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Intercropping Two Varieties of Maize (*Zea mays* L.) and Peanut (*Arachis hypogaea* L.): Biomass Yield and Intercropping Advantages

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Abstract Effect of different planting ratios of intercropping maize and peanut on Economical and Biological yield of maize (*Zea maize* L.) was evaluated in the Department of Agronomy, University of Zabol, during 2011. The treatments were compared in a randomized completely block design (RCBD) with nine planting ratios intercropping that were included. M: Sole maize var KSC 301(100% maize+0% peanut), M*: Sole maize var KSC 604 (100% maize+0% peanut), P: Sole peanut (100%peanut + 0%maize), MP: Intercrop of maize var KSC 301 50% + peanut 50%, M*P: Intercrop of maize var KSC 604 50% + peanut 50%, mP: Intercrop of maize var KSC 301 25% + peanut 75%, m*P: Intercrop of maize var KSC 604 25% + peanut 75%, Mp: Intercrop of maize var KSC 301 75% + peanut 25%, M*p: Intercrop of maize var KSC 604 75% + peanut 25%. The intercropped of maize and peanut in different planting ratio significantly affected the quantitative characters of the yield. The highest dry biological yield of maize (57.3t/ha) was obtained by sowing the crops in Intercrop of maize var KSC 604 75% + peanut 25%. The highest grain yield (10.0 t/ha) for maize was recorded from Sole maize var KSC 604(100% maize+0% peanut) and the highest dry biological yield for peanut (7.4 t/ha) was recorded from Intercrop of maize var KSC 604 50% + peanut 50%. The highest LER (2.30) and the lowest LER (1.27) was obtained by sowing the crops in ratio of Intercrop of maize var KSC 604 50% + peanut 50% and Intercrop of maize var KSC 301 25% + peanut 75% respectively. The results was shown that mixture were advantageous compared to both sole crops of maize and peanut.

Keywords Intercropping, Peanut, Maize, LER, Height Plant, Biological, Economical Yield

1. Introduction

Intercropping of two or more crops especially family Poaceae with Fabaceae is popular in many countries because yields are often higher than in pure cropping systems[11]. Cereal-legume intercropping plays an important design in allowance food production in both developed and developing countries, especially in situations of restricted water resources[20]. Moreira (1989) was express that mixed cropping especially with legumes can betterment both forage quality and quantity because legumes are well source of protein[14]. Intercropping of legumes and cereals is an old drill in tropical agriculture that dates back to old urbanity. The basis objective of intercropping has been to maximize benefit of resources such as area, light and nutrients[10], as well as to amendment crop quality and quantity[15]. Marchiol *et al* (1992) have reported an increase in plant height but a reduction in total yield and sheath of soybean grown in intercropping the maize as compared to its pure crop[12]. Others investigators have shown that intercropping of poaceae and fabaceae produce higher seed yields than either pure crop[15, 16]. In such intercropping, the yield development of the cereal portion[5]. Intercrops of legumes in cereals are a better choice to increase the quality of cereal fodder. However, intercropping gave higher crude protein yields than pure maize. Legumes can transfer fixed N to intercropped cereals during their together growing cycle and this N is an important resource for the cereals[1]. The efficiency of cereal-legume intercrops systems, to explication as land equivalent ratio (LER). Banik (1996) was showed that wheat and legumes (pea, lentil and gram) intercropping suggested that the intercropping advantage showed that a 1:1 replacement series intercropping under whole treatments was advantageous whereas a 2:1 replacement treatment[2]. Romheld (1987) was shown that peanut and maize have clearly different response mechanisms to Fe lack stress. Peanut is a 'strategy I' plant, while maize belongs to the 'strategy II' block. Strategy II plants are characterized by a higher Fe pursuit efficiency on soils with high pH and, in particular, with high bicarbonate consisting through the warding off at phytosiderophores into the rhizosphere[17]. The objectives of this research were: (1) to determine the effect of intercropping on the yield of maize

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and peanut grown under different intercropping patterns; (2) to determine the highest land equivalent ratio of different intercropping patterns of maize/peanut.

2. Materials and Methods

The field experiment was carried out on the University of Zabol farm, Iran (61° 41′E, 30° 54′N, and altitude 483m above sea level); average 30 years rainfall was 49 mm. The experiment was carried out during 2011 growing season on a sandy loam soil (Table 1).

All phosphorus (65 kg/ha) and potassium (200 kg/ha) and half nitrogen (290 kg/ha) were applied at sowing while balance of nitrogen was applied at stem elongation stage for maize. All other cultural practices including (Irrigation, thinning and weeding) were kept normal and uniform for all the treatments.

Experimental design and treatments

The treatments were compared in a RCBD design with nine levels of planting ratios in three replication (Table 2).

The treatment comprising the individual plot size was 4m × 6m. For this experiment, the recommended density of maize and peanut are expressed, pure crop densities being 10 and 10 plants/m^{-2} for both plants, respectively. Initially 3 seeds were sown per hole for maize. Quantity parameters were determined includes: Fresh and Dry Biological yield, Economical yield, Fresh and Dry weight of ear, height of plant for maize and Fresh and dry biological yield for peanut, LER (land equivalent ratio) measured for compared pure crop with intercropping system. LER is defined as the total land area required under mono-culture cropping giving the yields obtained in the intercropping system[13]. Total LER (LER_T), including maize partial LER (LER_M) and peanut partial LER (LER_P), was calculated as follows:

$$LER_T = LER_M + LER_P = YI_M/YS_M + YI_P/YS_P$$

Where: YI_M and YI_P are biomass yields per unit area of intercropped maize and peanut respectively, and YS_M and YS_P are biomass yields per unit area of pure cropped maize and peanut respectively.

3. Statistical Analysis

The data yield and quantity parameters were analyzed by Fisher's analysis of variance technique and Duncan test at 0.05 probability levels to compare means[19]. Data analyses were conducted using of SAS[18] as a RCBD experiment by 9 treatments with three replicates.

4. Results

Height plant, Fresh weight of Ear, Dry weight of Ear, Fresh Biological yield and Dry biological yield was greatly ($p<0.01$) affected by planting ratios but economical yield was affected (Table 3).

Table 1. Soil characteristics of the experiment area during the 2011 growing season

Year	Depth of soil (cm)	pH	Ec(mmohs/cm)	N (%)	P(ppm)	K(ppm)	Sand	Silt	Clay
2011	0-20	7.8	3.2	0.062	11	134	73	12	15

Table 2. The description of experiment treatments

Treatment	Description
M	Sole maize var KSC 301(100% maize+0% peanut)
M*	Sole maize var KSC 604(100% maize+0% peanut)
P	Sole peanut (100%peanut+0%maize)
MP	Intercrop of maize var KSC 301 50% + peanut 50%
M*P	Intercrop of maize var KSC 604 50% + peanut 50%
mP	Intercrop of maize var KSC 301 75% + peanut 25%
m*P	Intercrop of maize var KSC 604 75% + peanut 25%
Mp	Intercrop of maize var KSC 301 25% + peanut 75%
M*p	Intercrop of maize var KSC 604 25% + peanut 75%

Table 3. Analysis of variance for quantitative parameters of intercropping for maize

		Means of Square					
S.OV	df	Plant height	Fresh biomass Ear	Dry Biomass Ear	FBY	DBY	EY
Replication	2	210.5*	48.5	60.5*	41.3	6.2	5.8
Treatment	7	475.0**	1972.9**	105.4**	2481.5**	625.8**	12.6*
Error	14	60.7	226.4	10.3	130.3	26.9	4.7
C.V (%)	-	4.5	15.5	18.0	18.0	15.7	27.6

*, ** significant at $p<0.05$ and $p<0.01$, respectively.
PH: Plant Height, FBE: Fresh Biomass of Ear, DBE: Dry biomass of Ear, FBY: Fresh Biological Yield, DBY: Dry Biological Yield, EY: Economical Yield

Table 4. Means of quantities characteristics of maize as influenced by Planting Ratios

Planting Ratio	Plant Height (cm)	Fresh Biomass Ear(t/ha)	Dry Biomass Ear(t/ha)	FBY(t/ha)	DBY(t/ha)	EY(t/ha)
M	170.0 bc	24.3 cd	18.5 bc	54.6 cd	29.3 cd	9.7 a
M*	185.7 a	28.2 bc	20.1 b	68.8 bc	37.3 bc	10.0 a
MP	163.7 cd	18.8 de	13.9 cd	42.4 de	22.4 de	6.6 abc
M*P	185.0 a	32.3 b	21.5 b	79.4 b	41.4 b	9.2 ab
mP	155.0 d	32.7 b	20.6 b	87.8 b	42.7 b	9.0 abc
m*P	180.0 ab	41.7 a	27.3 a	111.1 a	57.3 a	8.6 abc
Mp	163.3 cd	13.2 e	9.4 d	29.2 e	13.1 e	4.9 c
M*p	155.0 d	15.9 e	11.3 d	37.7 de	20.2 de	5.1 bc

Any two means not sharing a common letter differ significantly from each other at 5% probability.
M: Sole maize var KSC 301(100% maize+0% peanut), M*: Sole maize var KSC 604(100% maize+0% peanut), P: Sole peanut (100%peanut+0%maize), Intercrop of maize var KSC 301 50% + peanut 50%, M*P: Intercrop of maize var KSC 604 50% + peanut 50%, mP: Intercrop of maize var KSC 301 75% + peanut 25%, m*P: Intercrop of maize var KSC 604 75% + peanut 25%, Mp: Intercrop of maize var KSC 301 25% + peanut 75%, M*p: Intercrop of maize var KSC 604 25% + peanut 75%

The mean plant height was 185.7 cm was obtained sole maize var KSC 604 that no significant different with Intercrop of maize var KSC 604 50% + peanut 50% and Intercrop of maize var KSC 604 75% + peanut 25%. The intercrop of maize var KSC 604 75% + peanut 25% produced the highest of fresh biomass of ear, Dry biomass of ear, fresh biological yield and Dry biological yield and the Intercrop of maize var KSC 301 25% + peanut 75% produced the lowest of fresh biomass of ear, Dry biomass of ear, fresht Biological yield and Dry biological yield (Table 4). The intercrop of maize var KSC 604 100% + peanut 0% produced the highest of economical yield (10.0 t/ha) and the intercrop of maize var KSC 301 25% + peanut 75% produced the lowest of economical yield (Table 4). The reason for increased seed yield in maize may be attributed to nitrogen fixing ability of peanut and extensive root system of maize.

Fresh Biological yield of peanut was greatly ($p<0.01$) affected by planting ratios (Table 5).

Table 5. Analysis of variance for FBY and DBY for peanut in intercropping

Means of Square			
S.OV	df	FBY	DBY
Replication	2	33.8	2.4
Treatment	6	108.8**	9.5*
Error	12	11.9	2.3
C.V (%)	-	22.4	24.1

*, ** significant at $p<0.05$ and $p<0.01$, respectively
FBY: Fresh Biological Yield, DBY: Dry Biological Yield

The highest and the lowest of Fresh Biological yield of peanut was obtained at Intercrop of maize var KSC 604 50% + peanut 50% (26.0 t/ha) and Intercrop of maize var KSC 301 25% + peanut 75% (8.6 t/ha) respectively (Table 6).

Land Equivalent Ratio (LER):

Higher LER in intercropping treatment was showed that yield advantage over pure cropping due to better land utilization. The mean LER values were always greater than 1.0 (Table7). Advantage from non legume–legume intercropping systems has been reported previously in crops such as wheat and legume[2], pea and barley[4], field bean and wheat[3] and maize and faba bean[9], mazie and cowpea[5]. The highest (Land Equivalent Ratio) LER was obtained by sowing the crop in a ratio of Intercrop of maize var KSC 604 50% + peanut 50% (2.30) and the lowest LER was obtained by sowing the crops Intercrop of maize var KSC 301 25% + peanut 75% (1.27). LER values were greater than one in all intercropping systems which indicated yield advantage of intercropping. Dhima *et al* (2007) were shown that when LER is greater than 1, the intercropping good the growth and biomass of the species. In contrast, when LER is lower than 1, the intercropping negatively effect on the growth and yield of plants grown in mixtures[6]. The LER values were greater than one, indicating more efficient benefits of plant growth factors by intercrops compared to pure crops[22]. Facilitative root interactions are most likely to be of importance in nutrient-poor soils and low input agro ecosystems due to crisis inter specific competition or facilitation for plant growth factors[7]. Because of the spatial and temporal different in the growth factors and different crop species; intercropped plants could improvement utilize nutrients from soils compared with pure cropped plants[21, 23].

Table 6. Means of FBY and DBY as influenced by Planting Ratios

Planting Ratio	FBY(t/ha)	DBY(t/ha)
P	20.7 ab	4.8 ab
MP	18.5 bc	4.1 b
M*P	26.0 a	7.4 a
mP	8.6 d	2.6 b
m*P	14.3 cd	2.3 b
Mp	9.7 d	2.3 b
M*p	12.4 cd	2.8 b

Any two means not sharing a common letter differ significantly from each other at 5% probability.
P: Sole peanut (100%peanut+0%maize), MP: Intercrop of maize var KSC 301 50% + peanut 50%, M*P: Intercrop of maize var KSC 604 50% + peanut 50%, mP: Intercrop of maize var KSC 301 75% + peanut 25%, m*P: Intercrop of maize var KSC 604 75% + peanut 25%, Mp: Intercrop of maize var KSC 301 25% + peanut 75%, M*p: Intercrop of maize var KSC 604 25% + peanut 75%

Table 7. Means of LER as influenced by different planting ratios

Planting Ratio	LER
MP	1.67 bcd
M*P	2.30 a
mP	1.27 d
m*P	1.53 cd
Mp	1.93 abc
M*p	2.13 ab

Any two means not sharing a common letter differ significantly from each other at 5% probability.
MP: Intercrop of maize var KSC 301 50% + peanut 50%, M*P: Intercrop of maize var KSC 604 50% + peanut 50%, mP: Intercrop of maize var KSC 301 75% + peanut 25%, m*P: Intercrop of maize var KSC 604 75% + peanut 25%, Mp: Intercrop of maize var KSC 301 25% + peanut 75%, M*p: Intercrop of maize var KSC 604 25% + peanut 75%.

5. Discussion

From this study, it can be concluded that maize benefits from intercropping with peanut. The reason could be due to the facilitative effect of peanut, which can uptake part of its nitrogen requirements through symbiotic biological nitrogen fix which, in turn, reduces the over overcharge pressure on soil nitrogen stock. Nitrogen fixing ability of faba bean roots and transfer of N fixed by faba bean to maize, extensive root system of maize for absorption of water and nutrients[4] and less competition of faba bean with maize resulted in no significant change in grain yield of maize at different densities of intercropping. Possible that peanut via N_2 fixation could secrete H^+ in soil; this acidification of the rhizo sphere could improvement dissolution of phosphorus in high pH soils[8] .Therefore, peanut prepare nitrogen and phosphorus for itself and maize in intercropping. This can increase total grain yield of two crops in intercropping system. From the above it can be concluded that there are opportunities for improving the productivity of peanut/maize in the southeast of Iran at the arid ecological zone using of intercropping is the best cropping systems, because at this system high yield was higher than compared to other pure crops. It is obvious from the results that peanut and maize intercropping is more effective compared to pure cropping. Results showed that intercropping at Intercrop of maize var KSC 604 50% + peanut 50% pattern is the most productive system, compared with the other treatments but no significant different to Intercrop of maize var KSC 604 75% + peanut 25% and the best of maize variety was KSC 604 compared to KSC 301.

6. Conclusions

Results showed that intercropping at Intercrop of maize var KSC 604 50% + peanut 50% pattern is the most productive system, compared with the other treatments but no significant different to Intercrop of maize var KSC 604 75% + peanut 25% and the best of maize variety was KSC 604 compared to KSC 301.

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