Analysis of explanatory factors for grain yield of alfalfa (*Medicago sativa* L.) in France

FNAMS
French Seed Growers' Association

Numerous insect pests in alfalfa seed crops

In France, several insect pests can attack alfalfa at the vegetative, flowering and pod ripening stages. The main insects concerned are pea leaf weevil (*Sitona lineatus* L.), pear-shaped alfalfa weevil (*Holotrichapion pisi* Fabricius), alfalfa weevil (*Hypera postica* Gyllenhal), alfalfa black weevil (*Colaspidema barbarum* Fabricius), aphids, mirid bugs (*Lygus* spp. & *Adelphocoris lineolatus* Goeze), alfalfa seed weevil (*Tychius aureolus* Kiesenwetter) and alfalfa moth (*Cydia medicaginis* Kuznetsov).

Sweeping net in an alfalfa field

Monitoring in fields

Monitoring of these insect pests in fields has been carried out for many years, generally with a weekly visit per field from May to August. Sampling is carried out with a sweeping net and the results are always expressed in terms of the number of **insects per 25 net sweeps**, except for alfalfa moth which is monitored with a pheromone trap.

Mirid bug (Lygus sp.)

Alfalfa seed weevil

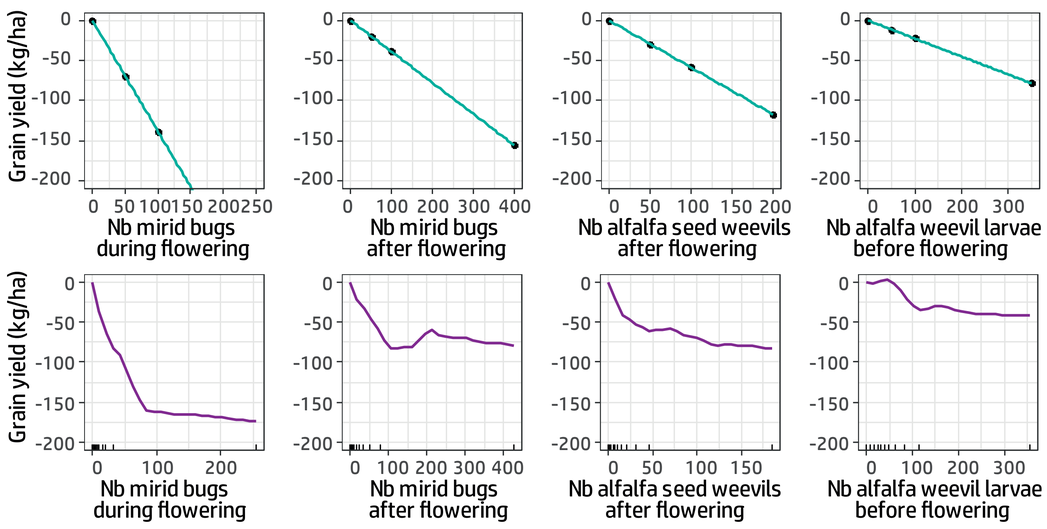
Alfalfa weevil larva

Database and objectives of the study

Data collected from 2006 to 2019 were analysed, representing a total of **795 fields**. The objectives of the study were 1) to assess which of the **available variables had the greatest effect on grain yield** and 2) to **clarify the pest harmfulness** on this crop. A total of 31 explanatory variables were available in the dataset concerning field characteristics (location, variety, area, etc.), crop management, insect pest populations and weather data.

Statistical analyses

The analyses were performed with R 4.0.5 through RStudio 2022.07.1. The dataset of 795 fields was split into a training set (90% of the data) and a test set (10%). **Eight different statistical models** were built and tested (linear fixed effects with or without stepwise, linear mixed effects with or without stepwise, random forests) on these two datasets. Their goodness of fit is evaluated via the adjusted r^2, the RMSE and the MAE. As the splitting of the initial set is random, the results and interpretations can potentially be variable depending on the fields selected. In order to interpret the results more robustly, 1000 random draws of the training and test sets are made, and their average goodness of fit is assessed.



Effect of mirid bugs, alfalfa seed weevils and alfalfa weevil larvae on yield as a function of alfalfa stage and statistical model (top : linear mixed effects ; bottom : random forest)

Best models

The average yield on the 795 fields is **443±252 kg/ha**.

Among the 8 statistical models tested, the 2 models with the best fit were the **linear mixed model** and the **random forest**. Nevertheless, the prediction quality for both remains rather low.

		Mean of 1000 draws		
Model type	Number of predictors	Adjusted r^2	RMSE (kg/ha)	MAE (kg/ha)
Linear mixed effects	13	0,30	188	150
Random forest	15	0,25	195	157

Table summarising the predictive quality of the two best statistical models

Best predictors of yield

Of all the models tested, the best predictors of yield were the number of **mirid bugs before and after flowering**, of **alfalfa seed weevils after flowering**, of **alfalfa weevil larvae before flowering**, region of production, variety, farmer and average temperature before flowering.

Harmfulness of most damaging insect pests

The individual effects of the most damaging pests identified by the statistical models on yield are presented below.

Depending on the pest and the stage of the alfalfa, as well as the predictive model used, the estimated yield loss corresponding to 1 insect caught in 25 net sweeps can vary from about **0.2 to 1.6 kg/ha**.

Discussion of the results and conclusion

The predictive quality of the 2 best models **remains rather poor**: other explanatory variables not available for our analysis should be introduced in the models to have a better explanation of the yield. Among the missing predictors, we can mention pollination and fertilisation quality, the pedology of the fields, the quality of the harvest or the presence of diseases.

The hierarchy of explanatory variables and pest nuisance in the models constructed is therefore to be **taken with caution**, even if they are **good first indicators** for better alfalfa seed production in France.

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