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Effect of planting pattern and population in potato + maize intercropping system under north-western hills of India

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ABSTRACT

An experiment was conducted for two seasons to evaluate two planting patterns and two population densities in potato + maize intercropping. Results revealed that although potato performed better in 2:2 intercropping system and maize in 1:1 intercropping system, maximum advantage in terms of yield and competition was obtained when both the crops were grown in intercropping with 75% of their sole crop population, irrespective of planting pattern. The relative crowding coefficient values indicated that at similar planting densities, maize was more competitive than potato in 1:1 planting pattern, whereas potato was more competitive than maize in 2:2 planting pattern. The competitive ratio also showed that performance of potato in terms of yield was better than maize when planted in 2:2 pattern. The land equivalent ratio and product of relative crowding coefficient indicated that potato + maize intercropping was advantageous when both the crops were planted with 75% density, either in 1:1 or 2:2 ratio. Net profit (~ Rs. 36,000/ ha) and B:C ratio (1.83) were also maximized under mid-hills of North-western hill regions of India.

Key words: Intercropping, maize + potato, planting pattern, population density, relative crowding coefficient.

INTRODUCTION

The advantages of intercropping are commonly attributed to the complementarity of resource capture patterns by crops and better input management (Rodrigo *et al*., 12; Nedunchezhiyan *et al*., 11). Intercropping not only increases the diversity, it also provides more stability and lower risk against the vagaries of nature. Potato (*Solanum tuberosum* L.) and maize (*Zea mays* L.) are the two important crops which have a good potential as intercrop in the north-western hills since both are grown simultaneously as rainfed from April-September. Intercropping of these two crops has shown yield advantage over the sole cropping of either of the crop (Dua *et al*., 5).

Resource capture by component crops in intercropping may depend upon morphological characteristics of individual crop. Maize is a taller crop compared to potato and therefore, asymmetric distribution of capture organs is likely to induce dominance relationships between plants which may affect their performance (Mushagalusa *et al*., 10). The difference in the morphology of these crops may be utilized to optimize resource utilization in the intercropping system through altered planting patterns and populations. The present study was, therefore, conducted to work out the different planting patterns as well as populations of potato and maize and to study its effect on yield, competition functions in potato + maize intercropping system, net returns and nutrient removal by the system.

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MATERIALS AND METHODS

The experiment was conducted under rainfed conditions at CPRI, Shimla, during summer season (April to September) for two years. The experimental site is situated at an elevation of 1,861 m above sea level at 31º05' 35" N latitude and 77º09' 88" E longitude and the soil is sandy loam in texture. The pH of the experimental site was 5.9 (slightly acidic) with 121% organic carbon and 256.7-140.8-323.4 kg/ ha of available N-P-K. The rainfall received during the crop seasons were 992 to 1,205 mm during the three seasons, respectively.

The intercropping treatments comprised of combinations of two planting patterns (2:2 and 1:1), two population densities (50 and 75% of sole population on row length basis) of two intercrops (potato and maize). Besides, two sole crop treatments of potato and maize were also kept for comparison. The experiment was carried out in randomized block design with three replications. The recommended spacings adopted were 50 cm × 20 cm for potato cv. Kufri Jyoti and maize cv. KH 101. In intercrop combinations, the populations were adjusted by changing the intra-row spacing. During both the years, potato and maize were planted in second fortnight of April; potato was harvested in first week of September, whereas maize was harvested in second fortnight of September. Recommended

doses of fertilizers (potato; 150:43.7:83 and maize; 120:26.2:33.2 kg N:P:K/ha, respectively) were applied as CAN, SSP and MOP and the crops were raised as per recommended package of practices (Anon, 2, 3). NPK application to component crops in intercropping treatments was made on the basis of their sole crop proportion sown.

To evaluate the productive efficiency of the intercropping; the land equivalent ratio (LER), relative crowding coefficient, aggressivity and competitive ratio were calculated as per Mead and Willey (9), De Wit (4), McGilchrist (8), and Willey and Rao (13), respectively. Potato equivalent yield (PEY) was calculated by converting the yield of component crops into potato yield on the basis of sale price. For calculating PEY as well as economics, the mean sale price of potato tubers, maize grains and stovers used were Rs. 400, 1,100 and 100/q, respectively. The nutrient contents in plant and soil samples were estimated using standard procedures.

RESULTS AND DISCUSSION

Potato tuber yield during both the years as well as the mean yield were highest (109.1 q/ha) in intercropping system where potato and maize were grown in 2:2 intercropping system with 75% of normal population of both the crops (Table 1). The tuber yield under this system was statistically similar with potato + maize (1:1) intercropping with 75% population each (100.8 q/ha). When the population of potato was kept 75%, the tuber yields were statistically similar irrespective of planting pattern and population density of component maize crop.

Maize grain yield during both the years, as well as its mean yield showed a significant improvement when population of maize was increased from 50 to 75%, irrespective of planting pattern and population density of component crop potato. Although the yield differences were not significant, maize yield in 1:1 intercropping system was higher than 2:2 system at similar level of potato population. The opposite results were observed in case of potato tuber yield.

The results indicated that potato performed better in 2:2 intercropping system, whereas the performance of maize was better in 1:1 intercropping system. This could be the result of difference in canopy structure of both the crops. Potato, which is shorter than maize, had a greater shading effect in 1:1 system since maize was planted in both the adjacent rows. In this system, maize had a better chance to grow at top as the competition for space from the adjacent rows was lesser, as short statured potato was planted in these rows. However, in 2:2 intercropping system, potato had a lesser competition compared to 1:1 system since competition from maize was only from one side; therefore competition for light was less, whereas maize had to face competition from adjacent maize row on one side.

The perusal of land equivalent ratio (LER) data indicated that intercropping of potato + maize was beneficial only when both the crops were planted with 75% of normal population (Table 2). There was

Table 1. Yield of component crops in potato + maize intercropping system under different treatments.

Treatment	Planting pattern	Population (as % of pure crop)		Potato tuber yield (q/ha)			Maize grain yield (q/ha)		
		Potato	Maize	1st y	2nd y	Mean	1st y	2nd y	Mean
Potato pure				218.8	162.1	190.4	0.0	0.0	0.0
Maize pure				0.0	0.0	0.0	51.9	64.7	58.3
Potato + maize	2:2	50	50	94.0	66.4	80.2	21.5	25.8	23.7
Potato + maize	2:2	50	75	91.1	71.4	81.3	28.2	33.9	31.0
Potato + maize	2:2	75	50	116.5	94.0	105.3	20.5	27.4	23.9
Potato + maize	2:2	75	75	119.3	98.9	109.1	27.6	36.8	32.2
Potato + maize	1:1	50	50	86.3	72.9	79.6	22.3	36.3	29.3
Potato + maize	1:1	50	75	83.6	68.1	75.8	30.8	43.3	37.1
Potato + maize	1:1	75	50	110.0	90.7	100.4	21.7	35.1	28.4
Potato + maize	1:1	75	75	112.9	88.6	100.8	29.3	41.4	35.4
CD at 5%				28.1	16.7	15.7	5.9	7.6	4.6
CV%				14.2	10.7	13.0	12.1	11.4	11.8

1st y = First year, 2nd y = Second year

no effect of planting pattern on LER in this case. The yield advantage, as indicated by increased LER in potato + maize intercropping, has been reported by many researchers (Ebwongu *et al.*, 6; Jamshidia *et al*., 7; Al-Dalain, 1).

The relative crowding coefficient (RCC) values showed that both the crops produced more yield than 'expected' when planting density was increased from 50 to 75%. The RCC values further revealed that when both the crops were planted at similar densities, maize was more competitive than potato in 1:1 intercropping, whereas *vice-versa* was true in 2:2 system. It indicated that yield advantage of maize was more than potato in 1:1 system, whereas potato produced higher yield than maize in 2:2 system. Like LER, product of RCC (Kab × Kba) also indicated that intercropping was beneficial when both the crops were planted with 75% density, either in 1:1 or 2:2 ratio.

The aggressivity value of potato (Aab) showed that at the same population of both the crops, potato was a 'dominant' species in 2:2 system, whereas it was 'dominated' species in 1:1 system, *i.e.*, the relative change in yield of potato was more than maize in 2:2 system, whereas in 1:1 system, change in maize yield was more than that of potato. Ebwongu *et al*. (6) also reported that maize is commonly regarded as the dominant plant in the association when the potato and maize are planted simultaneously.

The aggressivity value does not show the extent of dominance of a particular species, therefore, to know the exact degree of competition, competitive ratio (CR) values were also worked out. The CR shows how much a species produced more yield than another species over the respective expected yield. The CR indicated that potato in general outperformed maize in 2:2 intercropping and the highest value of 1.35 was obtained in 2:2 system where potato and maize were planted with 75 and 50% of respective sole crop population, indicating that the yield of potato was 35% higher than maize in terms of ratio of actual and expected yields.

The mean NPK uptake by maize was higher than potato. Maize removed 2.8, 4.2 and 2.2 times higher N, P and K, respectively, than potato in pure crop stands. This was due to higher total biomass production (Table 3). Under both planting patterns, N and K uptake by potato was significantly higher when its population density increased from 50 to 75%. However, under intercropping situation, P uptake by potato remained unaffected of population density and planting patterns. The highest removal of N (101.1 kg/ha), P (24.4 kg/ha) and K (101 kg/ha) by maize in intercropping situation was more in the treatments where potato + maize were planted in 1:1 ratio with 50 and 75% respective sole population. Since the NPK contents of maize grain and stover did not differ significantly due to treatments, highest removal of NPK under this treatment was the result of highest yield of maize under this treatment. Similar results were also obtained in case of mean total removal of NPK by the system. Since the mean NPK uptake by maize as intercrop situations was also 2.7, 2.6 and 2.1 times higher than potato, hence the uptake of NPK in the intercropping system was largely governed by maize.

Pure maize removed higher NPK than its applications thus leaving a negative balance of these nutrients. However, potato removed only 18.2, 10.9 and 24.5% of applied NPK. In the intercropping situations also there was a positive balance of NPK under all treatments. In general, removal of N was 33.9 to 46.5% of the applied N under different intercropping system. The corresponding figures for P and K were 28.5 to 44.2 and 43.3 to 69.9%. This led to a substantial balance of NPK under various inter-cropping treatments. The net profit from intercropping treatment was higher than sole cropping of either of crops only when both the crops were planted with 75% their normal population, irrespective of planting patterns. Among intercropping treatments, benefit:cost ratio (1.83) was also the highest under this situation.

It may be concluded from the study that the maximum advantage in terms of yield and LER can be obtained from potato + maize inter-cropping when both the crops are planted with 75% of their normal population, irrespective of planting pattern (1:1 and 2:2). Net profit and benefit:cost ratio were also maximum under this treatments.

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Table 2. Competition indices and economics in potato + maize intercropping systems under different treatments.

Treatment	Planting pattern	Population (as % of pure crop)		LER	Relative crowding coefficient			Aggressivity (Aab)	Competitive ratio (CR)	Cost of cultivation (Rs./ ha)	Gross return (Rs./ ha)	Net return (Rs./ ha)	B:C ratio
		Potato	Maize		Potato (Kab)	Maize (Kba)	Product (Kab × Kba)						
Potato pure			1.00							47,274	76,167	28,893	1.61
Maize pure			1.00							30,726	64,128	33,402	2.09
Potato + maize	2:2	50	50	0.83	0.73	0.68	0.50	0.03	1.04	39,000	58,094	19,094	1.49
Potato + maize	2:2	50	75	0.96	0.74	1.14	0.85	-0.21	0.80	39,200	66,645	27,445	1.70
Potato + maize	2:2	75	50	0.96	1.24	0.70	0.86	0.29	1.35	43,000	68,427	25,427	1.59
Potato + maize	2:2	75	75	1.13	1.34	1.24	1.66	0.04	1.04	43,200	79,084	35,884	1.83
Potato + maize	1:1	50	50	0.92	0.72	1.01	0.72	-0.17	0.83	39,000	64,031	25,031	1.64
Potato + maize	1:1	50	75	1.03	0.66	1.75	1.16	-0.48	0.63	39,200	71,125	31,925	1.81
Potato + maize	1:1	75	50	1.01	1.11	0.95	1.06	0.08	1.08	43,000	71,382	28,382	1.66
Potato + maize	1:1	75	75	1.14	1.12	1.54	1.73	-0.15	0.87	43,200	79,188	35,988	1.83

LER = Land equivalent ratio

Table 3. Nutrient balance sheet in potato + maize intercropping systems under different treatments (mean of two years).

Treatment	Planting pattern	Population (as % of pure crop)		Nutrient application (kg/ha)			Removal by potato (kg/ha)			Removal by maize (kg/ha)			Total removal by system (kg/ha)			Nutrient balance (kg/ha)		
		Potato	Maize	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
Potato pure				240.1	73.3	211.0	43.7	8.0	51.6	0.0	0.0	0.00	43.7	8.0	51.6	199.2	62.4	154.9
Maize pure				165.1	41.0	97.2	0.0	0.0	0.0	165.9	41.6	167.6	165.9	41.6	167.6	-16.6	-5.7	-83.2
Potato + maize	2:2	50	50	202.6	57.2	154.1	19.5	5.0	22.8	65.7	16.0	66.6	85.1	21.0	89.4	112.9	35.0	56.9
Potato + maize	2:2	50	75	243.9	67.5	178.4	19.6	5.1	22.8	85.6	21.0	84.8	105.2	26.1	107.6	134.9	40.2	60.6
Potato + maize	2:2	75	50	262.6	75.5	206.8	24.7	6.1	30.0	64.4	15.4	59.5	89.1	21.5	89.5	167.6	51.2	107.7
Potato + maize	2:2	75	75	303.9	85.2	231.1	26.9	6.2	30.7	83.2	21.2	77.8	110.1	27.4	108.4	185.7	55.3	112.6
Potato + maize	1:1	50	50	202.6	57.2	154.1	18.7	5.2	21.6	79.4	20.1	86.1	98.1	25.3	107.8	93.3	28.9	25.2
Potato + maize	1:1	50	75	243.9	67.5	178.4	17.1	5.2	20.9	101.1	24.4	101.0	118.3	29.6	121.9	111.4	33.9	33.8
Potato + maize	1:1	75	50	262.6	75.5	206.8	23.1	5.7	27.7	74.7	18.3	72.9	97.7	24.0	100.6	149.3	47.7	83.4
Potato + maize	1:1	75	75	303.9	85.2	231.1	24.2	5.9	28.3	93.6	22.5	91.1	117.7	28.3	119.4	176.9	54.0	89.7
CD (P = 0.05)							4.3	1.2	4.1	20.2	4.5	17.1	19.5	4.3	16.6			

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