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Effect of Salinity in LER Values under Two Crop Systems and two Kind Intercrops

Dimitrios BILALIS[1)], Dimitrios SAVVAS[2)] , Charis-Konstantina KONTOPOULOU[2)] , Konstantinos PADALEON[1)]

[1)] Department of Crop Science, Lab of Crop Prod. Agricultural University of Athens, Iera Odos 75, 11855, Athens, Greece; bilalisdimitrios@yahoo.gr
[2)] Department of Crop Science, Lab of Vegetables Prod. Agricultural University of Athens, Iera Odos 75, 11855, Athens, Greece

Abstract. In order to study the effect of salinity on the LER (Land Equivalent Ratio) median values of intercropping and solo-cropping cultivation, an experiment was set up at West Greece. The experiment was composed by two factors. The first and the main one was the crop system (organic, conventional) and the second one was the salinity (low/high level). The salinity occurred negatively in the corn-bean intercropping system as well as in the corn-cowpea intercropping system. Higher dry matter values were observed in the conventional system as well as in the low salinity level. As concerning the crop system the highest LER values were observed in the conventional system rather than the organic one. It is worth mentioning that the highest LER value was observed in the corn-cowpea system rather than in the corn-bean system. It must, also, be mentioned that high salinity level affected the bean crops much more than the cowpea crop in both solo and intercrop systems.

Keywords: salinity, LER, intercropping, crop systems

INTRODUCTION

Intercropping is a common cultivation system in organic agriculture. In organic agriculture, it is receiving increasing attention as it offers potential advantages for increasing sustainability in crop production (Bilalis *et al.*, 2010).

Organic agriculture seeks, at least in principle, to use nature as the model designing agriculture systems. Since nature consistently integrates her plants and animals into diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity. Diversity is nature's design. Intercropping, through more effective use of water, nutrients and solar energy, can significantly enhance crop productivity compared to the growth of solo crops (Francis, 1989).

Furthermore, intercropping maize-legumes improved the biological properties of soil. Generally, legume–cereal intercropping, i.e. the practice of growing two (or more) crops simultaneously in the same land area, offers a potential method of reducing inputs such as fertilizers (Herbert *et al.*, 1984). Intercropping cereals with legumes for forage or food production is extensively practiced in many parts of the world. Moreover, it constitutes a new, promising approach to weed management for low input organic agriculture, under Mediterranean conditions. Intercropping positively influences both crop growth and yield (Bilalis *et al.*, 2005).

Intercropping of maize and a legume for silage production may increase protein production in areas where on farm production of protein for dairy animals is insufficient (Pogue and Arnold, 1979; Herbert, 1984). In intercropping systems involving a legume and a non-legume, part of the nitrogen fixed in the root nodule of the legume may become available to the nonlegume component by mycorrhiza (Martensson *et al.*, 1998). So legumes, both alone and as intercrop with cereals, have been advocated not only for yield augmentation but also for maintenance of soil health, particularly in degraded soils (Banik and Bagchi, 1993). Intercropping has gained the interest of researchers because of the potential advantages it offers: overyielding, i.e. improved utilization of growth resources by the crop combined with improved reliability from season to season (Helenius, 1990), reduced inputs and better quality silage (Prithiviraj *et al.*, 2000) and weed control (Bilalis *et al.*, 2003).

In the maize-bean intercrop system LER values were statistically higher than in maize-cowpea. A similar trend in the LER values was reflected by root system parameters. Statistically significant correlations were observed between LER values for above ground plant characteristics and corresponding root characteristics, leading to the conclusion that the LER index may be used for root systems (Bilalis *et al.*, 2005).

Salinity causes large effects on higher plants, both halophytes and non-halophytes. In the latter, growth rate is generally reduced by salinity even at low salt concentration. However, within non-halophytes there is still large variability among species, ranging from extremely sensitive to tolerant species overlapping with halophytes (Brugnoli and Lauteri, 1991).

There are not references on salinity effect in intercropping systems. For this reason the aim of this study is to evaluate the salinity effect on LER values under two crop systems, organic and conventional.

MATERIALS AND METHODS

An experiment was conducted from April to June 2010 at Agrinio that is located in West Greece (38°35'15.41» N, 21°25'38.47» E) in a field certified for organic cropping since 2003. Two different intercrops were established following either organic or conventional cropping practices, specifically sweet corn (*Zea mays* cv. Bonanza F1), as the main crop and cowpea (*Vigna unguiculata* cv. Dolico Veneto) or common bean (*Phaseolus vulgaris* cv. Contender), as the secondary crops compared with monoculture of sweet corn. All crops were supplied with either good-quality or NaCl-enriched irrigation water corresponding to 0.5 or 10 mM NaCl, respectively. Each plot had six rows of sweet corn and additional ten rows of the secondary crop within the sweet corn. Plant spacing within rows of sweet corn and legumes was 0.3 m and 0.2 m, respectively. A split-split-plot experimental design was used with farming system type (organic and conventional) randomly assigned to whole plots (main plots). The salinity level was also randomly assigned to split plots within the main plot and the intercropping treatments as the sub-subplots. There were four replicated blocks; each block had 20 subplots and the size of each sub-subplot was 10.8 m². Plant samples of shoot were collected four times during the experiment at intervals of about 25 days, starting 30 days after sowing. The samples were dried at 70ºC to constant weight to determine total dry matter. Yield was determined by manually harvesting all plots. The agronomic benefit of the intercrops was evaluated by the land equivalent ratio (LER) index (Mead and Willey, 1980). The LER is defined as: LER= $(Y_{ab}/Y_{aa}) + (Y_{ba}/Y_{bb})$, where Y_{ab}= the yield per unit area of crop a in a intercrop, Y_{ba}= the yield per unit area of a crop b in a intercrop, Y_{aa} = the yield per unit area of crop a in a solo crop, and Y_{bb} = the yield per unit area of crop b in a solo crop (Ghanbari-Bonjar and Lee, 2002). In this research land equivalent ratio values are presented for the parameter of total dry weight. A LER value greater than 1.0 shows that intercropping is advantageous, whereas a LER value less than 1.0 shows a disadvantage. ANOVA and separation of treatment means based on the Duncan's multiple-range test was applied by employing the StatSoft statistical package.

RESULTS AND DISCUSSION

Between organic and conventional system, the higher median values of dry weight (kg·ha^{-1}) were observed in all classes of intercrop and solo cultivation (Tab. 1), although there were so significant differences observed. Specifically, the sweet corn dry yield (25,314 kg·ha^{-1} was higher from the bean (15,293.5 kg·ha^{-1}) and the cowpea (1,842.5 kg·ha^{-1}) dry weight on the organic system as well as on the conventional and the intercropping on both crop systems (Tab. 1). As concerning the salinity levels, the higher dry yield was observed on the low salinity level and especially in the corn-bean (32,842.8 kg·ha^{-1}) and corn-cowpea (32,686.2 kgha^{-1}) intercrop (Tab. 1).

The reduction in growth is consequence of several physiological response including modifications of ion balance, water status, stomatal behavior, photosynthetic efficiency, carbon allocation, and utilization (Flowers *et al*., 1977). Possible effects of heterogeneity of stomatal aperture and consequent overestimation as determined from gas exchange could explain these results (Brugnoli and Lauteri, 1990).

Tab. 1

Effect of salinity and crop system on dry weights of solo and intercropping cultivation.(kg·ha^{-1}) (Vi: cowpea intercrop, Pi: bean intercrop, Ci-P: corn-bean intercrop, Ci-V: corn-cowpea intercrop, Vs: cowpea solo, Ps: bean solo, Cs: Corn solo, Org.: organic, Con.: conventional, L: low, H: high)

	Vi	Pi	Ci-P	Vs	Ps	Cs	Ci-V
				CROP SYSTEM			
Org.	538.3	2,410.2	25,314.1	1,842.5	15,293.5	25,314	21,782.4
Con.	664.8	1,137.2	35,162.5	2,463.7	16,511.3	38,892.3	38,071.6
LSD $_{5\%}$	0.07	0.23	0.1	0.09	0.06	0.46	0.16
				SALINITY			
	Vi	Pi	Ci-P	Vs	Ps	Cs	Ci-V
L	747.5	2,441.7	32,842.8	2,552.8	19,196.2	35,095.2	32,686.2
H	455.5	1,105.8	27,633.7	1,752.8	12,608.5	29,111.1	27,167.9
LSD $_{5\%}$	0.18	0.24	0.054	0.12	0.13	0.059	0.058

As about the crop system, through the analysis of variance, the medians of LER index for the corn-cowpea intercrop were higher in the conventional system (1.28) rather than the organic system (1.20) with no significant differences. On the other hand, the medians of LER index for the corn-bean intercrop showed significant differences, with the conventional system median (1.145) higher than the organic one (0.996). The LSD compare for the salinity levels (high, low) showed no significant differences (Tab. 2). Both the medians of LER index for the corn-bean intercrop as well as the index for the corn-cowpea intercrop were higher on the low salinity level than the high one (Tab. 2). In conclusion, the factors interaction (crop system x salinity) showed no remarkable, significant differences.

Chloroplastic and cytosolic metabolites in low nitrogen crop system (like organic) and salt-stressed *Phaseolus* tended to be slightly lower than high nitrogen grown plants (in conventional agriculture case). As with the high nitrogen plants, there was also a small reduction in the pool size of these metabolites in the salt stressed low nitrogen plants relative to the controls (Seemann and Sharkey, 1986).

Tab. 2

Analysis of variance on corn-vigna and corn-bean intercrop. Org.: organic, Con.: conventional, L: low, H: high, LER C-V: LER corn- cowpea, LER C-P: LER corn-bean) (Different letters between LER Indexes and salinity levels-crop system indicate significant differences LSD test p<0.005).

Crop System	LER C-V	LER C-V
Con.	1.28 [a]	1.145 [a]
Org.	1.20 [a]	0.996 [b]
Salinity		
L	1.27 [a]	1.08 [a]
H	1.20 [a]	1.06 [a]
INTERACTION		
F x S	ns	ns

In table 3 it is shown that there is a difference between the LER medians, which is no significant, with the LER median for corn-cowpea intercrop (1.2425) being higher than the LER for corn-bean median (1.0706). Bean is known to be highly sensitive to salinity, whereas corn has been reported to as tolerant non-halophyte (Greenway and Munns, 1980).

Tab. 3

LER median values per intercrop. (LER C-V: LER corn- cowpea, LER C-P: LER corn-bean)

	LER SC-V	LER SC-P
mean	1.2425	1.070625
t-value	2.002497	
p-value	0.06365	

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