Barriers to adopting best management practices aiming at soil fertility and GHG mitigation across dairy farmers in The Netherlands

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Abstract: Although over the years various field management practices have been identified that have benefits for crop productivity and the environment the adoption of these practices is low. The underlying reasons for this low adoption rate are not very well understood. Decision making at farm level is a complex process in which expected outcomes, personal and others' experiences, and the degree of control as to implementation are all important.

In this study the barriers to adopting best management practices aiming at enhancing soil fertility and contributing to GHG mitigation experienced by dairy farmers on sandy soils in the Netherlands are identified following the theory of planned behavior. Using interviews and questionnaires, the attitude about expected outcomes of implementing a given practice, the extent of influence from referents such as other farmers and literature sources, and the level of control farmers have on relevant external factors were ascertained.

The study confirms earlier findings by Wauters et al. (2010) that attitude towards a given practice is an important factor. Additionally, our study shows that perceived behavioral control is important when the number of adopters is low. For grass-maize rotations on sandy soils in the Netherlands there appears to be a perceived trade-off between damage to the physical soil structure and yield improvement. For non-inversion tillage, increased weed pressure seems to be a large perceived obstacle among non-adopters.

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Keywords: dairy farmers, soil fertility, mitigation, adoption, non-inversion tillage, grass-maize rotation

Introduction

Field management practices such as the use of grass-maize rotations and non-inversion tillage are considered to be Best Management Practices (BMPs) because they contribute to increased, soil fertility and potentially also climate change mitigation. Although Dutch dairy and arable farmers acknowledge these positive effects, the implementation of these practices is not common. So far it is unclear what the main barriers are for farmers to adopt these, often low cost, BMPs.

The purpose of this study is to identify which drivers and barriers exist towards the implementation of BMPs. Decision making at farm level is a complex process in which according to the theory of planned behavior (Ajzen 1991) expected outcomes (Attitude (A)), others' experiences and social pressure (Subjective Norm (SN)), and the degree the farmers feels in control as to implementation (Perceived Behavioral Control (PBC) all are important. The theory of planned behavior has been used previously to identify barriers for adoption of specific field management practices (Wauters et al., 2010). In this study we use this theory to evaluate barriers towards the adoption of BMPs at two farm types in the Netherlands. For details on the theoretical framework and methodology we refer to the paper by (Bijttebier et al., 2014).

This paper presents the first results of the analysis of barriers found for the use of grass-maize rotation (instead of permanent grassland) and non-inversion tillage (instead of ploughing) by dairy farmers on sandy soils in the Netherlands.

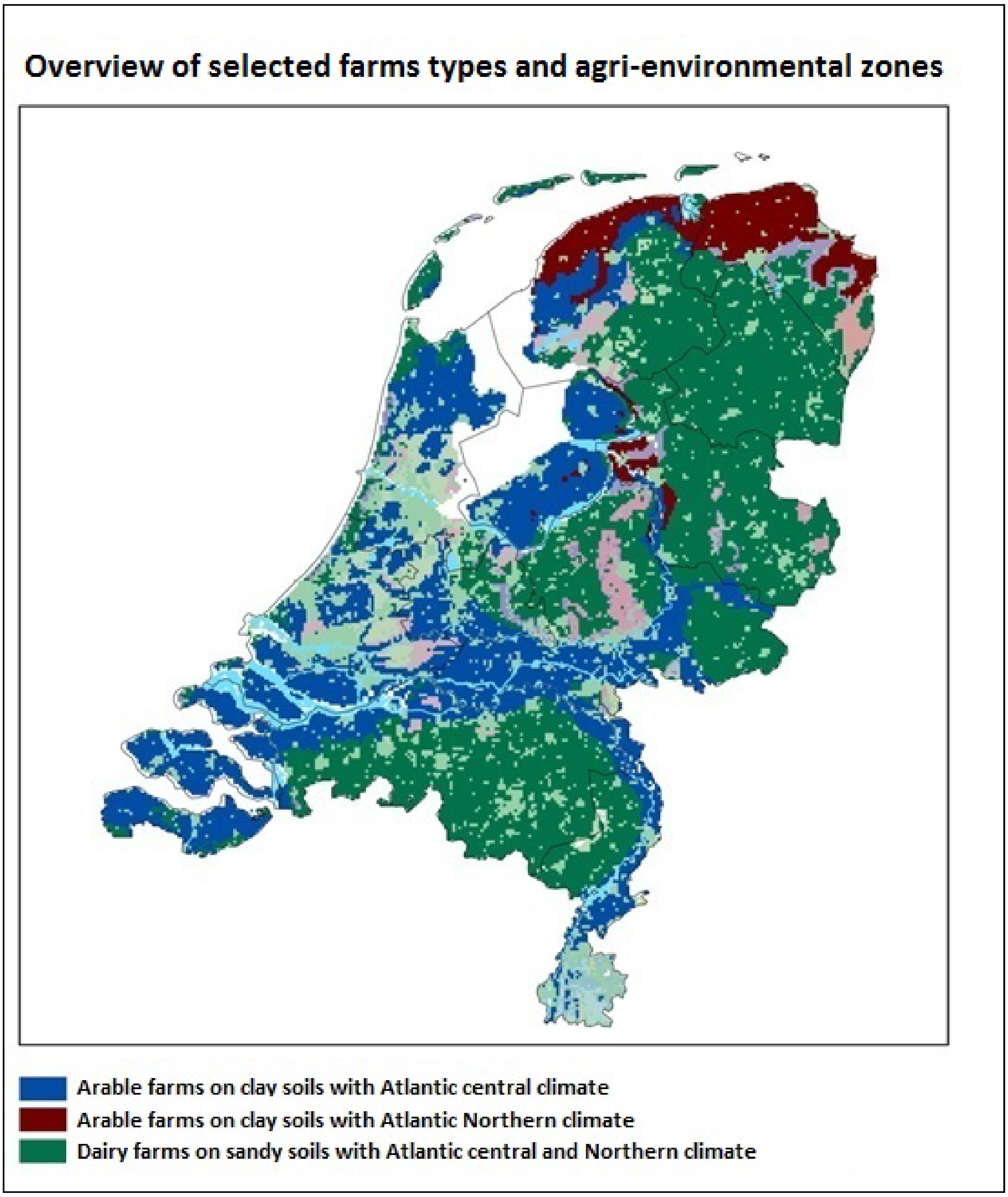
Methods

Study areas

The study areas were selected based on the farm typology developed in the Catch-C project. The typology uses a combination of farm specialization, land type, climate and soil type to arrive at Farm Type Zones (FTZs) (Hijbeek et al., 2013). For the Netherlands we selected two specializations: arable and dairy farms. Each of these was differentiated according to soil type (sand and clay) and climate zone (Atlantic Central and Atlantic Northern). In this paper we present results from dairy farms on sandy soils (green area in Figure 1). The effects of management on, for example, soil fertility, soil biology, greenhouse gas emissions, productivity have been derived from long-term experiments located in different environmental zones in Europe.

For each FTZ a small sample of farmers were first interviewed and then a larger sample was approached via an online questionnaire to obtain information on behavioral, normative and control beliefs.

Figure 1: Overview of the selected study areas with a description of climate and soil type. In this paper we present results on dairy farmers on sandy soils (green area)



Farmer survey

To find possible outcomes, referents and control factors for each BMP, semi-structured interviews were held on five dairy farms located on sandy soils. The farms were selected to include a geographically spread across our study area, both larger and smaller farm sizes, farmers both active and not active in study clubs and adopters and non-adopters of the chosen BMPs. During the winter of 2013 farm visits were conducted and possible outcomes, referents and control factors listed for each BMP.

From these interviews, a questionnaire was derived including questions on the outcomes, referents and control factors. The draft questionnaire was first tested and evaluated by an extension agent, a farm manager of an experimental farm and three farmers. During summer and autumn of

2013, 1000 dairy farmers on sandy soils were invited via a personalised letter to respond to the questionnaire via an internet platform. The questionnaire addressed both grass-maize rotation and non-inversion tillage practice. A grass-maize rotation is an alternative to the continuous cropping of maize and is defined as maize cropped on the same field after grass. Non-inversion tillage was defined as follows: the soil is not being ploughed for at least one year, other cultivation methods may be used, such as superficial, mechanical soil loosening operations (disks, chisels, sweeps, etc.).

Farmers' attitude towards each practice was assessed through sets of questions, each with a unipolar, 5-point scale: The first question of each set measured the behavioral belief strength of a possible outcome, for example whether non-inversion tillage leads to more weeds. The endpoints to these questions were *not likely – likely*. The second question measured the outcome evaluation, for example the expected effect of implementing BMP on weeds. The endpoints of these questions were *extremely bad – extremely good*.

The subjective norm of each practice was also assessed through sets of questions: The first question of each set measured the normative belief strength for a certain practice, for example whether other farmers support non-inversion tillage. The endpoints to these questions were to *totally disapprove—totally approve* engagement in a specified management practice. The second question measured the motivation to comply, for example how important the opinion of other farmers is. The endpoints to these questions were *not at all – very much*.

The degree of behavioral control was also assessed through similar sets of questions: The first question of each set measured the control belief strength, for example whether a farmer has mainly small plots. The endpoints to these questions were *not to agree – to* agree. The second question measured the control belief power, for example whether it is possible to use non-inversion tillage on small plots. The endpoints to these questions were *extremely difficult—extremely easy*.

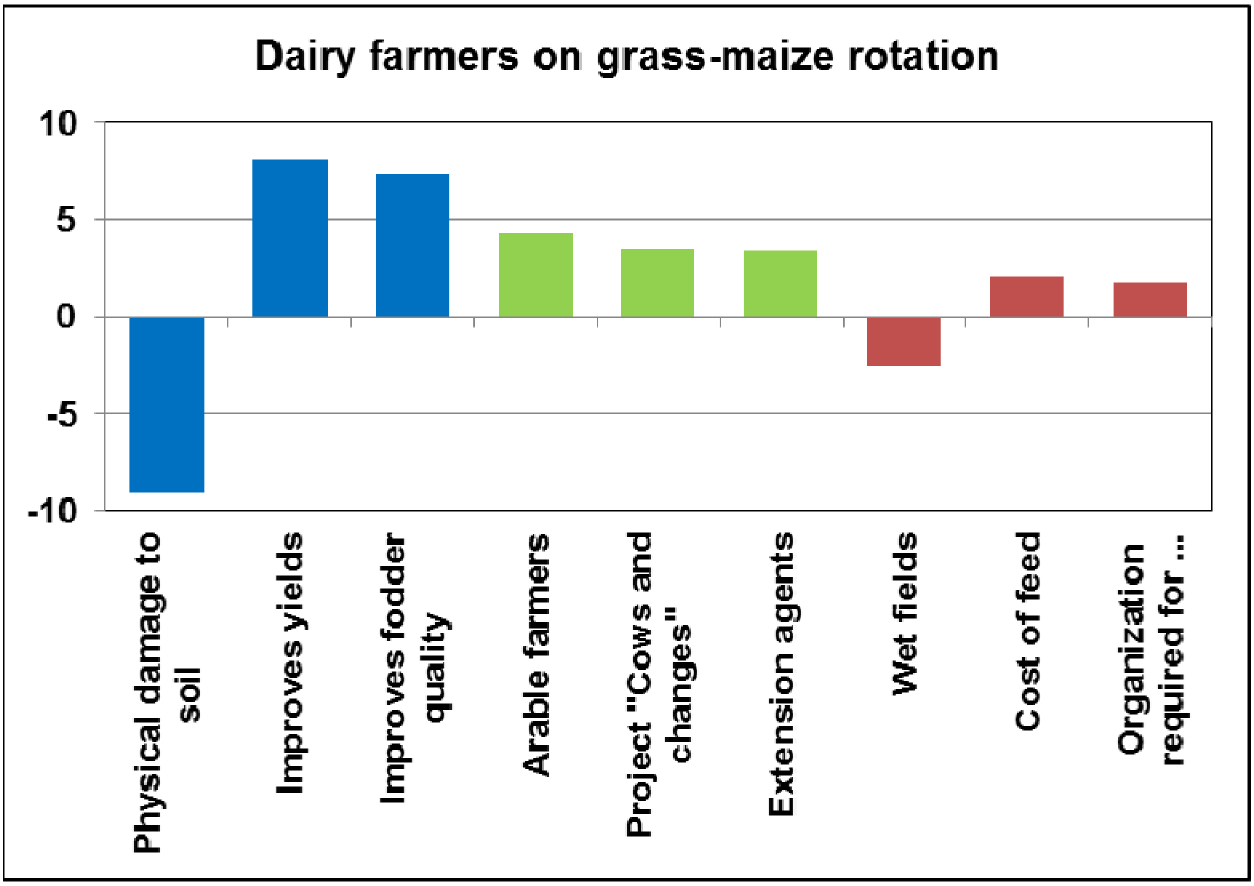
To understand which factors have the highest influence on actual adoption of a practice, behavior was measured as a dichotomous variable equal to 1 when the practice was applied and 0 when not. This divided the sample population in two groups: adopters and non-adopters. The Cronbachs' alpha was included to ensure the internal consistency of the answers given (Cronbach, 1951).

Results

Grass-maize rotations

From the semi-structured interviews among dairy farmers, 11 outcomes defining attitude, 4 referents defining the subjective norm and 10 control factors defining the perceived behavioral control for grass-maize rotations were found. The strength of each factor was investigated in the online farmer survey. A selection of the scores is presented in Figure 2.

Figure 2: Mean scores for behavioral belief strength x outcome evaluation (blue), for normative belief x motivation to comply (green) and control belief power x control belief strength (red) from dairy farmers on selected factors influencing the adoption of grass-maize rotations. Values can range between -10 and +10. Positive values mean that the factor can be a driver, negative values point out that the factor is a barrier.



The majority of farmers who filled in the questionnaire believe that grass-maize rotations improve the yield and fodder quality (Figure 2), but at the same time they also believe that grass-maize rotations negatively affect the physical soil structure. This is consistent with the scores on the control beliefs which show that most farmers do believe that costs of feed positively influence the adoption of grass-maize rotations but that wet fields hamper the uptake. Apparently there is a trade-off between the physical damage to the soil and the positive effect on yields. Some farmers attach more value to the yield improvement than the physical damage as shown by the number of adopters and non-adopters of this practice: 22 versus 29 (Table 1).

Table 1: Number of adopters and non-adopters and the scores for attitude, subjective norm and perceived behavioral control for grass-maize rotations of dairy farmers on sandy soils

	Adopters	Non-adopters
Farmers (n)	22	29
Attitude	2.20	1.97
Subjective norm	0.81	-1.75
Perceived behavioural control	13.29	11.45*

The Cronbachs alpha was 0.97. Significance of difference between Adopters and Non-Adopters of mean coefficients indicated as follows: (***) P<0.01; (**) P<0.05; (*) P<0.1.

For each category scores were aggregated to distinguish the relative importance of attitude, subjective norm and perceived behavioral control. Table 1 shows these aggregated scores. The difference between adopters and non-adopters seems small except for the subjective norm: non-adopters believe more referents have a negative perception about grass-maize rotations, although this difference is not significant. Only the perceived behavioral control has a significant difference between adopters and non-adopters. Adopters have for example a more positive view on the organization required, also when fields are more difficult to visit (lying for example farther away from the farm) In Table 2 the scores on specific factors are shown for adopters and non-adopters: adopters have not only a more positive perception on the outcomes of grass-maize rotations, but also a more positive view on the external factors.

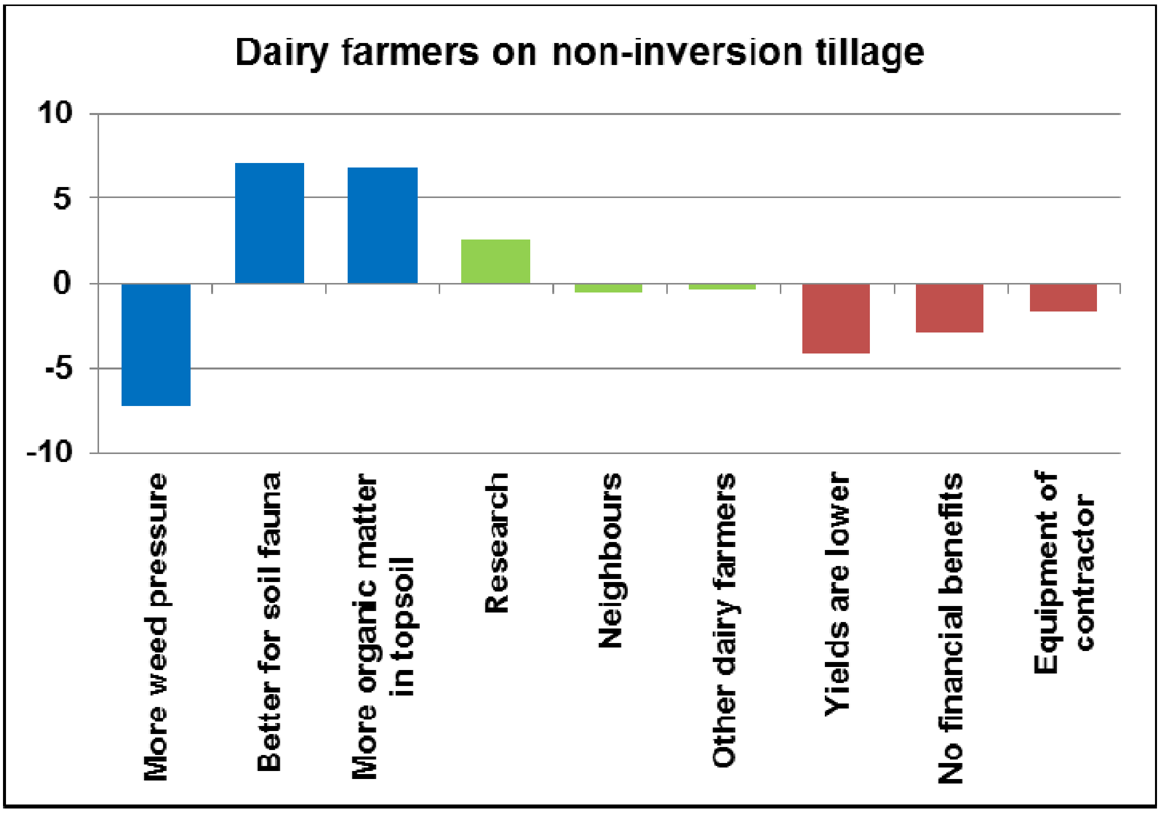
Table 2: Scores of specific beliefs from adopters and non-adopters among dairy farmers of grass-maize rotations

	Adopters (n= 22)	Non-adopters (n= 29)	P-value
	1= not likely; 5= likely		
Favours yields	4.6	3.9	0.001
Resowing improves sod	4.3	3.2	0.0045
Less soil diseases	3.3	2.9	0.009
	1= impossible; 5= nevertheless possible		
A lot of organization	4.5	3.5	<0.001
Fields difficult to visit	4.3	3.0	<0.001
Feed cattle in the stable	4.3	3.1	<0.001
Cost of feed increased continuously	4.4	2.9	<0.001

Non-inversion tillage

From the semi-structured interviews among dairy farmers, 10 outcomes defining attitude, 5 referents defining the subjective norm and 15 control factors defining the perceived behavioral control for non-inversion tillage were found. The strength of each factor was investigated in the online farmer survey. A selection of the scores is presented in Figure 3.

Figure 3: Mean scores for behavioral belief strength x outcome evaluation (blue), for normative belief x motivation to comply (green) and control belief power x control belief strength (red) from dairy farmers on selected factors influencing the adoption of grass-maize rotations. Values can range between -10 and +10. Positive values mean that the factor can be a driver, negative values point out that the factor is a barrier.



Most farmers believe that research is mainly positive about non-inversion tillage, and that this is different from practical know-how as it is believed that other farmers and neighbours are less positive about this practice (Figure 3).

The majority of farmers who filled out the questionnaire believe that non-inversion tillage leads to more organic matter in the topsoil and better soil fauna. At the same time, the majority of the farmers also believe that non-inversion tillage leads to more weed pressure. Apparently most farmers believe this combination leads to lower yields and no financial benefits as can be seen from the scores of the control factors, This is consistent with the lower number of adopters versus non-adopters: 26 versus 89 (Table 3).

Table 3: Number of adopters and non-adopters and the scores for attitude, subjective norm and perceived behavioral control for non-inversion tillage on dairy farms on sandy soils.

	Adopters	Non-adopters
Farmers (n)	26	89
Attitude	2.88	1.07***
Subjective norm	-0.33	-2.19***
Perceived behavioural control	11.87	9.79***

The Cronbachs alpha was 0.91. Significance of difference of coefficients of Adopters and Non-adopters of mean coefficients indicated as follows: (***) P<0.01; (**) P<0.05; (*) P<0.1.

For each category scores were aggregated to distinguish the relative importance of attitude, subjective norm and perceived behavioral control. Table 3 shows these aggregated scores. The difference between adopters and non-adopters are all significant and larger than the difference between adopters and non-adopters for grass-maize rotations. Interestingly, also the adopters think most referents have a negative perception on non-inversion tillage.

In Table 4 the scores on specific factors are shown for adopters and non-adopters. Adopters have not only a more positive perception on the outcomes of non-inversion tillage (especially about the effect on yield), but also a more positive perception about solving the weed problem.

Table 4: Scores of specific beliefs from adopters and non-adopters among dairy farmers of non-inversion tillage

	Adopters (n= 26)	Non adopters (n= 89)	P-value
	1 = not likely; 5 = likely		
Favours yields	4.50	2.89	<0.001
NIT increases pesticide use	3.00	4.01	<0.001
NIT saves time compared to ploughing	4.52	3.98	0.03
NIT is better for soil fauna	4.32	3.60	0.007
	1 = do not agree; 5 = agree		
Yields are lower	1.92	2.88	<0.001
No financial benefits	2.25	3.07	0.002
	1 = impossible; 5= nevertheless possible		
Unsolvable weed problem	3.6	2.5	<0.001

Conclusions and Discussion

Results presented show how underlying factors influencing farm decisions to adopt certain practices can be disclosed by applying the theory of planned behavior. Our study confirms findings of

Wauters et al. (2010) that attitude is an important factor. Additionally, our study shows that perceived behavioral control is important when the number of adopters is low.

For grass-maize rotations on sandy soils in the Netherlands there appears to be a perceived trade-off between damage to the physical soil structure and yield improvement. To avoid negative impacts on soil structure, timing of the different activities is important to avoid heavy machinery on wet soils. Farmers who apply grass-maize rotations have a more positive view on the organization required to achieve this, which shows this barrier could be removed for non-adopters, unless the two groups are different due to contrasting external factors not recognised here.

For non-inversion tillage, increased weed pressure seems to be a large perceived obstacle among non-adopters. Our study does not reveal why farmers who do apply non-inversion tillage have less concerns about increased weed pressure. Although all dairy farmers consulted in our study have sandy soils, there might still be differences in local soil conditions explaining the differences in expected outcomes of non-inversion tillage. Similarly, farm size and intensities will also differ, creating more or less organizational and financial capacities. In the next step of this study we will investigate such factors.

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