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Effect of Millet and Peanut Intercropping on Efficiency of Use the Environmental Resource and Soil Fertility

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ABSTRACT: Order to study the effect of density, the control weed and various proportions Millet (*Panicum miliaceum*) and peanut (*Arachis hypogaea* L.) intercropping an experiment was conducted in 2012 in Research station of agriculture, University of Zabol. The experiment design was factorial in randomized complete block design with three replications. Experiment factors consisted of planting proportions in 4 levels (sole crop of Millet, 50% Millet + 50% peanut, 100% Millet + 100% peanut and sole crop of peanut), control weed in 3 levels (non-weeding, once-weeding and twice-weeding) and the space between rows in 2 level (40 and 50 cm) has been considered. The evaluated Characteristics in environmental sources are (Photosynthetic Active Radiation, Temperature and soil Moisture), the nutrients of soil include (N, Mg, Ca, and C) and to evaluate intercropping of pure was used land equivalent ratio. All Characteristics of study except soil moisture, C, Ca and Mg were affected by planting system. There was significant interaction between planting system and density in the absorption of light, temperature and moisture of soil. The results showed that photosynthesis active radiation absorbed by the intercropping was higher than sole crop in both plants. The results showed that changes in soil nutrient capacity of single elements (N and C) in the treatment of mixed and monoculture peanut was more than monoculture Millet and divalent elements (Ca and Mg) in monoculture Millet more than mixed and peanut monoculture. The highest land equivalent ratio (1.65) was accounted additive intercropping (100% millet + 100% peanut). Treatment 100% Millet + 100% peanut was the best treatment because using sources and increasing soil fertility and crop yield in comparison to sole crop.

Keyword: PAR, Single elements nutrition, LER.

INTRODUCTION

During the past few decades, global approach to modern agriculture, like any other human activity causing damage to natural resources, pollution and environmental degradation and is caused ecological imbalance (Rezvani Moghaddam *et al.,* 2009). In many parts of the world, intercropping as a common cause of agro ecosystems management that is used which has several advantages compared to monoculture (Banik *et al.,* 2006). Rarely is used to sole crop system of all the moisture, nutrients and light available for plant growth. Intercropping with better and more effective use of resources to control grass weeds compared sole crops (Liebman and Davis, 2000). The researchers stated that the superior performance in mixed cultures may be caused by a combination of various factors such as better use of soil moisture, light and nutrients (Pandita *et al.,* 2000). Intercropping will help to increase fertility and soil structure stability (Vasilakoglou *et al.,* 2005). According to researchers sunflower intercropping with legumes is to increase soil cover, reduce erosion and increase soil carbon and nitrogen (Kandel *et al.,* 2000). The advantage of mixed cultures compared to pure cultures towards more use of light and moisture use efficiency (Watiki *et al.,* 1993). In intercropping beans and wheat due to lower soil temperature, reduced surface evaporation and increased water use efficiency (Ghanbari, 2000). Differences in root morphology in mixed cultures and the possibility of being away from the root is cause rooted in a greater volume of soil dispersion, and this is attracting more water than monoculture (Zhang and Li, 2003).

MATERIAL AND METHODS

A. Location of experiment

The research was done at agriculture research at Zabol University in planting year 2012. The location of the research was 483 meters above sea level, 61:41 from east and 30:41 from east and 30:45 from north. Soil of research was sandy loam with pH = 7.7 and EC = 2.1 ds/meter. According to coupon classification the weather in dray and hot climate with the average 49 mm annual rainfall.

B. Field experiment

The test in the form of 2×3×4 in completely accidental blocks designing was repeated for about 3 times. The first factor includes different planting rations in four stages (M: Millet, P: peanut, M1: 50% Millet + 50% peanut, M2: 100% Millet + 100% Peanut), the second factor; weeding in 3 stages (w: without weeding, w_1: once weeding, w_2: Twice weeding) and the third factor, Spacing between rows in twice levels (D_1: 40 cm and D_2: 50 cm). Peanut planting (*Arachis hypogaea* L.) and Millet (*Panicum miliaceum*) according to planting orderings is to totally 72 plots. Each plot includes 4 rows planting that twice lines of that are assumed as border, 6 meters long with space in mentioned rows and between 2 plots twice rows were left without planting. According to findings by analyzing soil before planting 150 kg of urea, 100 kg triple superphosphate and 50 kg sulfate potassium in a hectare for sole crop and Millet intercropping and 50-50-50 kg nitrogen in a hectare, phosphorus and potassium are mentioned sources to peanut planting Fertilizers road was added in 2 stages one 15 days after planting and the remaining of it before blooming. At the beginning of March to squash the small stones 2 disks were vertically connected. Intercropping treatment was done with additive and replacement way. Planting ratio was done by density bush changes (change between Twice bushes on row) and changeable spacing between 2 rows (40-50 cm) was done, the two fixed rows and plant spacing's on the additive treatment declined. Watering was done according to the times that plant needed. All of the treatments were farmed by one row of peanut and Millet. The planting time in the growth period were watering and working.

C. Quantitative traits

To calculate the final operation after removing 2 lines of margin and 0.5 meter from the beginning and the ending of each plot was done photo synthetic active radiation was evaluated by radiation machine model: DELTA-T. Light measurement in sunny days from 12:30 to 13:30 and 60 days after planting was done. The level of light above the canopy and soil level in five parts inside each plot was random measurement and the average was recorded. Final received amount of PAR in ratio of received radiation by plants got radiation and calculated on tip of canopy (Bantilan *et al.* 1976).

$$PAR\% = [1- (PAR_b / PAR_a)] \times 100$$

PAR_b: photosynthetic active light at the lower part of canopy, PAR_a: photosynthetic active light at the highest part of canopy.

60 days after planting in depth of 0-15cm at noon in a sunny day the temperature of soil was calculated. To do this we put the thermometer in 3 parts in each plot between the planting rows in depth of 15 cm and the average was calculated. As we expected the balance water- soil was affected by different planting systems and water- soil content in one step during the growth period (60 days after planting) in 0-25 cm depth was calculated. We took 100 cube- meters in each treatment of soil by a special ring and after that we put it on over machine in 110 degrees and after 2 days dry weigh again was weighed. Then we calculated wet amount of soil in each treatment of test by this amount (wet weigh). Then we calculated wet amount percent of soil in each treatment of test by this formula:

$$Q_t = V_m / V_t$$

Q_t = wet amount percent, V_m = amount of water Soil (difference between wet and dry weigh), V_t = All of sample soil (100 cm^3). To know about soil nutrients amounts after harvesting in ratio to calculating soil nutrients (N, Mg, Ca, C) “N” by kejeldal, “C” by walky black method, Ca and Mg by method absorbing atom machine. To evaluation intercropping of land equivalent ratio (LER) was used. This index of advantage in intercropping and the level of competence among the same types or helping intercropping system were said that by the use of the formula is calculated (Vandermeer, 1992; Li *et al.*, 1999 and Fetene, 2003).

$$LER = Y_{ca}/Y_{cc} + Y_{pa}/Y_{pp}$$

That relation Y_{ca}/Y_{cc} the Millet yield ratio in intercropping with peanut (lateral LER). LER = 1 shows the same production in monoculture and intercropping. In yield of biological intercropping result is more than monoculture and LER<1 showing lack of advantage intercropping (Mazaheri, 1998).

D. Data collect

The data were analyzed by SAS software and in spite of significant effect on doing test to compare the averages on LSR in probable level 5% was used.

RESULTS AND DISCUSSION

A. Photosynthetic Active Radiation (PAR)

Photosynthetic active radiation absorbed by the system is significantly influenced by the planting, but no significant different of weeding and densities and interactions between the three factors (weeding × planting system × density). Photosynthetic active in additive intercropping (75.5%) in comparison to other systems was the highest (Table 2).

And there was a significant treatment between this one and others. The minimum of receiving photosynthetic active in millet sole crop (62.05%). The amount of received active lighting in mixed treatment was most than sole crops (Table 2). According to results in table (1) there is a significant difference between different treatments weeding and density in bushes.

Table 1: Analysis of variance for photosynthesis active radiation, temperature and soil moisture content of intercropping millet and peanut.

sov	df	MS		
		T	**Q_t**	**PAR**
Replication	2	0.18^{ns}	0.0008^{ns}	156.5^{ns}
Planting system	3	106.6^{**}	0.0073^{ns}	633.4^{**}
Weeding	2	9.76^{**}	0.0012^{ns}	36.37^{ns}
Density	1	5.12^{**}	0.032^{**}	16.05^{ns}
Planting system × Weeding	6	1.09^{ns}	0.0026^{ns}	19.02^{ns}
Planting system × Density	3	6.38^{**}	0.023^{**}	744.09^{*}
Weeding × Density	2	4.87^{**}	0.0016^{ns}	95.59^{ns}
Planting system × Weeding × Density	6	1.24^{ns}	0.0033^{ns}	140.91^{ns}
Error	46	0.94	0.0026	132.09
CV (%)	-	3.56	21.85	16.47

*, ** significant at p<0.05 and p<0.01, respectively.

Note: T: temperature of soil, Qt: soil moisture, PAR: Photosynthesis Active Radiation

Table 2: Means of percentage photosynthesis active radiation, temperature and soil moisture of millet and peanut as influenced by the Planting system, density and weeding different levels.

Planting system	Temperature (°C)	Moisture (%)	PAR (%)
P	24.11d	25a	68.32ab
M1	28.55b	23.00ab	73.11a
M2	26.88c	24.00a	75.50a
M	29.72a	20b	62.05b
Weeding			
W_0	27.70a	23.00a	68.37a
W_1	27.66b	23.00a	70.12a
W_2	26.58a	24.00a	70.75a
Planting density			
D_1	26.86b	25.00a	70.22a
D_2	27.77a	21.00b	69.27a

Note: P, M1, M2 and M: Planting ratio, Sole crop peanut, 50% millet + 50% peanut, 100% millet + 100% peanut and sole crop millet. W_0, W_1, and W_2: Weeding, D_1, D_2: Planting density, 40 and 50 cm. Any two means not sharing a common letter differ significantly from each other at 5% probability.

Weed controlling received photosynthetic active radiation increased by 70.75% and in twice weeding treatment and more density the maximum received photosynthetic active lighting was concluded and there was a meaning fully Significant difference between treatments. Between 3 factors mixed treatment 100% millet + 100 % peanut with twice weeding and more density with the maximum received lights. Radiation is received more in vertical leaved plants and this structure takes lighter to reach to lower canopy parts and photosynthesis in canopy lower leaves in higher part is saved (Awal *et al.,* 2006). Peanut is such a plant that grows slowly and it does not have much shadow in low planting in comparison to soybean and corn, so in this plant nice planting density to increase light and increase in planting is clearer (Williams *et al.,* 1995). In the search of amount of receiving photosynthetic active radiation in mixed canopy corn and cowpea, 100% corn + 100% cowpea treatment receives more lighting cowpea can prevent light under canopy because of having wide leaves in comparison to corn (Ghanbari *et al.,* 2010). Peanut can stand the corn's shadow and because of having more time to grow, after harvesting corn with more growth we reach more deeds and this is because of growing efficiency of light in intercropping and peanut (Awal *et al.,* 2006).

B. Temperature and Soil Moisture

As you see in Analysis of variance Table 1 the relation and effect of (planting system, weeding and density) has a significant and soil temperature and density has a significant different on moisture content. The highest moisture soil and soil temperature recorded in peanut (25%) and millet sole crop (29.72°C). With more peanut from 50% to 100% the moisture of soil has increased and the soil temperature decreased (Table 2). Because the soil temperature under Canopy in intercropping in millet sole crop the temperature of soil was less so in intercropping was more.

The comparison between moisture and temperature in soil in weeding treatment and density shows more moisture and less temperature with more weeding and density. Acceding to the related effects between 3 treatment factors sole crop peanut with twice weeding and more density with having more moisture and the minimum temperature treatment was tested. Less temperature in mixed systems in comparison to sole crop in millet can say more light receiving by mixed canopy and more shadow by plant canopy. Researching about moisture in intercropping of corn and cowpea among different intercropping systems shows that 15% of replacement mixed and 10% increasing mixed with sole crop with more moisture (Ghanbari *et al.,* 2010). In corn intercropping and cauliflower in good density because of shadowing corn canopy mixed temperature is less. In mixed the positive effect of plant species increased ground cover, protection more soil moisture, decreasing evaporation in soil surface more Water use efficiency and increasing canopy moisture, decreases the temperature of canopy in sole crop (Anthony and Rene, 2008).

C. Organic Carbon and Nitrogen of Soil

As you see in Analysis of variance table Organic carbon and Nitrogen in soil after harvesting the product is influenced by planting system and density (Table 3). According to the Comparison of the results the maximum of organic carbon (0.88 meq/lit) and soil nitrogen (8.73%) were recorded in sole crop peanut. The amount of C and N in mixed treatment is more in comparison to millet sole crop and there is a significant difference between intercropping and sole crop treatment. About controlling weeds and density on soil nitrogen, it was showed that with more weeding and more density in amount two nutrients in soil was increased (Table 4). Legumes increase soil nitrogen and having deep roots with wheat, water and nutrients from different layers of soil receives better (Berdhal *et al.,* 2001). Legumes root, Cat ion exchange capacities almost two cereal roots (Ghanbari, 2000). The plant that has more cat ion exchange capacity is capable of receiving more Divalent elements (Haynes, 1980; Caradus, 1990).

Table 3: Analysis of variance for change soil nutrients of intercropping millet and peanut.

			M.S.		
SOV	**df**	**C**	**N**	**Ca**	**Mg**
Replication	2	0.0012^{ns}	0.056^{ns}	0.0000025^{ns}	0.00021^{ns}
Planting system	3	0.00012^{ns}	2.41^{**}	0.00000022^{ns}	0.0019^{ns}
Weeding	2	0.073^{**}	16.14^{**}	0.0000071^{ns}	0.0097^{**}
Density	1	0.3126^{**}	107.02^{**}	0.00012^{**}	0.017^{**}
Planting system × Weeds control	6	0.022^{**}	2.19^{**}	0.000028^{**}	0.0020^{ns}
Planting system × Density	3	0.027^{**}	2.06^{**}	0.00017^{**}	0.0037^{ns}
Weeding× Density	2	0.031^{**}	4.84^{**}	0.00027^{**}	0.0075^{**}
Planting system× Weeding × Density	6	0.030^{**}	3.71^{**}	0.00024^{**}	0.0053^{*}
Error	46	0.183	0.235	0.0000041	0.0023
CV (%)	-	9.84	7.77	6.81	2.56

*, ** significant at p<0.05 and p<0.01, respectively.

Table 4: Means of soil nutrient of millet and peanut as influenced by the Planting system, density and weeding different Levels.

Planting system	**C (meq/lit)**	**N (%)**	**Ca (ppm)**	**Mg (ppm)**
P	0.88a	8.73a	0.027d	1.832b
M1	0.43c	4.36c	0.028c	1.882a
M2	0.83b	7.92b	0.030b	1.902a
M	0.35d	3.94d	0.033a	1.907a
Weeding				
$\mathbf{W_0}$	0.57c	5.49c	0.029a	1.86b
$\mathbf{W_1}$	0.61b	6.11b	0.029a	1.87ab
$\mathbf{W_2}$	0.68a	7.12a	0.030a	1.90a
Planting density				
D_1	0.623a	6.05b	0.0298a	1.88a
D_2	0.626a	6.42a	0.0296a	1.87a

Note: P, M1, M2 and M: Planting ratio, Sole crop peanut, 50% millet + 50% peanut, 100% millet + 100% peanut and sole crop millet. W_0, W_1, and W_2: Weeding, D_1, D_2: Planting density, 40 centimeter, 50 centimeter Any two means not sharing a common letter differ significantly from each other at 5% probability.

That's why the power of competition peanut divalent calcium and magnesium absorption more from corn. In intercropping due to increased root density and the possibility of some nutrients that are not available in pure culture, nutrient absorption is increased and used more efficiently. Intercropping cereals and legume is an example of increasing nutrient uptake (Ghanbari, 2000). One of the factors to limit peanut is use inappropriate density, because favorable plant density for Varieties and in different climate, is not the same (Bell *et al.*, 1991).

D. Calcium and Magnesium in Soil

Analysis of variance showed that the weeding and density on magnesium and calcium in the soil after harvest has a significant effect (Table 3). The comparison between average planting systems show that the maximum of calcium and magnesium soil recorded respectively in millet sole crop (0.033-1.907 ppm) and mixed 100% millet + 100% peanut (0.03-1.902 ppm). The minimum of two elements in sole crop peanut existed. Mixed planting systems have more calcium and magnesium in comparison to peanut sole crop (Table 4). Study about weeding and plant density shows that by more weeding and density amount calcium and magnesium in soil after harvesting the product increased. Generally the treatment combination 100% millet + 100% peanut with twice weeding and the most density the maximum of magnesium soil and millet sole crop with the most density was better tested treatment.

E. Land Equivalent Ratio

There's a significant difference in efficient use of land and correlation planting system effect in weeding (Table 5). According to the compared average chart we can say that the highest Land equivalent ratio in mixture of 100% millet + 100% peanut is 1.65. According to yield intercropping in the treatment of ratio monoculture showed that two legume plants and grass nearby causes intercropping produces more products in ratio monoculture and the Biological fixation by peanut roots and increasing received lights. Weeding and interaction planting system, weeding, planting system and density a significant relation ratio and the efficient use of land was treatment by twice weeding with high density.

Table 5: Analysis of variance for Land equivalent ratio in the millet and peanut intercropping.

SOV	df	LER
Replication	2	0.018*
Planting system	1	2.035**
Weeding	2	0.044**
Density	1	0.006^{ns}
Planting system × Weeding	2	0.026*
Planting system × Density	1	0.069**
Weeding× Density	2	0.013^{ns}
Planting system× Weeding× Density	2	0.016^{ns}
Error	22	0.005
CV (%)		5.41

*, ** significant at $p<0.05$ and $p<0.01$, respectively.

Table 6: Means of Land equivalent ratio of millet and peanut as influenced by the density and weeding different Levels.

Planting system	LER
M1	1.18b
M2	1.65a
Weeding	
W_0	1.34b
W_1	1.44a
W_2	1.46a
Planting density	
D_1	1.45a
D_2	1.43a

Note: M1, M2: Planting ratio, 50% millet + 50% peanut, 100% millet + 100% peanut. W_0, W_1, and W_2: Weeding, D_1, D_2: Planting density, 40 centimeter, 50 centimeter. Any two means not sharing a common letter differ significantly from each other at 5% probability

Weed control and planting systems on the amount of land equivalent ratio was significant and two weeding treatments with higher density has a maximum efficiency of land use. In a test on sesame intercropping with green mung, bean and black mung, peanut and sun flower, they concluded, planting sesame with peanut in ration 1: 2 the maximum Land equivalent ratio (1.35) is among other plants (Sarkar and Kundu, 2001). In chickpea intercropping and barely the maximum Land equivalent ratio in 100% treatment chickpea + 100% barely the result of it 1.25 and we can call this biological nitrogen fixing by green pea roots (Daryai *et al.,* 2008). Getachew *et al.* (2006) showed that intercropping of barley and bean Land Equivalent Ratio is higher than compared with monoculture. The intercropping of chickpea and barley LER was higher than compared to pure crop; the reason for this can be attributed to biological nitrogen fixation (BNF) by roots of pea plant (Launay *et al.,* 2009). In intercropping due to increased root density and the possibility of some nutrients that are not available in pure culture, nutrient absorption is increased and used more efficiently. Intercropping cereals and legume is an example of increasing nutrient uptake (Ghanbari, 2000).

CONCLUSION

In using environmental sources intercropping is better than monoculture. Generally choosing suitable plants and choosing proper planting pattern in intercropping systems with controlling weeding. We can increase the proficiency in receiving light, moisture and nutrients. On the other hand, choosing suitable plant density in intercropping with complementally mode causes better use of sources and this cause's increase yield. Generally we conclude the intercropping in one of the ways to do suitable planting with the least consumption or without external input use of things that causes more nutrients for soil and more fertility and in addition to saving water sources and soil in long terms it increases agro ecosystem stability. The results showed that intercropping system compared with sole millet and peanut are effectively used of environmental resources. Intercropping systems of land equivalent ratio greater than one that indicates mixed cultures advantages of sole crop. Treatment 100% Millet +100% peanut was the best treatment because using sources and increasing soil fertility and crop yield in comparison to sole crop.

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