# Predicting productivity of Mediterranean herbaceous vegetation growing on a P-deficient soil

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# Predicting productivity of Mediterranean herbaceous vegetation growing on a P-deficient soil

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**SUMMARY** - Herbage production on many shallow Mediterranean montmorillonitic soils is severely restricted by phosphorus deficiency. A single addition of phosphorus fertilizer consistently increased herbaceous plant production in a community dominated by the dwarf shrub *Sarcopoterium spinosum* by a factor of 2.8 to 3.8 over 7 years. Even where phosphorus has been added and average annual rainfall is greater than 800 mm, inter-annual variation in biomass production remains relatively high (CV=0.33). This variation (year effect) is represented in this study by an effective growing day index, G, based on an estimate of the number of days during which the available moisture in the rooting zone can balance the current evaporation demand. This approach was tested on data from a field experiment conducted for 7 consecutive years on a *Sarcopoterium spinosum* dwarf shrub community in the western Galilee of Israel. The index *G* was found to be highly correlated with biomass production of the herbage patches growing between the shrubs. Biomass production could be well described as a linear function of *G* and with the slope related to the size of the pool of labile P in the soil. Plant performance was closely related to growing conditions in both autumn (early season) and spring (late season).

**Key words**: Biomass production, plant growth modelling, phosphorus deficiency, soil water balance, annual species.

***RESUME*** *- "Prédiction de la productivité de la végétation herbacée dans un sol Méditerranéen déficient en phosphore". La production herbagère sur beaucoup de sols montmorilloniques superficiels méditerranéens est sérieusement limitée par une déficience en Phosphore (P). La variation inter-annuelle de la production de biomasse reste relativement élevée, même quand du P a été ajouté et que les précipitations annuelles moyennes sont supérieures à 800 mm (CV=0.33). Dans cette étude, cette variation (l'effet annuel) est représentée par un index G, basé sur une estimation du nombre de jours pendant lesquels la disponibilité hydrique dans la zone racinaire peut contrebalancer l'évaporation courante. Cette approche a été testée sur les données d'une expérimentation en champ, conduite durant sept années consécutives, sur une communauté de buissons xérophytiques de type* Sarcopoterium spinosum, *en Galilée occidentale (Israël). On a constaté que l'index G est fortement corrélé à la production de biomasse des bandes herbagères se développant entre les buissons. La production de biomasse pourrait alors être décrite comme une fonction linéaire de G, la pente étant reliée à la quantité des réserves en P labile du sol. Le développement végétal est étroitement relié aux conditions de croissance, tant en automne (saison précoce) qu'au printemps (saison tardive).*

***Mots-clés*** *: Production de biomasse, modélisation de la croissance végétale, déficience en Phosphore, équilibre hydrique du sol, espèces annuelles.*

## Introduction

Phosphorus (P) is deficient in many Mediterranean soils, especially in terra rossa soils on hard Cenomanian-Turonian dolomite and limestone substrate in the Galilee in Israel. Consequently, herbage growth is severely restricted and offers poor competition to shrub species. Despite the overriding P deficiency and annual rainfall normally above 600 mm, herbage production varies from year to year with a coefficient of variation (CV) of ~33%. Addition of fertilizer P can substantially increase herbage productivity on such soils, sometimes several fold. However, production does not reach a more or less constant level determined by the amount of added nutrient, but continues to vary from year to year with a CV similar to that of the unfertilized herbage patches.

The present study was motivated by the need to explain inter-annual variation in herbage production on a sub-humid Mediterranean-type rangeland where, despite high seasonal rainfall, available soil water can vary from erratic and inadequate for potential plant growth in autumn and spring to more than

adequate during most of winter. The object of the present study was to determine whether this could be accomplished with an effective growing day index (*G*) based on an estimate of the number of days during which the available moisture in the rooting zone can balance the current evaporation demand (Henkin *et al.*, 1998) and a factor representing the seasonal change in the other weather conditions.

## Results and discussion

### Rainfall and response of herbage production to treatment differences

The correlation between rainfall and herbage patch biomass was low and not significant ($R^2<0.14$), neither in the control nor in the P treatments. In contrast, the model in its final form gave highly significant ($p<0.0001$) correlations with the observed data (Fig. 1) with a different response to treatment applied. The slopes of biomass response in the P1 and P2 treatments were 3.1 to 3.2 times higher than the slope in the control (P0).

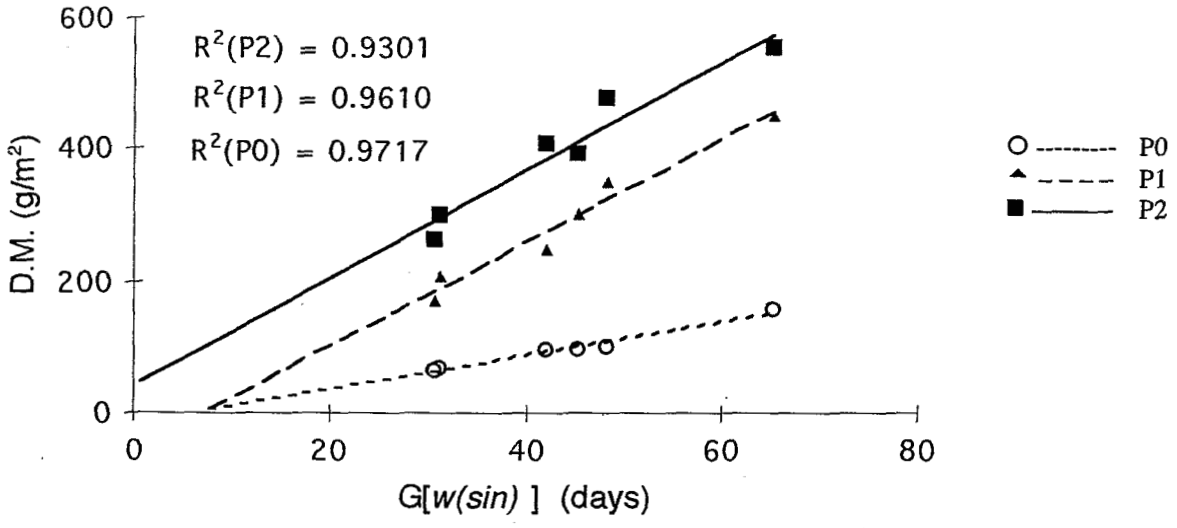


Fig. 1. Relationship between *G* and biomass production with *G* as a function of the sin weighting.

### Persistence of the P priming effect

The high correlation of the linear relationship between herbage production with the effective growing day index, *G*, at all P application levels, indicates that the effect of P priming, applied only once at the beginning of the experiment, continued unabated for 7 years. This could be possible if most of the exogenous fertilizer P was not fixed into the non-labile phosphate pool, but entered the reversibly adsorbed labile phosphate pool. It is possible that the phosphate added to this pool was not exhausted by the seventh year because during the experiment, the total amount of P taken up was approximately half of the amount applied. In addition, much of the P taken up by the herbage remained on the site and some, in the plant litter and seed, must have been recycled in the germinating vegetation and in the soil P.

## Conclusion

A single P priming treatment on the montmorillonitic soil on the experimental site changed the ecological status of the herbaceous vegetation associated with the prevalent *S. spinosum* dwarf-shrub

community: for up to 7 years it raised production substantially and induced legume dominance of annual leguminous species. Recycling of P taken up by the vegetation, inputs by the grazing animals and possibly greater P uptake efficiency by the dominant legume species, could have contributed to maintaining higher productivity unabated for 7 years. This did not preclude fluctuations of production between years. However, at all levels of P availability, these fluctuations were very closely related to the number of effective growing days derived from the cumulative soil water balance after weighting to account for the seasonal change in winter growing conditions.

**Reference**

Henkin, Z., Seligman, N.G., Noy-Meir, I. and Kafkafi, U. (1998). Effective growing days: A simple predictive model of the response of herbaceous plant growth in a Mediterranean ecosystem to variation in rainfall and phosphorus availability. *Journal of Ecology,* 86 (1) (in press).