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# The influence of excessive rainfall on the protective value of windscreens with respect to crop yields

SYED RIAZ HUSSAIN SHAH

Research Associate at the Institute for Biological Field Research (Itbon), Arnhem, Netherlands

## Summary

This research was carried out with artificial screens in order to determine the influence of windscreens for the development and yield of pods in bean (*Phaseolus vulgaris*) crop. This research revealed the following facts:

1. In the first months the growth of the crop was better under the protected than in the open area.
2. The number of pods in the protected area attained a lead of 60 % in the course of the months of May, June and July, when the rainfall was normal for the Netherlands climate.
3. Then this lead began to decrease. The reason was that the abnormal heavy rains started giving a negative influence to the windscreen. In the protected area, due to low wind velocity contributed by the windscreen, the excessive moisture accumulated in great amount, consequently plant diseases invaded and destroyed the pods as well as some other parts of the plant. Hence the initial surplus of 60 % in the yield of pods was lost. In the open area the winds dried the soil quicker, consequently there was only very little damage to the crop by heavy rains.
4. The author points out that in the regions where very heavy rains are anticipated, a great caution and a good analysis of the situation is needed before a shelterbelt project is carried out for increasing the crop yields.
5. The author adds that each crop behaves in a different way to the accumulation of moisture. In certain crops the damage may be high and in others low. If the crops are of the type which has no or little damage from the excessive moisture for a short period, it is recommended that shelterbelts or windbreaks should be established for increasing the yield of crops.

## 1. General introduction

Wind protection for agricultural purposes is obtained by many kinds of windscreens. Shelterbelts and windbreaks are the most important ones. Both are barriers of living trees and shrubs, the first consisting of three to twenty rows of trees according to different local circumstances and principally maintained for protecting farm fields, and the second of only one or two rows of trees for the protection of the farm home, other buildings, garden, orchard, and feedlots.

The difference in design and construction of shelterbelts results in better protective efficiency than windbreaks can provide. Hence shelterbelts are preferred over windbreaks when a large scale shelter programme is carried out. However, it will be fair to say that to do this most economically, in many countries it is essential to combine

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the windbreaks with the shelterbelts according to the microclimate and local conditions.

The major advantage of windscreens is that they reduce wind velocity, which in turn brings about many beneficial results. Wind erosion and silting of canals or ditches is reduced. Soil moisture is increased. Important above all, striking increases in yield of most crops are due to them. Further, living windscreens provide fuelwood and timber for the use of farmers, and protection to man and livestock from cold winds of winter and hot winds of summer.

In many cases far outweighed by these benefits, there can be, however, a few disadvantages. The major ones are :

- A. Reduction of the effective agricultural acreage;
- B. Competition for light, moisture, and soil nutrients between the trees and the adjoining strip of the crop;
- C. Obstruction of mechanized farming;
- D. Less possibility for drying in a wet period.

The great benefits from windscreens created a corresponding interest in many countries all over the world to use them. In the western European countries where there is shortage of land, intensive study was started on their influences on the microclimate and crops. In the Netherlands also a research programme was started. The author cooperated in it by conducting some experiments.

In the Netherlands and similar countries there is a high amount of rainfall, which sometimes can be distributed abnormally at the odd parts of the growing season. This paper is designed to make the analyses of excessive rainfall with respect to crop yield under wind protection. The author will be able to bring forward some of the adverse effects of the excessive rainfall on the protective value of windscreens and will finally point out his recommendations.

## 2. Methodology of the experiment

Five different field experiments were carried out in various parts of the Netherlands. In this paper, only the results with beans at Bruinisse (Zeeland) are discussed. The concerning field was acquired in the Agricultural Experiment Station at that place and was used to a width of 12 m and a length of 80 m. The orientation of the field was such as to face the winds coming from southwest. The soil had a good fertility, which was fairly distributed.

On May 7th, 1960, beans *Phaseolus vulgaris* cult. N-150<sup>1</sup> were sown. For the protection from the southwesterly winds, the author designed a special windscreen, which was 1 m in height and 12 m in length. It consisted of vertical strips of colourless plastic in wooden frames and was designed in such a way as to keep 33 % air-drainage through it.

There are a few great advantages for using artificial screens for experimental research work :

- A. It gives the research worker a chance to find his experiment field in open area and according to his crops requirement;
- B. There is no shading effect as of a natural screen on the adjoining strip of the field crop;

<sup>1</sup> In America this bean is called "field-bean".

C. There is also no competition for the soil nutrients and light, etc., between trees and the adjoining strip of the crop.

The screen was fixed in the field so as to divide it into two sections :

1. in front of the screen an area which was unprotected and open for the south-westerly winds;
2. in the leeward side an area which to varying degrees was protected from them.

### 3. Observations

A couple of days after the crop was sown, the screen was fixed. The experimental field was weeded out regularly. A good watch was kept if any external or abnormal factors were interfering with the growth of the plants. Regular visits were made to check the behaviour and the development of the plants.

As soon as the pods gave their first appearance, the author started his proper observations, i.e. countings of the total number of pods in the sampling plots. In total there were five of these countings, viz. on July 11, July 30, August 13, August 29 and September 16, when the plants were 65, 84, 98, 114 and 132 days respectively. The sampling comprised 50 different plots of 15 plants each, viz. 40 in the leeward and 10 in the windward side of the screen. According to their place in respect of the screen, they were indicated as  $1H_1$ ,  $2H_1$ ,  $3H_1$ ,  $4H_1$ ,  $5H_1$  till  $40H_1$  (leeward) and  $1H_w$ ,  $2H_w$ ,  $3H_w$  till  $10H_w$  (windward). Each " $H_1$ " and " $H_w$ " denotes the height of the screen, i.e. 1 m.

Informations regarding rainfall and temperature are given in the TABLES 1 and 3, those regarding wind conditions in FIGURE 2 and TABLE 2.

### 4. Results

In the first place, the author noticed the better development and growth of the plants in the protected zone than of the plants which were open to the winds.

The results of the five main observations can be seen in FIG. 1. Analysis showed the following: in observation 1 (July 11) the number of pods was 40 % higher in the protected than in the unprotected area, in observations 2 and 3 (July 30 and August 13) even 60 % higher, in observation 4 (August 29) only 30 %, and in observation 5 (September 16) the numbers in the two areas were the same. So, the promising surplus of numbers in the protected area underwent a sudden decline in August, and at the end there was no surplus at all. Further, the moment in which the obviously positive influence of the windscreen started to decrease corresponded with the beginning of a period of abnormal and excessive rainfall, in the months of August and September (see TABLE 1). It seems reasonable to suppose that there must be some connection between this excessive rainfall and the decrease of the number of pods.

### 5. Discussion

In a region suffering from very high rainfall, as was the case in August and September 1960 in Zeeland, a negative influence on the yield may be expected from wind protection if in the same period the windscreen is effective indeed. Then, as a matter of fact, the wind reduction is detrimental because it retards the evaporation.

Probably by the accumulation of excessive moisture, the different plant diseases come in and the plants under the windscreen protected area starts rotting.

Moreover, the water supply within the plant may determine cell size. If for a certain period of time the in-coming of water is greater than the out-going, the water pressure within the plant increases and the cells just back of the growing points are elongated. The increasing supplies of water may result in growth cracks. Furthermore, a great amount of excessive moisture in the soil may inhibit the growth of roots due to absence of oxygen in the soil.

The author therefore strongly recommends to take caution before establishing shelter-belts or windbreaks for especially increasing the yield of crops in the regions with an extreme wet climate. As a matter of fact, in the countries with a wet climate and with low temperatures little practical value may be expected from a programme for the establishment of such windscreens. But it is to be added that the different crops react to the accumulation of moisture in different way from each other. Certain crops are extremely sensitive and are damaged greatly, while others are perhaps less sensitive, hence are not damaged badly. The relation of the climate and the influence of windscreens on the yield of the different crops have to be investigated for each case and for each crop before the windscreens establishment programme is carried out.

TABLE 1. Rainfall in Zeeland during the growing season of 1960<sup>1</sup>

Month	Time period	Total quantity of rainfall mm	Number of hours rainfall	Thunder and lightning
May	First 10 days	1	1	—
	Second 10 days	29	17	1
	Last 11 days	28	15	—
	Total of month	57	33	1
	Av. of last 30 years	49	—	4
June	First 10 days	10	11	—
	Second 10 days	13	4	1
	Last 10 days	6	4	—
	Total of month	29	20	1
	Av. of last 30 years	52	—	5
July	First 10 days	24	21	—
	Second 10 days	21	7	—
	Last 11 days	36	22	3
	Total of month	81	50	3
	Av. of last 30 years	66	—	4
Aug.	First 10 days	15	15	1
	Second 10 days	66	28	—
	Last 11 days	44	10	—
	Total of month	125	53	1
	Av. of last 30 years	63	—	5
Sept.	First 10 days	38	10	—
	Second 10 days	17	27	—
	Last 10 days	59	27	—
	Total of month	114	64	—
	Av. of last 30 years	74	—	3

<sup>1</sup> Sources of TABLES 1—3: Royal Netherlands Meteorological Institute at De Bilt.

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FIG. 1. The development of the number of bean pods under the protection of the artificial windscreen at Bruinisse (Zeeland)

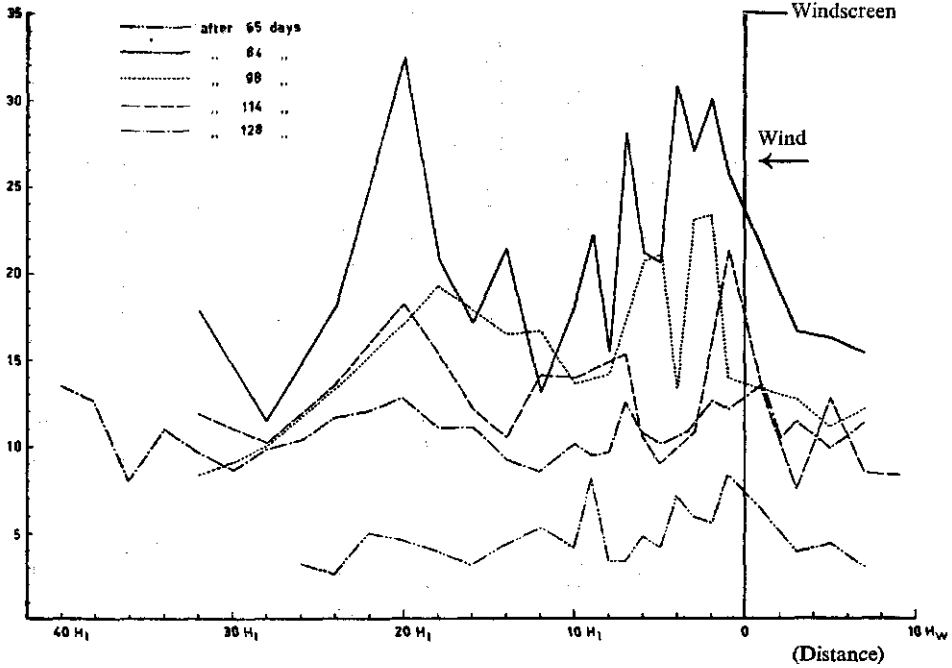


FIG. 2. Winds during the growing season of 1960 in Zeeland. Their procentual distribution is indicated by the width of marks, and their medium velocity by the length (up to outer rim of compass-cards = 5 m/sec)

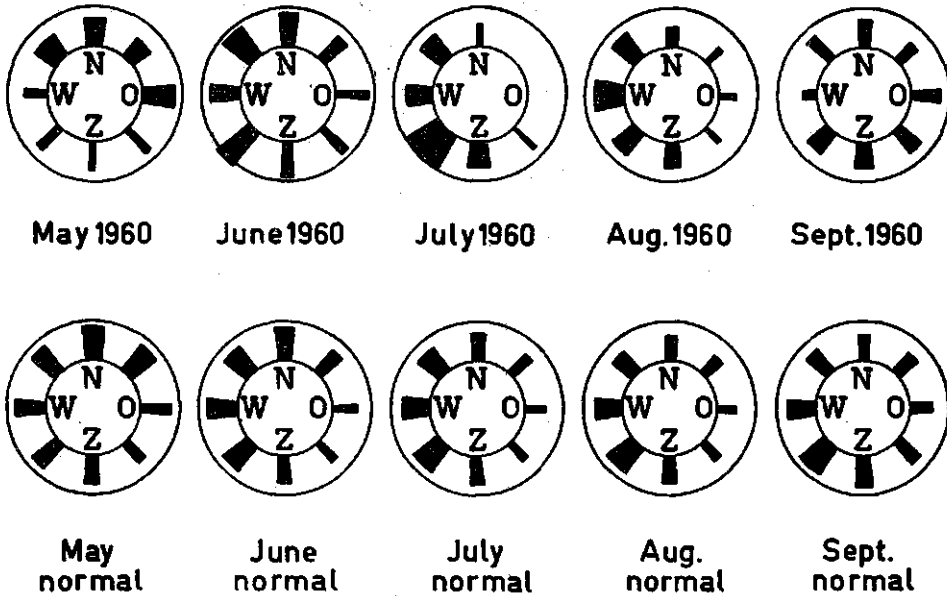


TABLE 2. Wind conditions in Zeeland during the growing season of 1960

Month	Time period	North		North-		East		South-		South-		West		North-		No wind		
		%	V	%	V	%	V	%	V	%	V	%	V	%	V			
May	First 10 days	23	4	23	4	16	5	4	5	4	3	3	3	11	4	10	3	7
	Second 10 days	20	4	30	4	20	6	5	4	4	3	3	3	11	4	7	3	—
	Last 11 days	34	5	12	4	2	3	5	3	4	3	8	4	12	5	14	4	6
	Av. of month	25	4	21	4	12	5	5	4	6	3	5	3	11	4	10	4	5
	Av. of last 30 years	17	4	17	5	11	4	6	3	9	5	14	5	16	5	10	4	1
June	First 10 days	12	5	15	4	17	4	6	4	8	7	19	9	20	7	3	5	—
	Second 10 days	13	6	2	5	1	3	1	2	7	5	39	8	31	7	4	3	0
	Last 10 days	33	6	10	4	9	5	3	3	—	—	1	6	14	6	32	6	0
	Av. of month	19	6	9	5	9	5	3	4	5	6	20	8	22	7	13	6	0
	Av. of last 30 years	14	4	11	4	7	3	4	3	7	5	16	6	26	6	15	4	1
July	First 10 days	6	5	—	—	—	—	5	5	11	5	35	9	20	7	23	5	—
	Second 10 days	3	5	—	—	—	—	3	6	18	8	49	8	25	7	3	5	—
	Last 11 days	6	3	4	2	1	2	—	—	6	6	31	6	37	6	14	4	2
	Av. of month	5	4	1	2	0	2	2	5	11	7	38	8	28	6	13	4	1
	Av. of last 30 years	9	3	9	3	7	3	5	3	5	5	20	6	28	6	13	4	0
Aug.	First 10 days	18	4	10	3	3	3	2	3	5	5	26	5	18	5	18	3	1
	Second 10 days	11	5	13	3	4	3	4	4	8	5	27	7	20	7	12	6	—
	Last 11 days	2	2	3	3	6	3	10	4	15	5	26	7	28	7	9	5	2
	Av. of month	10	4	8	3	4	3	5	4	9	5	22	7	22	7	13	4	1
	Av. of last 30 years	10	3	9	4	8	3	5	3	11	5	24	6	24	6	11	4	1
Sept.	First 10 days	8	3	4	2	3	3	3	3	8	4	33	7	18	6	18	4	6
	Second 10 days	10	4	8	4	20	5	24	5	10	5	5	5	3	9	6	8	0
	Last 10 days	12	3	27	4	27	6	4	5	9	5	8	5	5	10	7	10	1
	Av. of month	10	4	13	4	16	5	12	5	12	5	15	6	9	7	10	6	
	Av. of last 30 years	9	3	11	3	10	3	6	3	16	6	18	6	19	6	10	4	2

% = Number of hours in percentages; V = Average velocity in m/sec.

TABLE 3. Temperatures (in °C) in Zeeland during the growing season of 1960

Month	Time period	Average 24 hours	Average daytime	Average daily max.	Average daily min.
May	First 10 days	12,5	14,1	17,4	8,1
	Second 10 days	13,6	14,2	17,2	10,9
	Last 11 days	12,8	13,6	15,6	10,6
	Av. of month	13,0	14,0	16,7	9,9
	Av. of last 30 years	12,0	13,0	15,9	8,9
June	First 10 days	16,3	17,5	20,5	12,8
	Second 10 days	15,6	16,7	19,3	12,7
	Last 10 days	15,8	16,7	19,4	13,4
	Av. of month	15,9	17,0	19,7	12,9
	Av. of last 30 years	15,0	16,1	18,7	12,0
July	First 10 days	15,2	16,0	17,8	13,0
	Second 10 days	16,1	17,2	18,9	13,7
	Last 11 days	16,4	17,2	18,9	14,3
	Av. of month	15,9	16,8	18,5	13,7
	Av. of last 30 years	17,2	18,2	20,9	14,3
Aug.	First 10 days	17,0	18,0	20,6	13,9
	Second 10 days	15,5	16,1	18,3	13,2
	Last 11 days	17,6	18,3	20,7	15,6
	Av. of month	16,7	17,5	19,9	14,3
	Av. of last 30 years	17,3	18,2	20,8	14,4
Sept.	First 10 days	15,5	15,9	18,1	13,5
	Second 10 days	16,2	16,9	19,6	14,0
	Last 10 days	12,8	13,3	15,7	10,1
	Av. of month	14,8	15,4	17,8	12,6
	Av. of last 30 years	15,3	15,9	18,5	12,8

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Samenvatting

*De invloed van overdadige regenval op de beschuttingswaarde van windsingels voor landbouwgewassen*

Het onderzoek ter bepaling van de invloed van windsingels op de ontwikkeling en oogst van bruine bonen (*Phaseolus vulgaris*) werd uitgevoerd met behulp van een kunstmatig windscherm. Hierbij bleek:

1. In de eerste maanden was de groei van het gewas beter op het beschermde dan op het onbeschermde veld.
2. Op het beschermde veld bereikte het aantal peulen in de loop van de maanden mei, juni en juli — toen de regenval normaal was voor het Nederlandse klimaat — een kwantitatieve voorsprong van 60 %.
3. Daarna nam de voorsprong af omdat door abnormaal zware regenval het windscherm een negatieve invloed op het gewas uitoefende. Waterovermaat deed ziekten ontstaan, die peulen en andere plantedelen te gronde richtten. Bij gevolg ging geheel de aanvankelijke voorsprong verloren. In het vrije veld daarentegen droogde de grond snel genoeg op, waardoor het verlies zeer gering bleef.

4. Voor gebieden waar kans op veel neerslag bestaat, is dan ook grondig overleg geboden alvorens men tot aanleg van windsingels besluit.
5. Gewassen die weinig of geen schade van een gedurende korte tijd vallende overmatige neerslag ondervinden, zijn met windbeschutting gebaat.

### Résumé

#### *Influence de pluies excessives sur la valeur protectrice des rideaux d'arbres pour la récolte des plantes agricoles*

La recherche pour déterminer l'influence des rideaux d'arbres sur le développement et la récolte des haricots bruns (*Phaseolus vulgaris*) a été exécutée à l'aide d'un paravent. D'après ceci il en résulte :

1. Dans les premiers mois la croissance des légumineuses protégées contre le vent fut meilleure que dans le champ non protégé.
2. Dans le champ protégé, dans les mois de mai, juin et juillet, le nombre de gousses des haricots atteignit une augmentation de 60 % comparé au nombre de gousses des plantes sur le champ témoin, lorsque les précipitations avaient un cours normal pour les Pays-Bas.
3. Après cette période l'avance diminua, ceci à la suite de très grandes pluies. Le paravent à ce moment avait une influence négative. On considéra que dans le champ protégé la quantité excessive des pluies amena des maladies, qui détruisaient aussi bien un certain nombre de gousses que d'autres parties de la plante. C'est pour cette raison que l'augmentation constatée au début s'évanouit vers le fin. Dans le champ non protégé le terrain put sécher plus rapidement et par conséquent les pertes furent minimales.
4. Dans des régions où l'on peut attendre de grandes pluies, il faut très prudemment tenir conseil avant de planter des rideaux d'arbres ayant pour but l'augmentation de la récolte.
5. Pour les cultures qui peuvent supporter un excès d'humidité pendant une période de courte durée et dont il est démontré qu'elles ne subissent peu de ou même aucune perte, on peut recommander la plantation de rideaux d'arbres.

### Zusammenfassung

#### *Der Einfluss von heftigen Regenfällen auf den Schutzwert von Windschutzstreifen in Verbindung mit der Ertragsleistung der Kulturen*

Diese Untersuchungen zur Bestimmung des Einflusses von Windschutzstreifen auf die Entwicklung und Ernte von braunen Bohnen (*Phaseolus vulgaris*) sind mit künstlichen Windschirmen ausgeführt worden. Das Folgende zeigte sich :

1. In den ersten Monaten war der Pflanzenwuchs im geschützten Gebiet besser als im ungeschützten.
2. Die Anzahl der Schoten in der geschützten Zone erreichte, bei Regenfällen die für das niederländische Klima normal waren, im Laufe der Monate Mai, Juni und Juli einen Vorsprung von 60 %.
3. Zuzufolge abnormal schwerer Niederschläge bekam der Windschirm einen negativen Einfluss, sodass der Vorsprung abnahm. Durch starke Erhöhung der Bodenfeuchtigkeit traten Krankheiten ein, welche die Schoten und andere Pflanzenteile beschädigten, weshalb der anfängliche Vorsprung gänzlich verschwand. Hingegen waren im ungeschützten Gebiet die Verluste sehr gering.
4. Deshalb sei in Gegenden wo manchmal viel Niederschläge zu erwarten sind, grosse Vorsicht geboten bevor man sich zu der Anlage von Windschutzstreifen entschliesst.
5. Beim Anbau von Gewächsen die von einem kurz andauernden Übermass an Feuchte wenig oder keinen Schaden erleiden, sind Windschutzstreifen zu empfehlen.