 2. Effect of cropping system and sowing date on canopy development (per cent) at different days after sowing of maize and *kharif* legumes

Treatment	15 DAS			30 DAS			45 DAS		
	1993	1994	Pooled	1993	1994	Pooled	1993	1994	Pooled
Cropping system									
T_1 Sole maize	10	10	10	55	48	52	80	75	78
T_2 Sole cowpea	19	19	19	85	81	83	98	95	97
T_3 Sole blackgram	17	18	17	86	80	83	96	95	95
T_4 Sole soybean	4	3	4	47	41	44	76	71	74
T_5 Maize + cowpea	15	17	16	72	67	70	93	90	92
T_6 Maize + blackgram	15	14	15	74	68	71	91	87	89
T_7 Maize + soybean	11	10	11	62	56	59	86	81	84
CD (P = 0.05)	NS	NS	NS	3	3	3	7	3	2
Sowing time									
Early (1)	12	13	12	69	65	67	88	85	87
Normal (2)	15	14	14	71	65	68	91	87	89
Late (3)	12	13	12	66	60	63	87	82	85
CD (P = 0.05)	NS	NS	NS	3	3	3	7	3	2
Cropping system x sowing time									
T_1 x 1	10	8	9	54	50	52	83	78	81
T_1 x 2	10	12	11	60	48	54	81	79	80
T_1 x 3	9	11	10	52	46	49	77	69	73
T_2 x 1	15	17	16	85	83	84	96	94	95
T_2 x 2	22	18	20	89	83	86	100	98	99
T_2 x 3	20	22	21	82	78	80	99	93	96
T_3 x 1	17	19	18	86	82	84	94	94	94
T_3 x 2	20	18	19	87	83	85	99	99	99
T_3 x 3	14	16	15	84	76	80	94	92	93
T_4 x 1	4	2	3	49	41	45	77	71	74
T_4 x 2	6	4	5	49	45	47	79	73	76
T_4 x 3	3	2	3	43	39	41	73	68	71
T_5 x 1	17	19	18	73	67	70	91	89	90
T_5 x 2	17	19	18	72	68	70	95	91	93
T_5 x 3	11	13	12	70	66	68	93	90	92
T_6 x 1	10	14	12	73	67	70	91	89	90
T_6 x 2	18	14	16	75	69	72	93	89	91
T_6 x 3	16	16	16	75	67	71	88	84	86
T_7 x 1	9	11	10	63	59	61	85	83	84
T_7 x 2	13	11	12	66	60	63	89	83	86
T_7 x 3	11	9	10	58	50	54	85	78	82
CD (P = 0.05)	5	3	2	5	7	6	3	3	13

DAS, Days after sowing

dates were non-significant except sole soybean. This indicates high cost of cultivation and low maize-equivalent yields. Thus, soybean was found to be economically not feasible during *kharif* season at recommended cultural practices in Doon valley.

Although, normal sowing involved numerically lower cost of production and contributed towards higher profitability of maize equivalents than early followed by late sowings over crop species combinations but the differences were non-significant.

The interactions showed statistically negative net return from late soybean followed by normal and early sole soybean, late sole blackgram and late maize + soybean due to

Table 3. Effect of cropping system and sowing date on net return, cost, production of maize equivalent and profitability of maize equivalents from maize and *kharif* legumes

Treatment	Net return (Rs/ha)			Cost of production			Profitability of maize equivalent (Rs/ha)		
	1993	1994	Pooled	1993	1994	Pooled	1993	1994	Pooled
Cropping system									
T_1 Sole maize	6,127	5,914	6,021	213	246	230	212	204	208
T_2 Sole cowpea	1,574	1,365	1,470	344	423	384	81	27	54
T_3 Sole blackgram	1,598	934	1,266	367	424	396	58	26	42
T_4 Sole soybean	–3,242	–3,182	–3,212	1,162	1,105	1,134	–737	–655	–696
T_5 Maize + cowpea	7,659	5,875	6,767	225	290	258	200	160	180
T_6 Maize + blackgram	6,503	6,454	6,479	234	261	248	191	189	190
T_7 Maize + soybean	3,331	1,985	2,658	332	389	360	93	61	77
CD (P = 0.05)	1,441	940	1,916	NS	259	401	NS	257	404
Sowing time									
Early (1)	3,362	2,398	2,880	324	409	367	101	41	71
Normal (2)	5,762	4,955	5,359	263	368	316	162	82	122
Late (3)	969	938	753	646	567	607	–221	–117	–169
CD (*P* = 0.05)	1,441	940	1,916	NS	NS	NS	NS	NS	NS
Cropping system x sowing time									
T_1 x 1	5,189	4,638	4,914	226	263	245	199	187	193
T_1 x 2	8,640	9,520	9,080	172	183	178	253	267	260
T_1 x 3	4,551	3,585	4,068	240	291	266	185	159	172
T_2 x 1	738	711	725	371	400	386	54	50	52
T_2 x 2	3,956	5,004	4,480	239	239	239	186	211	199
T_2 x 3	29	–1,620	–796	423	631	527	2	–181	–90
T_3 x 1	2,456	–316	1,070	283	478	381	142	–28	57
T_3 x 2	3,633	3,991	3,812	244	259	252	181	191	186
T_3 x 3	–1,293	–874	–1,084	574	536	555	–149	–86	–118
T_4 x 1	–2,293	–2,803	–2,548	622	717	670	–197	–267	–232
T_4 x 2	–1,515	–4,680	–3,098	537	1,191	866	–112	–741	–428
T_4 x 3	–5,918	–2,062	–3,990	2,328	1,406	1,867	–1,903	–956	–1430
T_5 x 1	7,860	5,396	6,628	217	331	274	208	113	134
T_5 x 2	10,466	8,399	9,433	186	203	195	239	247	243
T_5 x 3	4,652	3,831	4,242	271	331	274	208	119	164
T_6 x 1	5,865	6,379	6,122	241	300	271	184	150	167
T_6 x 2	8,985	8,780	8,882	196	199	198	229	251	240
T_6 x 3	4,659	4,204	4,432	264	284	274	161	166	164
T_7 x 1	3,719	2,780	3,250	311	377	344	114	73	96
T_7 x 2	6,171	3,671	4,921	264	304	284	161	146	154
T_7 x 3	102	–497	–198	421	485	453	4	–35	–16
CD (P = 0.05)	1,175	4,140	1,241	382	136	247	382	129	248

high cost of production of maize equivalents than prices of maize equivalents leading to negative profitability of maize equivalents. Timely sown maize + cowpea yielded maximum and statistically highest net return than any other cropping system at different sowing dates.However,variations in cost of production and profitability of maize equivalents under various crop species combinations evaluated at different sowing dates were non-significant except interactions yielding negative net returns in all sowing dates of sole soybean and late sowings of sole blackgram, maize + blackgram and maize + soybean.

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