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EFFECT OF FERTILIZER APPLICATION ON DIVERSITY AND PRODUCTION OF WEEDS IN CROP-LESS FIELDS

By

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تأثير التسميد على تنوع وانتاجية الأعشاب الضارة في حقول خالية من المحاصيل

كمال حسين شلتوت و بن بوست

تهدف هذه الدراسة إلى تقييم تأثير التسميد (النتروجين ، الفوسفور ، البوتاسيوم والكالسيوم) على تنوع وانتاجية الأعشاب الضارة في حقول خالية من المحاصيل . وقد أظهرت الدراسة تأثر انتاجية هذه الأعشاب تأثراً كبيراً بالتسميد وخاصة النتروجين . وقد تميز الغطاء النباتي بعد الحرث في الخريف بالتنوع المنخفض والسيادة الكبيرة لنبات أبيرا سبيكا فنتي ، غير أن هناك اتجاة نحو زيادة التنوع ونقص السيادة عند المعاملة المشتملة على كل العناصر . وقد نوقش التداخل بين النبات السائد (أبيرا سبيكا فنتي) من جهة والنباتات ذات التواجد المتكرر (ماتريكاريا ركيوتيتا ، بوا أنيوا) من جهة أخرى على ضوء قابلية التنافس بينهم .

Key Words: Apera spica-venti, Competition, Diversity, Fertilizers, Weed production.

ABSTRACT

The present study aims at assessing the effect of fertilizer application (with monofactorial deficiency of nitrogen, phosphorus, potassium and lime) on the diversity and production of weeds in cultivated but crop-less fields. The biomass production of the weeds is highly affected by the nutrient application, particularly that of nitrogen. The weed vegetation after cultivation in autumn is characterized by a low species diversity and strong dominance of *Apera spica-venti.* However, there is an affinity for increasing species diversity and decreasing dominance in the treatment with full added nutrients. The dynamics of interaction between the dominant species *(Apera spica-venti)* with other frequent species *(Matricaria recutita* and *Poa annua)* is discussed in the view of their competitive abilities.

INTRODUCTION

Arable weeds have been the subject of much research, largely directed towards the discovery of methods for their elimination from the crops (Backer, 1974). The economic appraisal of a weed vegetation in relation to its interference with crop production is depending, among other factors, on the floristic composition of this vegetation (Post, 1986). Thus it would be of great help for the advisory of weed control measures if this composition and other characteristics of the weed vegetation such as biomass production and overall competitive ability could be forecasted.

Some previous works were oriented to study certain topics related to the ecology and biology of weeds such as phenology (e.g. Morillo and Munoz, 1984, Shaltout and El-Fahar ,1991), the effect of different fertilizer levels on the production and composition of weed species (e.g. Hoveland *et al.,* 1976, Mahn 1984, Streibig *et al.,* 1984, Mohler and Liebman, 1987), and the ability to compete with the crops (e.g. Gustavsson, 1986).

The present study is part of a multidisciplinary research project conducted by the Agricultural University at Wageningen (The Netherlands) for constructing an advisory model for weed control management. It aims at assessing the effect of fertilizer application (nitrogen, phosphorus, potassium and lime) on the diversity and production of weeds under arable field conditions without competition of a crop and without weed control.

MATERIALS AND METHODS

For studying the effect of nutrient application on the weed diversity and production, two blocks, each of 6 plots were cultivated on 10 October 1986 with a tractor mounted rotary cultivator. After that, the soil has been compressed with a roller of a seeding machine, and seedbed has been prepared with a hand rotary cultivator. The area of each plot was 2 x 2 m. The nutrient components tested were nitrogen (N), phosphorus (P), potassium (K), and lime (Ca). The fertilizer was added to the soil before seedbed preparation in standard dosages following standard advisory practices after chemical analysis of soil nutrient status related to a crop rotation with 25% winter cereals, 25% spring cereals, and 50% root crops. The distribution of these elements in the first block was as follows:

Plot No.	Added Elements	Lacked Element
1	N, K, Ca	P
2	P, K, Ca	N
3	N, P, K	Ca
4	N, P, Ca	K
5	-	N, P, K, Ca
6	N, P, K, Ca	-

The second block was considered as a replicate for the first one.

The sampling process of the weed seedlings started just after beginning of spring germination in April 1987. The delay of the sampling until that time was due to an abnormal cold spring season. In each plot, 2 small quadrats, each of an area of 20 x 20 cm, were laid down randomly using random subdivision numbers. The weeds present in each quadrat were counted, clipped and brought to the laboratory to obtain the biomass of each weed species in a quadrat and per individual (based on oven dry weights after 16 hours at 70°C). The sampling process was carried out five successive times (I-V in tables and figures), with about fortnightly intervals until the end of the growing season in July 1987.

Species richness was calculated as the average number of species per quadrat. Relative evenness was calculated following Sahnnon-Weaver index, $H' = \sum_{i=1}^{s} Pi \log Pi$, and relative concentration of dominance was calculated using Simpson index, $C = \sum_{i=1}^{s} Pi^2$, where s is the number of species and Pi is the importance value of the ith species, (Whittaker 1972, Pielou, 1975). Simple linear regression and correlation coefficients were calculated to depict the relation between time of harvest and the relative contribution to the total biomass, density, and individual weight of the common and other weed species.

RESULTS

The total number of weed species recorded in the present study is 20 (Table 1). *Apera spica-venti* is considered the most frequent species in all the six treatments. *Matricaria recutita* and *Poa annua* are the next important species. The lowest number of weed species is recorded in the non-fertilized treatment (12 species), and the highest is recorded in PKCa and NPCa treatments (17 species), The non-fertilized treatment as well as the PKCa treatment (lack of N) have much lower weed biomass as compared with the other treatments. The decrease of the total weed biomass as well as the biomass of *Apera spica-venti* in relation to nutrient deficiency can be arranged in the following sequence: NPKCa ⟶ NPK ⟶ NPCa ⟶ NKCa ⟶ and ⟶ PKCa. While the biomass of *Apera spica-venti* has more or less a continuous increase till the end of the season, the biomass of all the other species reached their maximum values earlier (particularly *Poa annua*), and dropped dramatically just after their reproductive stages (Fig. 1).

Table 1
Duration of the weed species occurrence in the different treatments expressed as percentage of the period of observation (April-July 1987).

Species	Treatment						Presence in the six treatments
	NKCa	PKCa	NPK	NPCa	____	NPKCa	
Apera spica-venti	100	100	100	100	100	100	6
Matricaria recutita	100	100	100	100	100	100	6
Poa annua	100	100	100	100	100	100	6
Juncus bufonius	90	80	90	90	90	90	6
Polygonum aviculare	100	90	80	90	80	70	6
Capsella bursa-pastoris	60	70	40	40	30	50	6
Polygonum persicaria	50	70	50	50	30	30	6
Veronica arvensis	40	50	10	20	40	20	6
Stellaria media	20	40	20	0	10	10	5
Trifolium repens	10	20	0	10	0	0	3
Spergula arvensis	70	10	70	60	20	80	6
Viola arvensis	50	30	60	60	30	50	6
Ranunculus repens	20	0	20	30	10	20	5
Chenopodium album	20	10	10	10	0	20	5
Polygonum convolvulus	20	10	0	20	0	20	4
Vicia sativa	0	10	20	10	0	10	4
Polygonum lapthifolium	0	10	20	10	0	10	4
Rorippa palustris	0	0	0	10	0	0	1
Arabidopsis thaliana	10	0	0	0	0	0	1
Erigeron canadensis	0	10	0	0	0	0	1
Total number of species	16	17	15	17	12	16	

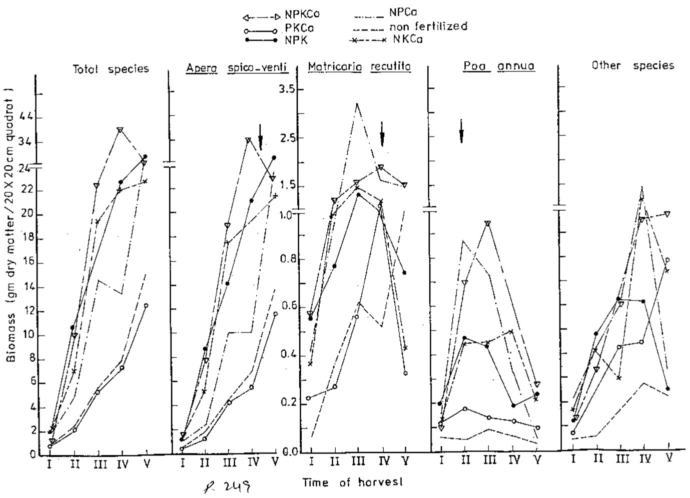

Fig. 1: Dynamics of weed production in relation to time of harvest and nutrient application. the arrows over the curves represent the time of the active reproductive stage (flowering and fruiting) for the corresponding species.

The variation in the weed species richness in relation to harvest time and treatment indicates that there is a gradual increase in the number of species for all treatments till reaching a maximum at harvest III. After that there is a decrease till the end of the season (Table 2). The lowest species richness by the end of the season is that of non-fertilized and PKCa treatments (6 species/quadrat). The PKCa treatment has the lowest value of H' (0.19) and a high value of C (0.92). The highest H' value (0.30) and the lowest C value (0.84) at that time are those of the NPKCa treatment. This is associated with a high species richness (8 species/quadrat).

The dominant species, *Apera spica-venti,* started with relative contribution to the total biomass ranging between 43% to 77% and ended with range of 90-96%. This progressive increase in the dominance of *Apera spica-venti* is associated with a decrease in *Matricaria recutita, Poa annua* and the other weed species (Fig. 2). This relationship is quite clear after calculating the correlation coefficients between the time of harvest and the relative contribution of these species. While r values are significantly positive regarding *A. spica-venti,* they are significantly negative regarding other species (Table 3). The rate of increase in the relative contribution of *A. spica-venti* is lowest at the non-fertilized treatment (m = 0.18) which associated with the lowest rate of decrease of *Matricaria recutita* (m = -0.07) and the next lowest rate of decrease of *Poa annua* (m = -0.16). On the other hand the highest rate of increase of *A. spica-venti* is observed in the PKCa treatment which associated with the highest rate of decrease of *Poa annua* and the next highest rate of decrease of *Matricaria recutita.*

There is a gradual increase in the average individual weight of *Apera spica-venti* and *Matricaria recutita* for all treatments. This increase has a significantly positive correlation with the time of harvest and associated in some cases (NPK and non-fertilized treatments) with significantly negative correlation between the time of harvest and the density. The general trend of change of both characters in relation to time of harvest regarding *Poa annua* is an associated increase followed by an associated decrease till the end of the season for many of the treatments (Fig. 3).

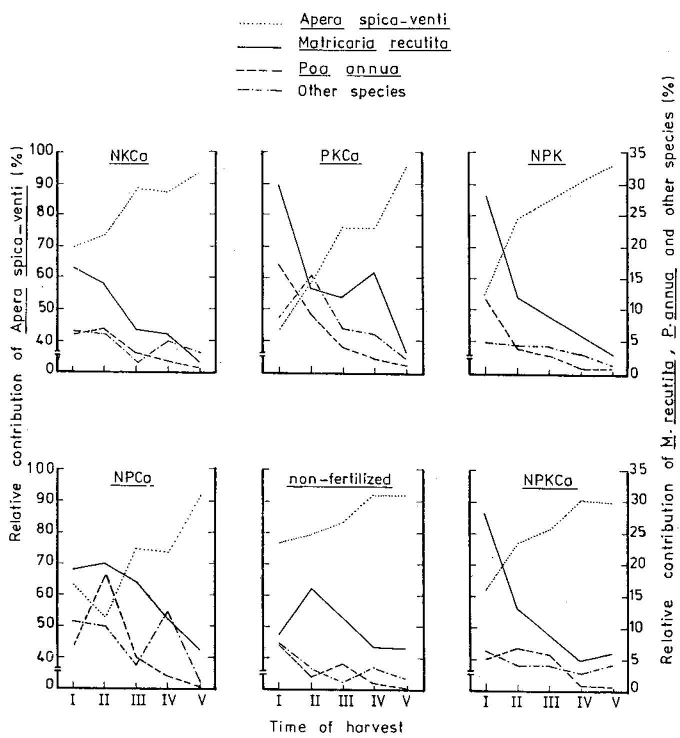

Fig. 2: Relative contribution of the common and other weed species to the total weed production in relation to time of harvest and nutrient application.

DISCUSSION

The present study indicates that the production of weed vegetation is highly affected by the nutrient application. The most obvious effect is that of the deficiency of nitrogen. The reduction in the biomass of the dominant species, *Apera spica-venti,* and consequently the total biomass, due to lack of nitrogen in comparable to the reduction due to the lack of all the tested elements (P, K and lime). The growth of this species as a result of nitrogen fertilizer is also depicted by Svensson and Wigern (1982) and Ferrari *et al.,* (1984). The role of fertilizers, especially that of N- fertilizers, seems uncompletely known regarding the weed vegetation (Mahn, 1984). Some more detailed studies have been dedicated to this question. According to the study of Fawcett and Slife (1978), the enhancement of the growth of the weed vegetation as a result of nitrogen application in the seedbed may be due to improving the seed viability and germinability of weeds. With regard to the role of phosphorus and potassium, Hoveland *et al.,* (1976) have mentioned that, weeds are generally more sensitive to low soil P than K. This is in agreement with the present study as the reduction in the weed biomass due to lack of P is higher than that of K. Phosphorus is quite often a limiting plant nutrient and may have some explanatory value (Streibig *et al.,* 1984).

Table 2
Variation in the species richness (S), relative evenness (H') and relative concentration of dominance (C) for the weed vegetation in relation to time of harvest and nutrient application. The values of S are approximated to the nearest one.

Harvest	Treatment																	
	NKCa			PKCa			NPK			NPCa			-			NPKCa		
	S	H'	C	S	H'	C	S	H'	C	S	H'	C	S	H'	C	S	H'	C
0	5	-	-	4	-		4	-		4	-	-	5	-	-	5	-	-
I	9	0.54	0.54	6	0.60	0.36	7	0.53	0.44	8	0.59	0.40	6	0.41	0.60	8	0.50	0.52
II	9	0.48	0.60	8	0.64	0.41	8	0.42	0.67	8	0.61	0.38	7	0.35	0.68	7	0.37	0.63
III	8	0.30	0.82	11	0.51	0.64	9	0.38	0.76	10	0.45	0.64	7	0.34	0.73	9	0.31	0.70
IV	9	0.34	0.79	9	0.45	0.63	8	0.28	0.86	9	0.50	0.60	7	0.29	0.82	9	0.29	0.85
V	9	0.25	0.91	6	0.19	0.92	7	0.19	0.94	7	0.22	0.88	6	0.23	0.86	8	0.30	0.84

Table 3
Simple linear regression (m) and correlation (r) coefficients between the time of hargvest and the relative contribution of the common and other
* : P ≤ 0.05, ** : P ≤ 0.01, *** : P ≤ 0.001

Species	Treatment					
	NKCa	PKCa	NPK	NPCa	-	NPKCa
Apera spica-venti	m 0.28	0.49	0.41	0.33	0.18	0.29
	r 0.094**	0.97***	0.96**	0.89*	0.97***	0.93**
Matricaria recutita	m -0.22	-0.27	-0.30	-0.17	-0.07	-0.25
	r -0.98***	-0.86*	0.95**	-0.93**	-0.54	-0.90*
Poa annua	m -0.14	-0.28	-0.20	-0.25	-0.16	-0.12
	r -0.94**	-0.98***	-0.91*	-0.82*	-0.88*	-0.79
Other species	m -0.07	-0.19	-0.11	-0.14	-0.09	-0.04
	r -0.61	-0.76	-0.93	-0.65	-0.66	-0.71

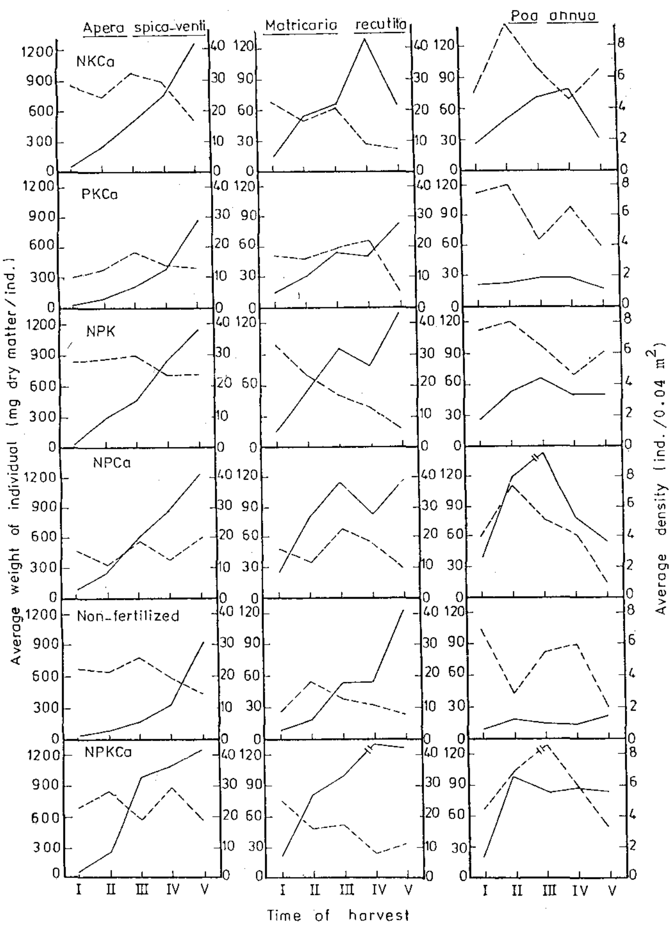

Fig. 3: Relationship between the average individual weight and the density of the common weeds in relation to time of harvest and nutrient application.

Species diversity is of theoretical interest for communities and ecosystems (Whittaker 1972, Pielou, 1975). Generally, the present study indicates that the weed vegetation after different nutrient treatments is characterized at the end of the season by a low diversity (a low species richness and relative evenness, a high relative concentration of dominance). The lack of a certain nutrient also affects the diversity of weed communities. This is quite clear in the present study comparing the value of diversity indices that characterized the weed vegetation of the non-fertilized and PKCa (lack of N) plots with that of full added nutrients (NPKCa).

The strong dominance of some species in a certain community may confirm the hypothesis of niche-pre-emption which is often invoked in plant communities to explain low diversity (Whittaker, 1972). Similar conclusion regarding weed communities in Taiwan have been reported by Oka et Liu (1984). This may be a result of the extravagance of herbicide application which often leads to eradication of sensitive species. The resistant species will then be able to increase densities (Holzner 1978, Mahn, 1984). The strong dominance of *Apera spica-venti* may be interpreted in the view that many weeds have evolved in competitive systems that permit monospecific communities that are extremely stable in a changing environment (Young and Evans, 1976). Such weed may occupy, in the absence of the crop, the niche of that crop. But in the presence of the crop this behaviour may be changed as the crop rapidly occupies space in the community (as a result of subsidized energy by man: fertilizer application, weed control, etc.), thereby slowing the growth of the weeds, even though the weeds and the crops germinated synchronously (Mohler and Liebman, 1987).

Apera spica-venti, in the present study, seems to be the best competitor as compared with its associates. It has an increase in the relative contribution to the total biomass, in relation to time of harvest, associated with a decrease in the same variable regarding the other species. This may be related to an early vigorous start in seedling growth, large seed reserves (Holzner *et al.,* 1982), a vigorous and early root systems, foliage produced earlier and higher than that of neighbours. The success of any species depends on such attributes (Harper, 1977). On the other hand, *Poa annua* had a reduced growth and finished its life cycle, giving seeds, within few weeks as compared with its normal life cycle that extends over several months till august (Sprague and Burton, 1937). This precocious reproduction may be a fitter strategy in order to avoid more vigorous neighbours (e.g. *Apera spica-venti).* Similar behaviour regarding *Poa annua* is reported by Harper (1977).

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