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Mixed Cropping system with Biofertilizer under dry land condition: II. Evaluation of land use efficiency

Masoud Rafiee
Department of Agronomy and Plant Breeding, Islamic Azad University, Branch Khorramabad, Khorramabad, Iran
Email: rafieemasoud@yahoo.com

ABSTRACT
In order to evaluate land use efficiency using the Land Equivalent Ratio (LER) of chickpea - barley mixed cropping under drought stress and vermicompost consumption, two separate factorial experiments were carried out under well watered and dry land condition in RCBD with three replications in temperate condition of khorramabad. Chickpea -barley mix cropping (sole chickpea, %75 chickpea: 25% barley, %50 chickpea: 50% barley, 25% chickpea: 75% barley, and sole barley) and fertilizer (vermicompost biological fertilizer, ammonium phosphate chemical fertilizer, vermicompost + %75 chemical compound fertilizer) were studied. Result showed that wet- and dry forage yield were significantly affected by environment and decreased in dry land condition. Yield and LER based on wet matter decreased by decreasing chickpea ratio, and based on dry matter increased by increasing barley ratio in mixed cropping combinations. Compound fertilizer with no difference from chemical fertilizer, had more wet forage yield advantage than sole vermicompost, and recommended because of reduction in chemical fertilizer application.
Key words: *Land equivalent ratio, Vermicompost, Wet forage yield, Dry forage yield.*

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INTRODUCTION

A primary and direct way of increasing diversity of an agro ecosystem is intercropping system that allows interaction between the individuals of the different crops and varieties [1, 2]. One of the most important reasons for planting two or more crops together is increasing production per area [3]. An important tool for the study and evaluation of intercropping systems is the Land Equivalent Ratio (LER). Mixed cereal-legume cropping can supply valuable forage in dry areas, as well as improving soil characteristics to approach sustainable farming systems in these regions. It is reported that intercropping of vetch-barley in Syria for forage production also led to higher land productivity [4]. Mixed cropping of barley and durum wheat can help combine important characters in a cropping system so as to enhance productivity through complementary resource uses in drylands [5].

The different Vicia species are used as direct grazing and also for their green forage, hay and seed [6]. A 50:50 mixture of barley-hairy vetch produced the highest dry forage yield [7]. Maximum LERs of 1.066 and 1.039 for grain and biological yield achieved from two corn varieties 50%SC704:50%SC604 intercropping combination [8].

Cross-sowing of deenanath grass (*Pennisetum pedicellatum*) with cowpea (*Vigna unguiculata*) at 12 and 40 kg seeds ha−1, respectively, gave the highest fresh fodder, DM and CP yields and net returns, with the highest LER (1.52), than other sowing methods [9]. In some agricultural systems the management methods are improving in order to reduce agrochemical consumption, to compensate increasing production costs, to reduce impacts of chemicals on environments and to conserve soil fertility. Herein, expanding fodder crops cultivation has suggested as an alternative approach to synthetic fertilizers [10, 11].

With combination of vermicompost bio-fertilizer and chemical fertilizers not only the amount of chemical fertilizers is reduced but also soil physical- and chemical characteristics are improved. Consumption of 50% chemical fertilizers with 5 tons per hectare composted sheep manure was suitable for corn production [12]. Evaluation of the effect of two types of compost on soil characteristics and corn yield and reported that use of combined treatments of compost and chemical fertilizer produced higher yield than

chemical fertilizer alone [13]. Use of bio-fertilizer phosphate solubilizing leading to increased tolerance on corn plant in conditions of water stress and reduced the use of chemical fertilizers [14].
The object of this study was to find the best combination of chickpea and barley in the mixed cropping system mixture with vermicompost bio-fertilizer under well watered and dry land condition in respect to LER.

MATERIALS AND METHODS

A factorial experiment was used based on RCBD of three replications in research field of Islamic Azad University, branch Khorramabad, west Iran (48°21'E, 33°29'N, 1190 m), during early 2013.
Two separated experiments include normal (well irrigated) and dry land conditions were studied. In each experiment two factors include fertilizer (vermicompost biological fertilizer, ammonium phosphate chemical fertilizer, and compound fertilizer of vermicompost + %75 ammonium phosphate) and chickpea - barley mixed cropping of 100:0, 75:25, 50:50, 25:75, and 0:100, respectively, were used in a silty clay loam soil. 10 ton ha-1 vermicompost and 60 Kg ha-1 ammonium phosphate added to soil.
The chickpea (cv. Grit) and barley (cv. Izeh) in plant density of 40 and 400 plant m-2, respectively, were mixed sown when frosty season was terminated on 2th of March, 2013 in a replacement series experiment. Each plot consisted of 5 rows with 25 cm spacing (1.5 m width) and 6 m long. There was 50 cm distance as a border line between the plots. All agronomic practices like irrigation in well watered experiment and weed control were kept normal and uniform in treatments.
Crops soilage was harvested at 50% flowering of chickpea, when barley kernels were at early doughy stage (early June). Areas of 4m2 (5.3 m from 3 middle rows) were hand harvested from each sub plot to estimate biological yield and total LER calculated.
The LER was calculated using the formula LER= Σ (Ypi/Ymi), where Yp is the yield of each crop in the intercrop or polyculture, and Ym is the yield of each crop in the sole crop or monoculture.
Data so collected were analyzed statistically using fisher's analysis variance techniques and LSD at 5% probability level was employed to test the significance among treatments means.

RESULTS AND DISCUSSION

Forage yield:

Wet ($p<0.01$) and dry ($p<0.05$) forage yield were significantly affected by drought stress in dryland condition and decreased from 23142.3 and 3403.5 kg ha-1 in well watered condition to 13047.4 and 2133.4 kg ha-1 in dry land condition, respectively (Table 1).
The highest wet and dry forage yield of 22525.1 and 3146.7 kg ha-1 were achieved from chickpea and barley monocultures, respectively. Wet forage yield decreased significantly ($p<0.01$) by increasing barley rate in mixed cropping, so the lowest wet forage yield of 13327.0 kg ha-1 was found in barley monoculture. On the other hands, dry forage yield increased by increasing barley rate in mixed cropping and the lowest dry yield of 2549.4 kg ha-1 was found in chickpea monoculture. It is reported that SC604 and SC704 intercropping in 1:1 ratio gave 15.3% and 7.8% greater grain yield compared 1SC704:3SC604 and 3SC604:1SC704 combinations, respectively [8].
Wet, but not dry forage yield was significantly ($p<0.05$) affected by kind of fertilizer. Maximum and minimum wet forage yield of 19431.3 and 15976.2 kg ha-1 were attained by compound and chemical fertilizer, respectively (Table 1). However, no wet forage yield difference was observed among vermicompost and compound fertilizers.
Karimi et al [15] and Mohammadian and Malakuti [13] reported that Integrated use of chemical fertilizers and vermicompost could be contributing to the increase in corn yield, which is consistent with these results.

LER:

No LER significant difference was found between well watered and dry land conditions, but LER for dry matter was more than 1 and for wet matter was lower than 1 in two conditions (Table 1). Based on dry matter, maximum LER of 1.11 was achieved by 25:75 chickpea - barley mixed cropping and minimum of 1.02 and 1.05 were from 75:25 and 50:50 chickpea - barley mixed cropping, respectively. LER for wet matter were 0.92, 0.80 and 0.73 in 75:25, 50:50 and 25:75 chickpea - barley mixed cropping, respectively. So, Chickpea based on wet matter and barley based on dry matter showed LER advantage like forage yield in mixed cropping combination.
Chemical fertilizer, Vermicompost, and compound fertilizer had no significant effect on LER for both wet and dry matter, but highest LER of 1.13 and 0.84 based on dry and wet matter, respectively were attained by compound fertilizer, represented the importance of biological fertilizer in mix cropping systems to increase land use efficiency.

Highest LER of 2.00 and more yield advantage was reported by Laster [16)] in 1:1 ratio of soybean and bean intercropping than all sole cropping systems. Beets [18], also reported that corn and soybean intercropping in 1:1 combination gave greater total LER of 1.35 than other combinations. Mazaheri and Oveysi [18] showed that 1:1 ratio of corn SC704: SC604 combinations had less competition and greater mixture yield. Mazaheri et al. [8] found the maximum LERs of 1.066 and 1.039 for grain and biological yield from two corn varieties 50%SC704:50%SC604 intercropping combination.

Table 1. Mean comparison of wet and dry forage yield and total LER at various drought conditions, mixed cropping combinations and fertilizers.

LER Dry matter	LER Wet matter	Dry forage yield (kg ha-1)	Wet forage yield (kg ha-1)	
1.09	0.84	3403.5	23142.3	S1
1.03	0.79	2133.4	13407.4	S2
ns	ns	*	**	
0.31	0.24	824.1	4235.6	LSD(5%)
		2549.4	22525.1	M1
1.02	0.92	2581.8	20762.2	M2
1.05	0.80	2728.7	18201.6	M3
1.11	0.73	2855.5	16564.5	M4
		3146.7	13327.0	M5
ns	ns	*	**	
0.19	0.21	382.2	2497.4	LSD(5%)
1.12	0.79	2431.8	15976.2	F1
1.07	0.83	2887.4	19414.1	F2
1.13	0.84	2995.6	19431.3	F3
ns	ns	ns	*	
0.41	0.22	833.1	2253.3	LSD(5%)

S1 and S2: Well watered and dry land environment, respectively. M1 to M5: chickpea - barley mixed cropping of 100:0, 75:25, 50:50, 25:75, and 0:100, respectively. F1 to F3: Chemical fertilizer, vermicompost and compound fertilizer, respectively.
ns, * and ** : Non significant and significant at 0.05 and 0.01 probability level, respectively.

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