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&Biogéochimie des Sols
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Supagro, Montpellier, France

Ecole Nationale Supérieure
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The intercropping maize -common bean improves the rhizobial efficiency and phosphorus uptake in calcareous phosphorus deficient soils

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Introduction

P lithosphere (0.1%)

P avaialability

Soil type

Farming system

P fertilizers

P depletion

Sustainable agriculture

P bio-avaialability

Cereals-legumes intercropping system

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Introduction

Intercropping vs Sole crop

- Most studies reported that legumes-cereals dual intercropping compared to the corresponding sole cropping results in environmental sources use efficiency for plant growth and thus stable yields due to interspecific complementarily, facilitation and competition

Fallow and cereal farming systems in Algeria

- Actually, one role of legume crops is a fallow replacement in cereals agro-ecosystems of North Algeria.

Aims

1) Does introduction of common bean in sole crop or intercropping with maize in calcareous soils increase P bio-availability and P concentration in plants for the two species?

2) Does legume introduction increase the growth and yield of each legume and cereal species?

3) Is there a difference in the formation of symbiotic nodules on the root common bean in pure legume cropping or in cereal-legume intercropping?

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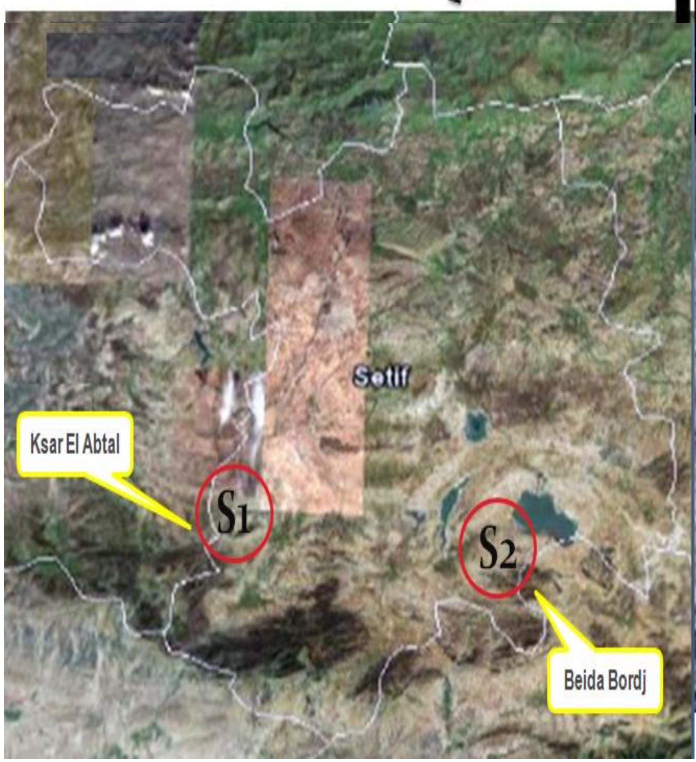
Materials and methods

Experimental sites location



✓S1 (35°57.82'N)

✓S2 (35°51.13'N)

Materials and methods

Cropping system

Plant material

❖ Common bean (*Phaseolus vulgaris*. cv. El Djadida)

❖ Maize (*Zea mays*. cv. Filou)

❏ Sowing and management of field experiment during both growing seasons 2011 and 2012, were carried by farmers with their cultural practices as a management option.

Experimental design

Materials and methods

Data collection and statistical analysis

- The nodulation, shoot, root biomass, P uptake and Olsen-P concentration in the rhizosphere of two species were measured at the flowering stage; however grain yield was estimated at harvest time

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Materials and methods

Data collection and statistical analysis

❑ Effect of crop treatments on plant growth, nodulation, grain yield and the rhizosphere soil Olsen P were tested using one-way ANOVA

❑ Two-ways analyses of variance were performed on plant P concentration and plant P uptake considering crop treatments and soil P level (S1 and S2) as factors.

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Results and discussions

Typology of experimental sites

Table 1 Physical and chemical soil properties of the experimental sitesS1 and S2. Values represent the mean of 4 replicates ± SE (standard errors). Within a column, different letters denote significant difference at $P < 0.05$.

Sites	Clay (%)	Loam (%)	Sandy (%)	pH	$CaCO_3$ (%)	N (g kg^{-1})	MO (%)	total-P (mg kg^{-1})	Olsen-P (mg kg^{-1})
S1	41.6 ± 0.7 a	31.3 ± 0.09 b	26.8 ± 0.2 a	8.1 ± 0.01 a	24.6 ± 0.4 a	0.9 ± 0.03 b	1 ± 0.08 a	95.7 ± 2.9 b	5.5 ± 0.3 b
S2	40.5 ± 0.3 a	33.2 ± 0.2 a	26.3 ± 0.2 a	7.9 ± 0.07 a	23.9 ± 0.1 a	2.3 ± 0.12 a	1.2 ± 0.05 a	257.3 ± 8.1 a	21.8 ± 0.6 a
	Clay (%)	Loam (%)	Sandy (%)	pH	$CaCO_3$ (%)	N (g kg^{-1})	MO (%)	total-P (mg kg^{-1})	Olsen-P (mg kg^{-1})
p value	0.2	<0.001	0.14	0.17	0.19	<0.001	0.25	<0.001	<0.001

The two experiments sites (S1 and S2) were characterized by a calcareous soil and contrasting in P available content

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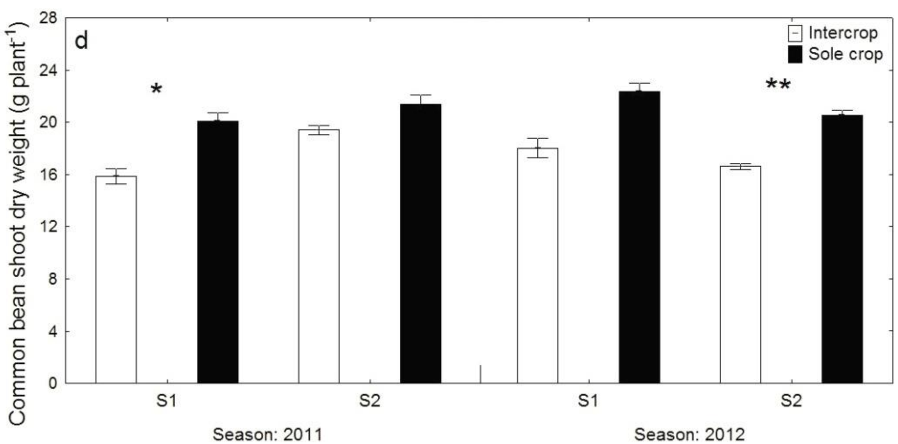
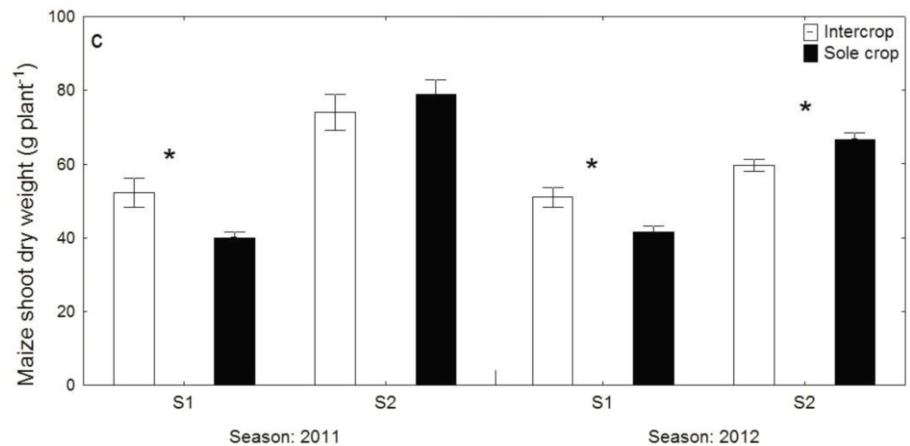
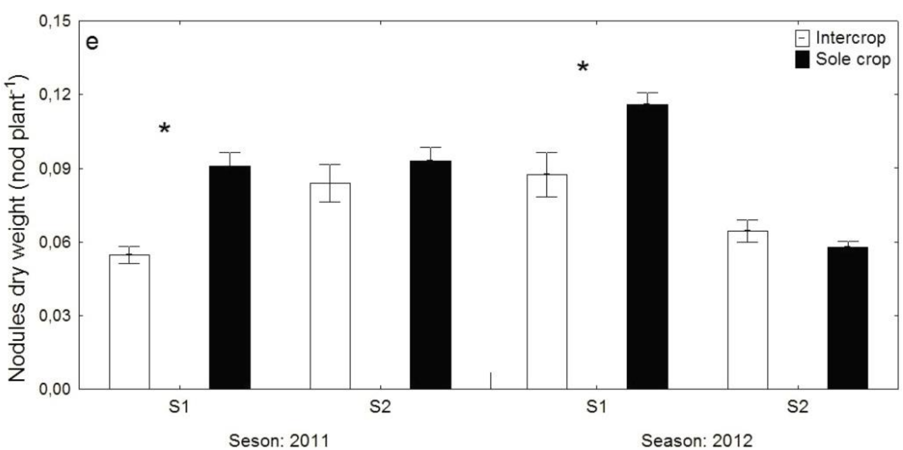
Results and discussions

Plant growth, nodulation and grain yield

Figure 1: Dry weight of shoots (c and d) and nodules (e) of maize and common bean as monocrops or intercrops under S1 and S2 conditions. *Significant difference at P<0.05. sole crop). *, ** Significant difference at p<0.05 and p<0.01, respectively.







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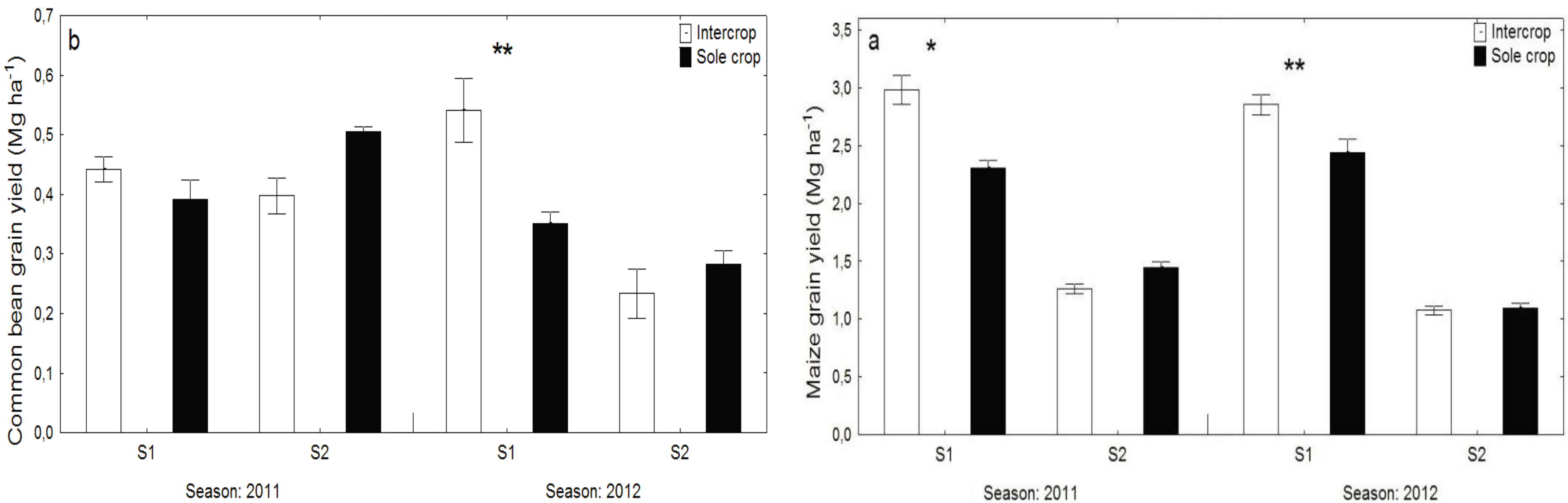
Results and discussions

Figure 2: Grain yields (Mg ha-1) of maize (a) and common bean (b) as monocrops or intercrops under S1 and S2 conditions. *Significant difference at P<0.05. sole crop). *, **Significant difference at p< 0.05 and p< 0.01,respectively.

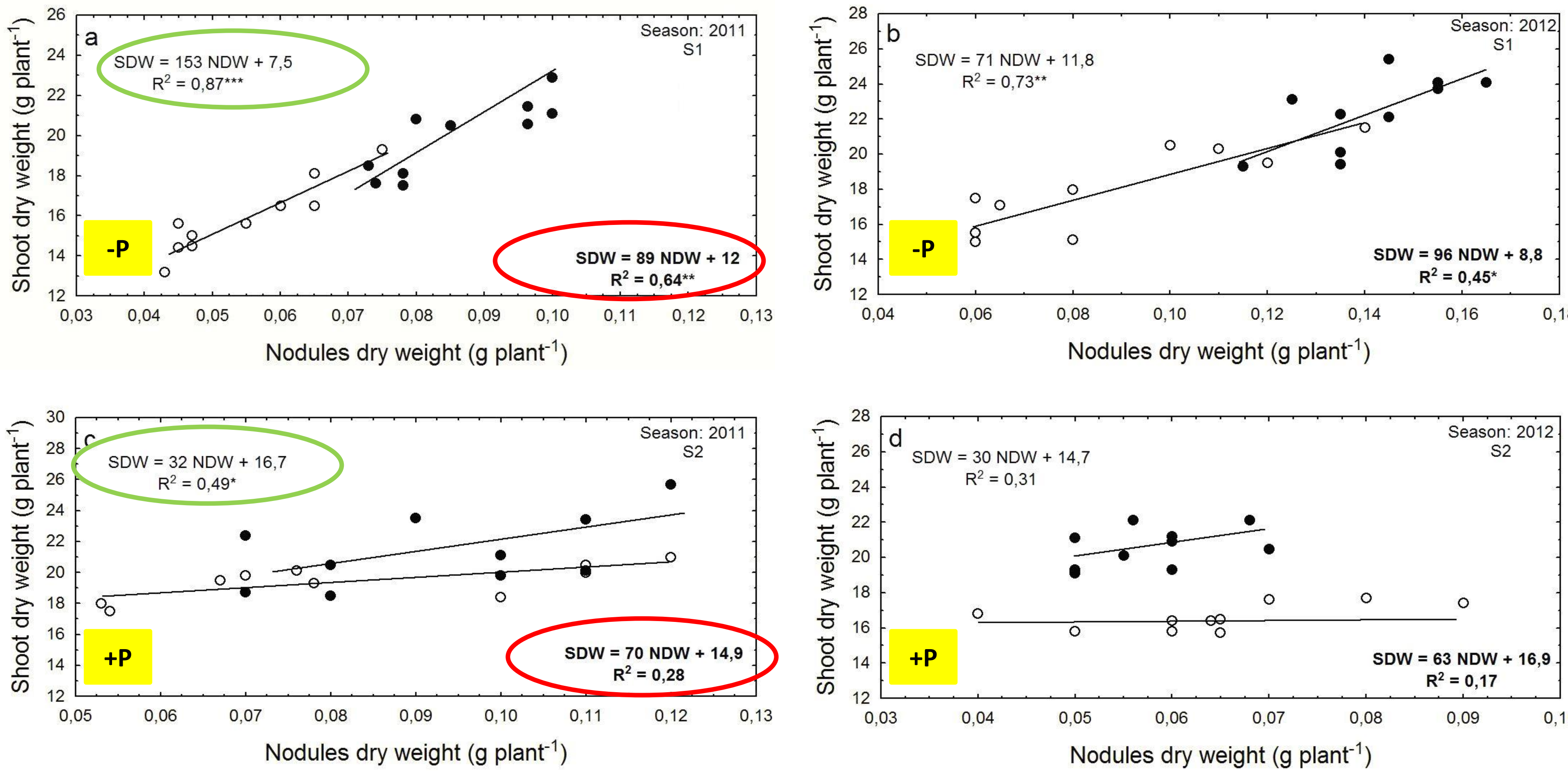


For intercropping system, grain yield of either maize (Dahmardehet al. 2010) or durum wheat (Zhang et al. 2003) was increased when intercropped with cowpea and faba bean.

Results and discussions

Efficiency in use of the rhizobial symbiosis (EURS)

Figure 3: Efficiency in use of the rhizobial symbiosis of common bean as monocrops (filled circle) or intercrops (opened circle) under S1 and S2 conditions. The equations inserted in the graphs describe the regression function of intercropping (light gray text) and of sole crop (dark gray text)



Results and discussions

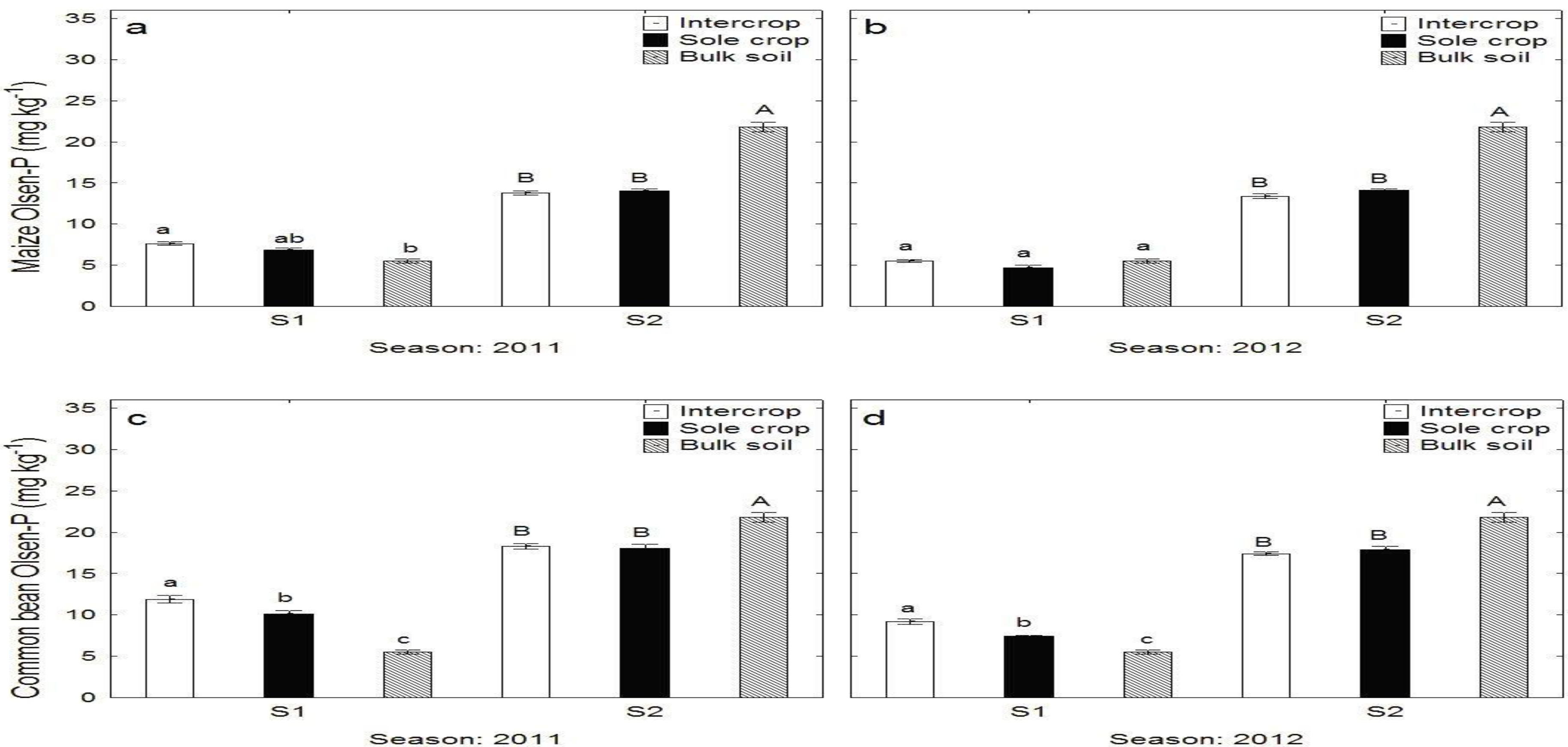
Efficiency in use of the rhizobial symbiosis (EURS)

The differences in EURS among crop treatment may offer an important clue in investigating the key processes that influence P availability under either P deficiency or P sufficiency.

Results and discussions

Rhizosphere P availability

Figure 4: Olsen-P (mg kg^{-1}) in the rhizosphere soil of maize (a and b) and common bean (c and d) in response to crop treatments and experimental sites (S1 and S2) conditions. Greek letters were not significantly different at $p<0.05$.



Results and discussions

Rhizosphere P availability

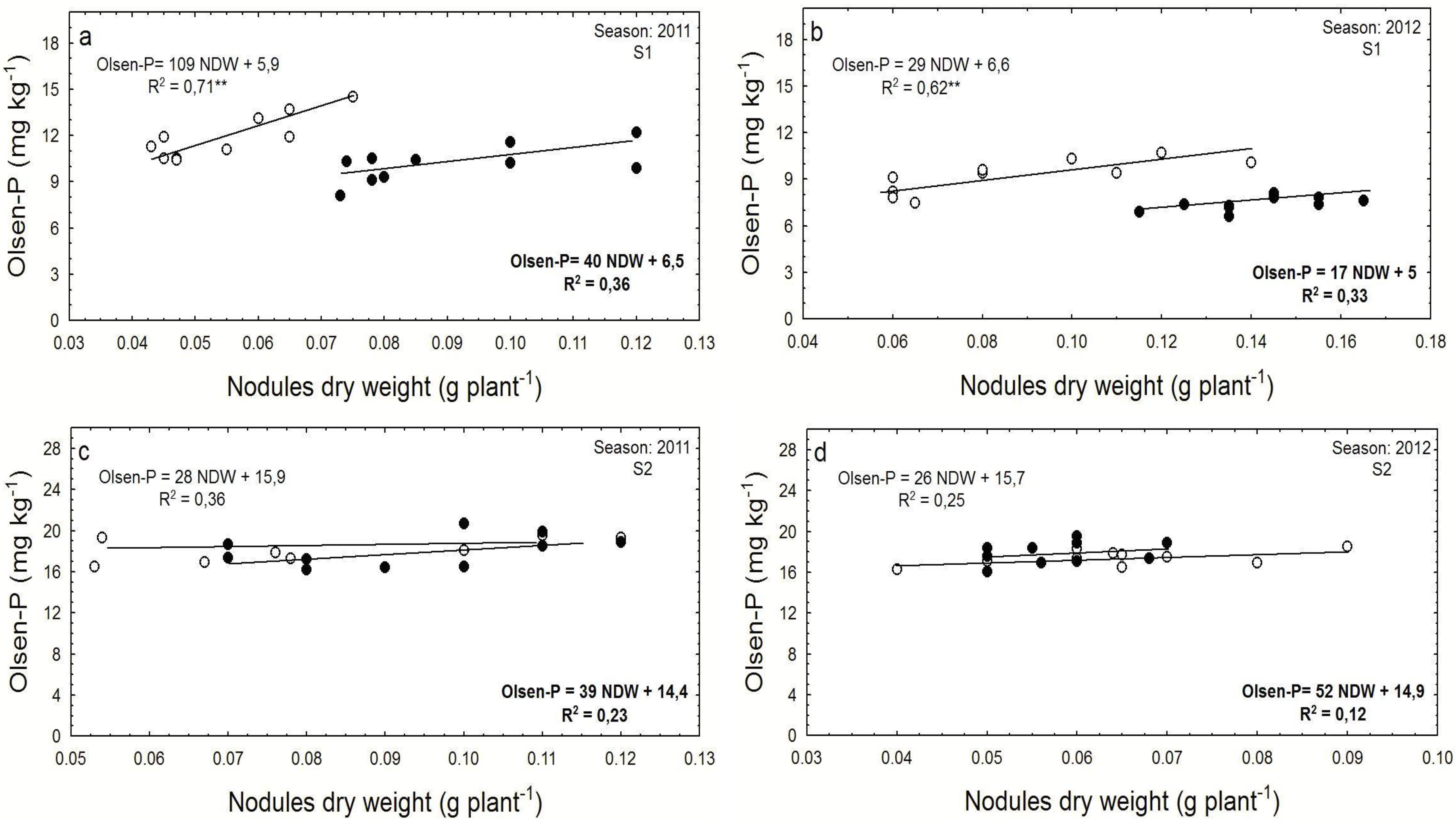
Thus, the increase in P availability under calcareous P-deficient soil was probably related to the increase of EURS especially when common bean intercropped with maize.

Legumes relying on N_2 fixation generally can contribute to increase P availability in the rhizosphere through rhizospheric acidification mechanisms resulted from an increase in proton release by legumes roots (Latati et al., 2014) or acid phosphatases (Bargaz et al. 2012).

Results and discussions

Rhizosphere P availability

Figure 5: Relationship between nodule biomass and rhizosphere soil Olsen P of common bean either in intercropping (opened circle) or sole crop (filled circle) under S1 and S2 conditions.



Results and discussions

Relationship between nodulation and rhizosphere P availability

The positive effect of nodule growth on altering P availability was confirmed, since we found a significant correlation between nodule biomass and Olsen-P in the rhizosphere of intercropped common bean in low P conditions (Fig. 5).

Li et al. (2008) and Betencourt et al. (2012) suggest that intercropping changed indirectly the P availability in the rhizosphere of intercropped species through microbial activities.

Results and discussions

Rhizosphere P availability

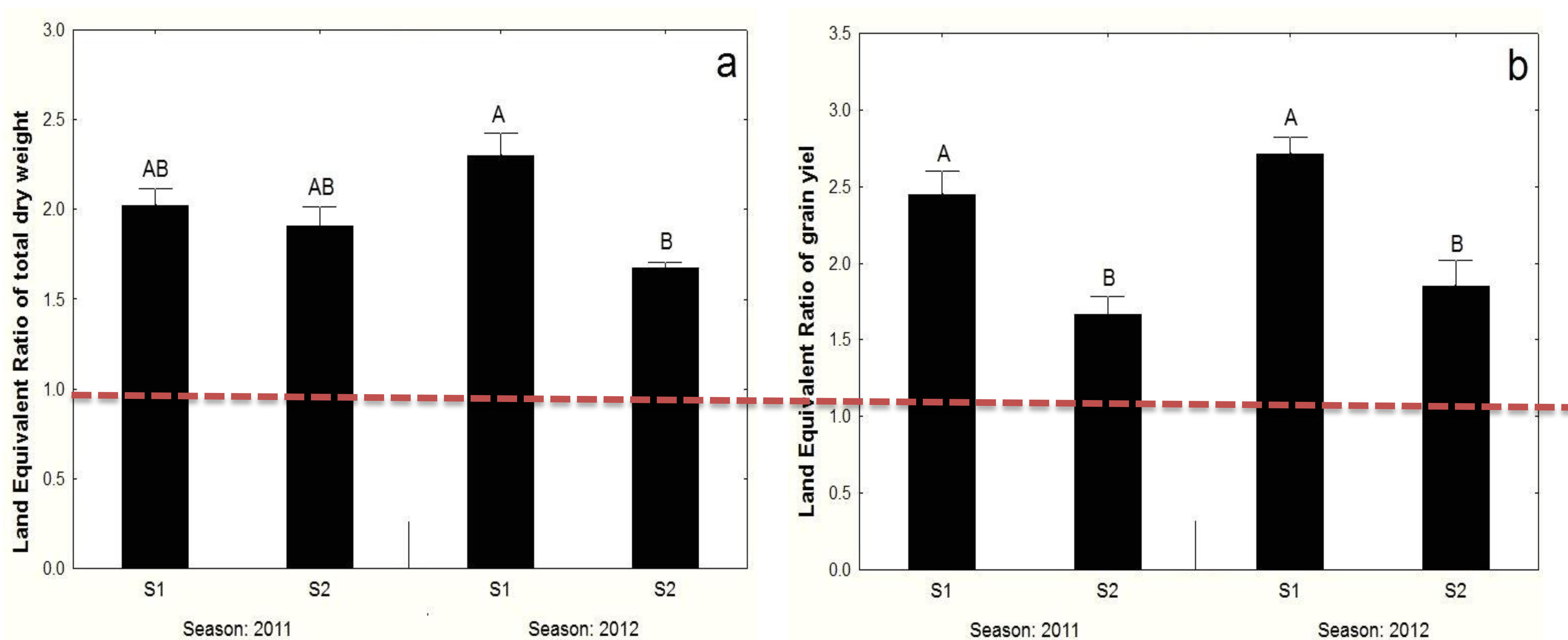
Enhancement of rhizosphere P availability was clearly observed when the two species were intercropped was not significantly affected by total P uptake, except for maize at P deficient soil. While a significant decrease of these parameters was observed in high P soil in sole or intercropping

In case of maize, the observed increase of both P uptake and plant biomass was associated with an increase of grain yield for intercropped maize, especially in low P soil (Fig. 2a), though no significant effects were observed in sufficient P soil (S2)

Results and discussions

Advantage of intercropping maize-common bean (LER)

Figure 7: Land equivalent ratio of total dry weight (a) and grain yield (b). Greek letters were not significantly different at p<0.05.



Results and discussions

Advantage of intercropping maize-common bean (LER)

This result confirmed the advantage of intercropping maize-common bean over sole cropping system as sustainable agriculture. These results were especially confirmed under P limitation in the soil (S1).

Intercropping systems that constantly give LERs greater than one are considered to be more efficient systems from a land use point of view than monocrops (Willey 1979).

Conclusion

We showed that P availability increased in the rhizosphere of either maize or common under low P soil conditions, but this increase was larger when the two species were intercropped. Such an increase was to some extent associated with an increase of efficiency in EURS and for common which occurred to fix high amounts of N_2.

Conclusion

While we observed a positive effect of intercropping on P uptake by maize at P deficiency, P nutrition was decreased for either maize or common bean under P sufficiency.

Conclusion

This common bean facilitation would have been related to enhancement of P bioavailability in the rhizosphere due to a high rate of N_2 fixation in calcareous P-deficient soils. Thus, understanding other factors affecting rhizospher P availability likely to be necessary in developing strategies to improve the symbiotic rhizobial efficiency for intercropped legumes under stressful conditions such as P deficiency.

Acknowledgements

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