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Brian Benson**

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EDITORIAL

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This is the first Internet publication of the Asparagus Research Newsletter. The decision To make the Asparagus Research Newsletter (ARN) available over the Internet was made to provide the information contained in this publication to a greater number of interested people than previously via the hard copy publication of the ARN. The ARN is provided without cost to those that wish to download the publication. The main focus of the ARN is and has been to provide a medium for the exchange and extension of asparagus research information throughout the world.

The contents of the Asparagus Research Newsletter is dependent upon the contributions of papers from research and industry personnel. The number of contributions in past editions have ranged from as few as 2 to as many as 16. I would like to encourage you to continue your submission of papers for future editions. I will accept: (1) finished research papers, (2) updates on current research projects or programs, (3) reports on asparagus industries, (4) announcements of meetings and symposiums and (5) other topics that are of interest to the international asparagus industries and researchers.

Contributions of papers, etc. should be sent to me by E-Mail and also as a hard copy and on a floppy disc by mail to the above address. The format of the research papers should follow the protocol used in major research journals. The official language will be English.

Brian Benson

**10th International Asparagus Symposium
Niigata University, Niigata City, Japan**

The 10th International Asparagus Symposium will be held from August 30 to September 2, 2001 at Niigata University in Niigata City, Japan under the auspices of the International Society for Horticultural Science and the Japanese Society for Horticultural Science. It will provide a good opportunity for world scientist and technologists to present or display their up-to date research papers and exchange their ideas on all aspects of asparagus science, technology and marketing. The scientific program will include invited lectures, voluntary oral and poster presentations. The official language of the symposium will be English.

The topics addressed in the symposium will be 1) Physiology of growth and development, 2) Cultural technology and systems, 3) Genetics and breeding, 4) Biotechnology, 5) Functional effects for human health, 6) Plant protection, 7) Marketing and 8) Others.

The Abstracts book and ACTA Horticulturae proceedings of this symposium will be published. A one-day professional field tour and symposium banquet will be arranged for the participants. For accompanying persons, sight-seeing tours are planned. Accommodations will be prepared in Niigata City. Niigata City is situated in the middle of Honshu Island and along the Japan Sea. It can be reached in 2 hours by a bullet train from JR Tokyo Station which is connected with Narita International Airport by limousine or train (1 hour).

In addition, a pre-symposium tour (August 27-29, Tokyo-Nagano-Niigata) and a post-symposium tour (September 3-5, Niigata-westernJapan) will be arranged.

For details please contact the symposium convener:

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SUBSCRIPTIONS AND ARTICLE CONTRIBUTIONS

There will be no subscription fees for the Asparagus Research Newsletter .

The contributions should be sent to me by E-Mail and also as a hard copy and as a file or files on a floppy disc so that I can edit the text and tables to prepare a uniform presentation in the following edition.

Send Article Contributions to:

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ASPARAGUS CULTIVAR EVALUATION AFTER FOUR YEARS OF HARVEST

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Abstract

Under Dutch conditions the best results in green spear production are obtained with local varieties. Gijnlim produced the highest yield combined with a good quality.

Introduction

Green asparagus has been introduced in the Netherlands in the 1980's. Traditionally white asparagus is grown, but mainly on sandy soils. Whereas green asparagus is grown on clay soils. The choice of a suitable variety is very important because asparagus is grown for ten years or more. In the Netherlands the cultivars available were developed especially for white spear production. Knowledge on the suitability of these cultivars for green spear production was scarce but necessary. Therefore in 1991 field trials were started to compare twelve asparagus cultivars under Dutch circumstances. The aim of this study was to elucidate whether green spear production required different varieties than are used for white spear production. A suitable cultivar should combine a good quality and a high yield.

Materials and Methods

Two field trials were established in Colijnsplaat and Zwaagdijk in 1991. Details on the experiment are given in table 1. The experiments were carried out with 12 cultivars in a randomised block design.

Table 1. Technical data on the field experiments at Colijnsplaat and Zwaagdijk.

Treatments	location	
	Colijnsplaat	Zwaagdijk
Soil type	loamy clay	clay
fraction smaller than 0.061 mm	31	22
pH	7.4	6.8
organic matter content %	1.5	6.0
previous crop	smooth stalked meadow grass	courgette
number of replicates	4	3
sowing date	5 April 1991	5 April 1991
planting date	4 June 1991	5 June 1991
plant distance	1.50 * 0.2 m	1.50 * 0.2 m
plot size	1.50 * 8 m	1.50 * 7 m
harvest period 1992	none	4 May - 15 May
harvest period 1993	20 April - 19 May	1 May - 19 May
harvest period 1994	1 May - 24 June	13 May - 19 June
harvest period 1995	4 May - 21 June	28 April - 24 June
harvest period 1996	1 May - 21 June	7 May - 21 June

Asparagus was grown under normal agricultural practise as described by Poll (1992). Asparagus spears were harvested daily. The period of harvesting ranged from the end of April until the 24th of June (table 1). Spears were graded into three classes (1, 2, and 3). Class number 1 was subdivided into grades depending upon the diameter of the spear:

Table 2. Grades of asparagus spears.

Grade	spear diameter
AA	> 20 mm
A	16-20
B	12-16
C	10-12

The harvested spears were counted and weighed per class. The number of open headed and bend spears was established also. The mean total spear weight and the mean spear weight in class 1 were calculated. The percentage of spears in classes 1, 2 and 3 was calculated based upon weight of the harvested spears. The percentage of open spear heads and bend spears was calculated.

Spear quality was determined two times per season on both locations, except in 1993 when quality of the spears was observed once. The total spear harvest of approximately one week was judged by a committee of people. This committee was formed by people from breeding stations, farmers and researchers. Judgements were made on spear tightness, homogeneity of the spears, the bending of the spears, the surface roughness and the colour. A mark between 1 and 9 was given for each quality characteristic. A higher rating was given when the cultivar was better on the given characteristic.

Statistics

Data on yield, spear weight, percentage of spears in different classes were analysed by analysis of variance (ANOVA). For each year the mean of the quality ratings was calculated. ANOVA was conducted on the means of the quality characteristics over the years and locations.

Results

The yield of the cultivars tested was relatively stable at Colijnsplaat (figure 1) during 1994 until 1996. At Zwaagdijk spear yield increased every year (figure 2). A tendency was found that in the Northern part of the Netherlands problems with open spears were less severe. In 1996 *Stemphylium* was found on the harvested spears. The fungus was found during a cool period after some rainfall.

Discussion

Five years after planting the first results are presented. It should be pointed out that the growing of asparagus might extent 5 more years or even longer. No data on productivity under Dutch circumstances are available yet.

The performance of Violetto d'Albenga as a green asparagus crop was poor. However Violetto is interesting because of its purple colour. A speciality market might be available for this variety. Known green asparagus cultivars disappointed in the trials in the Netherlands so far. Cultivars, usually grown for white spear production, yielded better in green spear production than Jersey Giant, Huchels Leistungs Auslese and Spaganiva. The results are in accordance with the results of Uragami and Nagai (1993) who also found that Gijnlim and Vulkan (Lucullus 234) gave better yields than Jersey Giant over a 4 year period. However, Mullen *et al.* (1993) found that Jersey Giant performed better than Gijnlim in field trials in California. These data indicate that the site on which asparagus is to be grown is decisive for the choice of the cultivar. In Germany farmers are advised to use Dutch and German cultivars because they are better suited to the local conditions (Paschold *et al.*, 1993).

From these preliminary results it is concluded that research will be continued on the cultivars Backlim, Calet, Horlim, Gijnlim, Thielim and Venlim. The other cultivars will not be tested in the forthcoming years mainly because of poor quality or low productivity. An economic evaluation will only be useful at the end of the experiments.

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Table 3. Mean yield, spear weight, percentage of spears per class, grading and quality aspects, observed at Colijnsplaat and Zwaagdijk.

Cultivar	yield		spear weight (g)		grading based on total weight (%)			grading based on spear weight of class 1 (%)				% open spears	% bending spears
	(t/ha)	relative	total	class 1	class 1	class 2	class 3	AA	A	B	C		
Backlim	6.0	114	30.9	34.5	72	21	7	9	39	42	11	8	10
Boonlim	4.8	85	27.4	30.4	63	28	9	4	31	49	16	14	10
Calet	6.0	111	15.9	21.1	56	13	31	0	2	39	58	5	3
Gijnlim	8.1	144	25.3	28.6	75	15	10	3	22	55	21	3	10
Horlim	5.9	109	25.8	29.1	72	17	10	4	22	53	21	6	9
Huchel	4.9	89	23.2	27.2	69	17	14	2	17	54	26	6	7
Jersey Giant	3.6	61	19.3	23.4	70	12	18	0	6	52	41	2	6
Vulkan	6.9	124	22.0	25.5	62	25	13	1	13	55	30	12	7
Spaganiva	4.8	86	20.5	24.9	69	14	18	1	13	52	34	5	5
Thielim	5.9	106	29.2	31.9	68	23	8	8	32	45	15	9	11
Venlim	6.7	124	29.3	32.9	70	22	8	6	33	49	12	7	11
Violetto	2.7	46	21.7	26.6	75	10	16	3	15	53	29	0	6
mean	5.5	100	24.2	28.0	68	18	14	3	20	50	26	6	8
lsd (=0.05)	0.8	15	2.0	1.9	3	3	3	3	5	5	6	2	2

Table 4. Mean rates for homogeneity of the spears, spear tightness, straightness and surface roughness given by the committee at Colijnsplaat and at Zwaagdijk in the years 1993 - 1996.

Cultivar	homogeneity of the spears	spear tightness	straightness of the spears	surface roughness	<i>Stemphylium</i> ^a i
Backlim	6.5	6.1	6.3	5.9	6.1
Boonlim	6.0	5.6	6.2	5.8	5.7
Calet	7.1	6.4	6.9	6.8	5.2
Gijnlim	6.8	6.7	6.7	6.5	6.8
Horlim	6.3	6.3	6.4	6.2	6.1
Huchel	5.7	5.9	6.3	6.0	5.4
Jersey Giant	6.5	6.8	6.5	6.3	5.0
Vulkan	6.5	5.3	6.5	6.0	5.4
Spaganiva	6.1	5.9	6.6	5.9	6.2
Thielim	6.2	5.9	6.2	5.9	5.7
Venlim	6.3	6.1	6.1	5.9	5.8
Violetto	5.7	7.6	6.4	7.0	7.1
mean	6.3	6.2	6.4	6.2	5.9
lsd (= 0.05)	0.3	0.3	0.3	0.2	0.8

a: *Stemphylium* was observed in 1996, at the first committee meeting at both locations. b: a higher rating means the variety performs better on the given characteristic

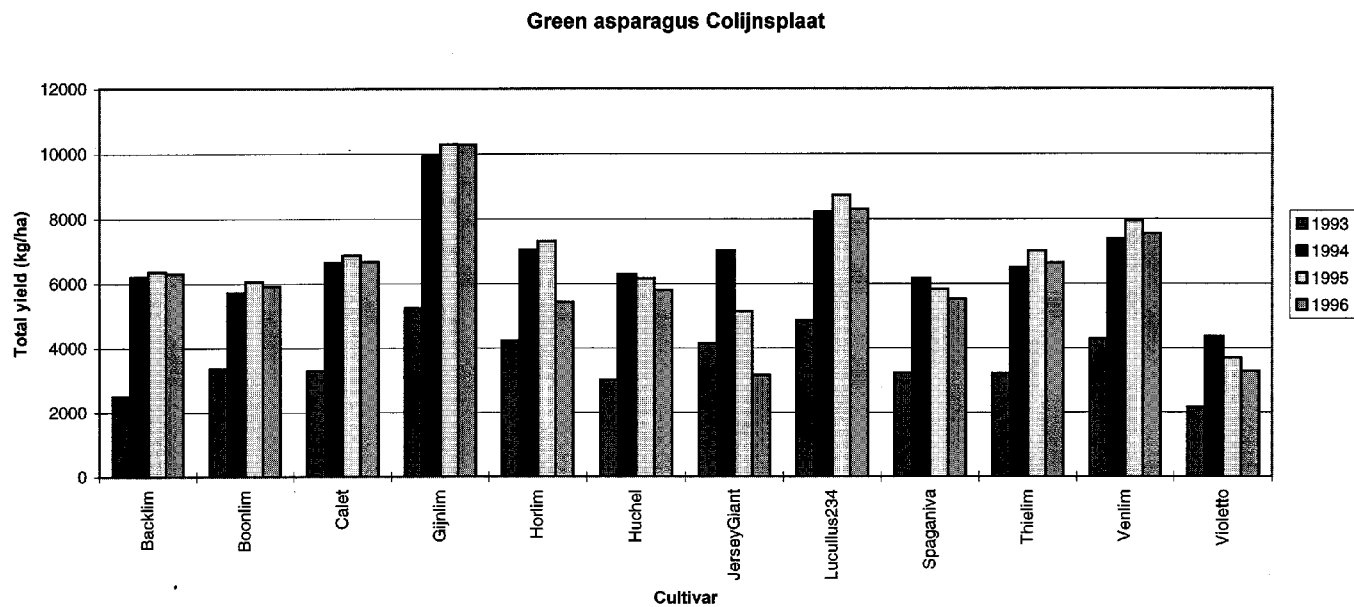


Figure 1. Yield off green aparagus in the years 1993 to 1996 at Colijnsplaat.

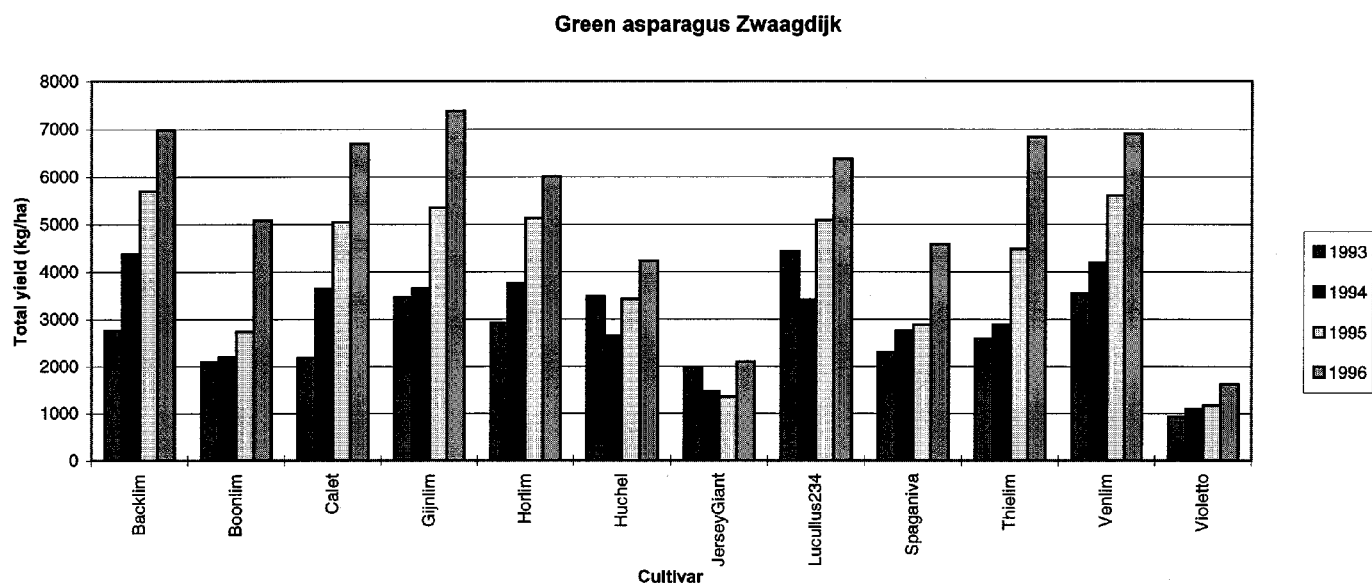


Figure 2. Yield of green asparagus in the years 1993 to 1996 at Zwaagdijk.

THE DEGREE OF GROWTH FOR GREEN SPEARS FOR THE HARVESTING AND GRADING STANDARDS FOR ASPARAGUS

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Abstract

This experiment studied the different 4 categories of the “degree of growth” of fresh green asparagus spears on the nutritional composition, specific gravity, weight loss, respiration rate and the incidence storage rot. The results show that the degree of growth of the spear is an important morphological characteristic for harvesting and grading fresh green asparagus spears. The 4 “degree of growth” categories described by the authors are useful for harvest criteria and post harvest storage and are based on scientifically measurable physiological and biochemical changes that occur during the growth of the spear.

Keywords

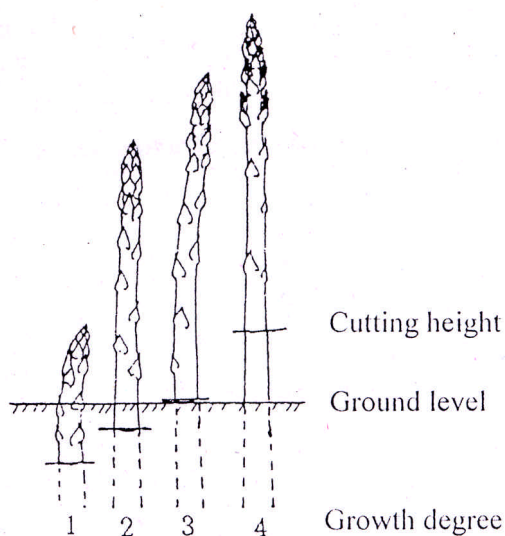
Fresh green asparagus, degree of growth, harvesting and grading standards

1. Introduction

It has been reported in both domestic and foreign literature that the grading of green asparagus is roughly described in categories such as: very tight heads, tight heads, loose heads, open heads, closed head with open foliage, etc. These descriptions are based on previous knowledge of spear grades are not easily utilized by growers, marketers or consumers. There are many examples of commercial advertising that mistakenly show loose headed asparagus as horticultural acceptable specimens. Therefore, it is important and necessary to make an appropriate, simple and easy method of characterizing the standards for grading fresh green asparagus spears for this industry and the consumers.

2. Materials and Methods

Mary Washington 500W and F₂ of UC 157 asparagus cultivar spears were used in this study. The spears were separated into 4 “degree of growth” categories (Fig. 1.) , as standards , depending on the morphological development of the spear. A spear with the “degree of growth 1” had a tight head with overlapping bud scales, a “degree of growth 2” spear had a tight head with bud scales slightly open (a small gap between each bud scale), a “degree of growth 3” spear’s head was elongating and a “grain-like” (florets) between the bud scales, and the “degree of growth 4” spear had an elongated head with branching appearing between the bud scales (the longest branch less than 1 cm)



The spears were harvested and graded into uniform spear diameters for each of the 4 “degree of growth” categories and then trimmed to a 10 cm length. Spear samples of each “degree of growth” category were analyzed for the effect of “degree of growth” on spear quality characteristics when stored under the following conditions: Exp. I, 1 kg of pre-cooled green spears were sealed in 0.03 mm polyethylene plastic bags and stored in a ventilated storage room at 8°C to 11°C ; Experiments II and III, 200 g of green spears were sealed in 0.015 mm polyethylene plastic bags and stored in a mechanically cooled room at a

temperature of $0^{\circ} \pm 1^{\circ}\text{C}$: Exp. IV, 200 g of green spears were sealed in 0.015 mm polyethylene plastic bags and stored in a ventilated room with a temperature of 16°C to 18°C.

Fig. 1. Degree of Growth Categories

2.1 Methods of analysis

The nutritional content of the spear were analyzed for dry matter, raw protein, raw ash, raw fat, carbohydrate, carotene, vitamin C and Fe (Huang, 1991). The specific gravity was determined by weight in grams divided by volume of water displaced at three times following harvest using 2 replications. Weight loss percentage was calculated after 8 hours at 23°C. Rate of respiration of the spears was measured on 3 replicates of 200 grams of spears using a gas-circulation method at 23° C. Spear rot was classified into 4 grades: Grade 0, no spear rot; Grade 1, rot area less than 0.5cm^2 ; Grade 2, rotted area between 0.5 to 2.0cm^2 ; Grade 3, rotted area between 2.0 to 4.0cm^2 and Grade 4, rotted area greater than 4cm^2 . The rot index was calculated as follows:

$$\text{Spear Rot Index} = \frac{\text{rot grade} \times \text{spear number in the rot grade}}{\text{number of spears}} \div 4$$

3. Results and Analysis

3.1 Analysis of nutrient composition of spears in “degree of growth” categories.

Water content and raw protein decreased as “degree of growth” increased. Dry matter, raw fat, carbohydrate, raw ash, carotene and vitamin C increased

Table 1. Nutritional analysis of green asparagus spears from 4 “degree of growth” categories

Degree of Growth	Water %	Dry Matter %	Raw Protein %	Raw Fat %	Carbo-hydrate %	Raw Ash %	Carotene mg/100g	Vitamin C mg/100g	Fe mg/100g
1-2	92.75	7.25	2.27	0.29	4.04	0.65	0.25	27.4	0.80
3	92.24	7.76	1.80	0.40	4.90	0.66	0.26	27.9	0.75
4	91.75	8.25	1.48	0.76	5.18	0.83	0.27	33.2	0.77

3.1 Specific gravity of “degree of growth” categories

The specific gravity of the spears decreased as the “degree of growth” categories increased. Using “degree of growth” category 2 as a base, the specific gravity of “degree of growth” category 1 was found to be higher and the specific gravity’s of “degree of growth” categories 3 and 4 were lower.

Table 2. Specific gravity of spears in 4 “degree of growth” categories

“Degree of Growth” categories				
Date	1	2	3	4
August 14	0.917	0.896	0.875	0.803
August 15	0.897	0.870	0.852	0.819
August 16	0.900	0.883	0.864	0.811
average	0.905	0.883	0.864	0.811
Percent of “2”	102.5 %	100 %	97.85 %	91.85 %
± %	2.5 %	0.0 %	-2.15 %	-8.15%

3.2 Weight loss of spears in 3 “degree of growth” categories

The weight loss of spears in 3 “degree of growth” categories was higher in those spears with the greater “degree of growth” as shown in table 3. Conversely the specific gravity of the spears was less as the “degree of growth” increased. These two characteristics of the spears indicate that spears at the 1 or 2 “degree of growth” have a greater capacity to maintain water content and density than the 3 or 4 “degree of growth” spears which improves the maintenance of quality during post harvest storage.

Table 3. Weight loss of spears stored at 23°C for 8 hours.

“Degree of Growth”	Sample Weight (g)	Weight after 8 hours (g)	Weight loss (%)
2	200	198.0	1.0
3	200	196.0	2.0
4	200	194.0	3.0

3.4 Respiration rate

The respiration rate of green spears increased with the “degree of growth” of the spears. Spears in the 3rd and 4th “degree of growth” categories had respective respiration rates of 10.1 % and 27.5 % higher than the 2nd “degree of growth” spears (table 4). However, the rate of change in the respiration rate of the spears between the “degree of growth” categories decreased with time.

Table 4. Respiration rate of spears (mg/kg hr⁻¹) in the “degree of growth” categories at 23°C

Hours after harvest	“Degree of Growth” categories		
	2	3	4
4	633.6	682.0	745.6
8	589.6	651.2	710.2
12	426.6	462.0	620.4
28	354.2	411.4	470.8
Average	501.2	551.7	639.0
% difference of 2nd Degree of growth	100 %	110.1%	127.5%

2.1 Spear Rot Index as a measurement of post harvest quality

The spear rot index increased with the “degree of growth” categories when the spears were stored under different storage conditions of temperature and time, (table 5). The 4th “degree of growth” category had the highest spear rot index under all of the storage conditions and is considered to be unacceptable for any extended post harvest storage or shipping. The average of the 1st, 2nd and 3rd degree of growth categories were significantly different than the 4th “degree of growth” category average at the 1% and 5% level. A significant difference was found between the 1st and 3rd “degree of growth” categories at the 5% level.

Table 5. Spear Rot Index of green spears in 4 “degree of growth” categories after storage at 4 different conditions of temperature and time.

Storage Temp (°C) and time (days)	“Degree of Growth” categories			
	1	2	3	4
8 –11 °C, 10 days	0.118	0.140	0.138	0.974
0 ± 1 °C, 30 days	0.296	0.101	0.349	0.804
0 ± 1 °C, 47 days	0.276	0.373	0.502	0.738
16 – 18 °C, 51 days	0.057	0.206	0.406	0.699
Average	0.187	0.205	0.349	0.838
% of 2 nd “degree of growth” category	91 %	100 %	170 %	392 %
Significance test 5%	c	bc	b	a
Significance test 1%	B	B	B	A

2. Discussion

As the “degree of growth” of the spears increased, the dry matter, raw fat and ash, carbohydrate, carotene and vitamin C increased while the water content and raw protein decreased. These physiological and biochemical changes resulted in spears that became less suitable for long term post harvest storage as “degree of growth” increased. The 2nd “degree of growth” spear had the highest specific gravity and best post harvest storage characteristics and is considered to be the “degree of growth” for harvesting green asparagus spears. Second “degree of growth” spears yielded less than the 3rd and 4th “degree of growth” spears but because of the 2nd “degree of growth” spears’ higher quality the improved marketability of spears provides both the grower and the marketer with a better product. Because the spears in the 3rd and 4th “degree of growth” categories did not have the physiological/ biochemical characteristics necessary for extended post harvest storage, these spears should not be marketed in situations where they need to be shipped.

The utilization of a “degree of growth” category by the grower for harvesting and the use of a “degree of growth” by the marketers of asparagus to grade green asparagus spears into marketable categories has been shown to be worthwhile. Scientific determinations of the physiological and biochemical changes that take place when a green spear is harvested at different “degree of growth” has been shown. The “degree of growth” categories can be easily related to grower, marketer and consumer by pictorial means. The use of “degree of growth” categories as standards in the green spear industry in China will help to improve the acceptance of green asparagus spears into the Chinese market. The use of high yielding, tight headed asparagus cultivars will improve the yield of spears that can be harvested by a grower thus increasing his income while providing the Chinese market with high quality green asparagus spears.

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INFLUENCE OF THE PHOSPHORIC FERTILIZATION IN THE FORMATION OF DRY MATTER AND NUTRIENTS EXTRACTION IN A CROP OF GREEN ASPARAGUS (*Asparagus officinalis*, L.)

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ABSTRACT

This work studied the influence of the phosphorus fertilization on the formation of dry matter and nutrients extractions in a crop of green asparagus (var. Plaverd), located in the Protected Geographical Indication of Huétor-Tájar (Andalusia, Spain).

The results show that the influence of the phosphorus applications in the production of dry matter in the asparagus plant, is more pronounced in the second year than in the first year. The root system had the largest formation of dry matter, around 47 %, followed by the ferns around 37.6 %, spears around 14.6 % and the seed berries with values something lower to 0.8%.

The medium levels of annual nutrient extraction expressed in kg.ha⁻¹, for a plantation with density of 15000 plants/ha were of 109.4 (N), 8.16 (P), 101.2 (K), 42.61 (Ca), 9.17 (Mg), 9.20 (Na), 5.68 (Faith), 0.358 (Mn), 0.106 (Cu), 0.139 (Zn) and 0.148 (B).

Key words: Green asparagus, phosphorus fertilization, nutrients extraction

1. INTRODUCTION

The accumulation of the dry matter in the crop of the green asparagus in mediterranean climates is characterized for a maximum in the dry weight of the plant in the period from final of September to the beginning of December. The cladodes contained their maximum dry matter in summer, while the stalks attained maximum dry matter content in the autumn. Regarding the underground part, the rhizome maintains a practically constant dry weight during the whole vegetative cycle, while the roots had their largest dry weight at the end of this vegetative cycle (Espejo, 1994).

The calculation of the extractions is based on the evaluation of the formed vegetable matter and in the mineral analysis during the vegetative cycle. Most of the authors

participation in the assimilation nutritious total of the year (60-90% in plants in full production), should be included in this calculations (Kaufmann and Kaufmann, 1967), however, due to the difficulty of the extraction of the root system, there are few papers that report information on the dry matter and nutrient content of the root system.

According to Kaufmann and Kaufmann (1967), it is an error to establish relationships between the nutritious extractions and the obtained crop, as used in manuals of recommendations of fertilizers, because the climatic conditions during the harvesting of gathering influence strongly on the expression of the potential of crop of the plant.

In spite of the differences, all the works coincident in the fact of always shows a total low extractions compared with other cultivations. In general, the order of extraction of the elements is in the first place the K, continued closely by the N, Ca, P and Mg. It is remarkable the fact indicated by diverse authors about the low extraction of P for the asparagus (Morse, 1916; Brown et al., 1961; Hartmann, 1985), although the extractions of this element increase with the age of the plant, mainly in calcareous soils, due to the acidification of the soil by the root exudates (Espejo et al., 1997).

Regarding the scarce works found in the bibliography on the microelementos extractions, Brown and Carolus (1965) and Espejo and Gonzalez (1992) have found that Fe is the micronutrient extracted in largest quantities with significant differences, followed by the Mn, while Cu, Zn and B which are taken up in small but similar quantities.

The objective of the present work is to study the influence of the phosphoric fertilization in the formation of dry matter and nutrients extraction in a crop of green asparagus along its vegetative cycle during two serial years. This crop is grown on a calcareous soil, where the levels of phosphorus are not high.

2. MATERIAL AND METHODS

The experience is developed in the Protected Geographical Indication of Huétor-Tájar (Andalusia, Spain) during the years 1994 and 1995, using the variety Plaverd (due to its biggest interest for production and representativeness in the study area). The age of the plantation at the beginning of the study was two years, and the soil on which the cultivation is developed is a calcic Luvisol (FAO, 1989).

The experiment involves the study in a randomized triplicates design in parcels of 45 m², with a density of plantation of 15000 plants/ha, where the following variants of phosphoric fertilization are included:

- 0 Kg P/ha:
 - Pre-harvest: 100 kg N/ha and 62.3 Kg K/ha
 - Cover: 300 Kg N/ha
 - Post-harvest: 50 kg.ha⁻¹ de N of slow release
- 11 Kg P/ha:
 - Pre-harvest: 100 kg N/ha, 11 kg/P ha and 62.3 Kg K/ha

- Cover: 300 Kg N/ha
- Post-harvest: 50 kg.ha⁻¹ de N of slow release

The determinations and methods used for determinations of soil and in the vegetable material, are expressed in a previous work of the authors (Espejo et al., 1996). Statistical analysis was done with a computer package Statgraphics 5.0 (Statistical Graphics Corporation, 1991) they were carried out the following statistical treatments: multiple analysis of variance based on the LSD criterion, in order to studying the influence of the phosphoric fertilization in spears, shoots, cladodes, seed berries, rhizomes and roots, as well as to study the influence of the phosphoric fertilization in the production of dry matter and in the extractions of total nutrients of the asparagus plants for the two experimental seasons. An analysis of multiple regression was run in order to find the correlation degree between the production of total dry matter and the different studied nutrients.

3. RESULTS AND DISCUSSION

The soil in which the experience is developed (Table 1) is of clayey nature, basic pH and calcareous character, with medium or low organic matter content, according to the recommendations given by Kaufmann and Kaufmann (1967) and Hartmann (1989). The saturation percentage in exchangeable sodium is lower to 15 % and the conductivity electric measure in the saturation extract indicates absence of negative saline effects in the soil (Francois, 1987). The levels of N are relatively low, which is the reason of using a high dose of N in fertilization (250 kg.ha⁻¹.year), showing a good nutritive potential in K, Ca and Mg. The contents of assimilable P are very low, and so, it is needed a phosphoric fertilization, because although the soil is calcareous, according to the radicular exudates acidified the soil increasing the available-P (Espejo et al., 1997).

Micronutrients, were in sufficient quantities to guarantee the correct nutrition of the plant, except the Zn that is lower due to the calcareous nature of the soil, and the B that is in a level something under, next at the critical level proposed by Knott (1960).

Table 2 shows the analyses of the soil of the different experimental parcels after the harvesting for both experimental years. In the first experimental year a slight fall the pH of the arable layer is observed, coinciding to Espejo et al. (1997). An impoverishment was also observed in organic matter with respect to the O.M. content of the soil before the experiment started, which is logical if we keep in mind that during the harvesting the soil has been lacking vegetable cover that provides organic matter to the soil, taking place mineralization of the existent one.

An increase was not shown in the contents of N in the different parcels, it can be observed in the contents of K. As for the P, a slight increase is observed in parcels fertilized with P. Lastly, regarding the analyzed micronutrients, they are not significant differences among the different studied parcels.

For the second experimental season the analyses of the soil reveal a decrease of the pH, independently of the treatment used fertilizer that drives to identical final values, what corroborates that pointed by Espejo et al. (1997). A descent of the content of organic matter is also observed with regard to the previous season, what confirms that

organic matter of the soils dedicated to the crop of the green asparagus. The values of N, P and K are very similar to observed in the previous season.

The Table 3 shows the medium chemical composition of the spears during the two years, being observed that the dose fertilizer hasn't a significant influence in the mineral composition of the spear, while the sampling date have a marked influence on this mineral composition, especially during the first year, originating an increase of the levels of all the nutrients analyzed except Na, Cu and Zn when advancing in the harvesting date (Amaro Lopez et al., 1995). On the other hand, it is necessary to indicate, according to the previously mentioned bibliography, that the levels are medium to high for K, Fe, Mn and Cu, of medium to lower for Ca, Mg and Zn, lower for N and B and very low for P.

Table 4 presents the compositions mineral content of stalks and cladodes for both years. In general, bigger mineral contents are observed in the cladodes than in the shafts, agreeing with that pointed by Hagg and Belfort (1985). Comparing with the consulted bibliography lower levels of N and P is detected, normal of K, Mg and Na and high for Ca, while for micronutrients they are high for Fe, Mn and Cu, medium for Zn and low for B.

Regarding the influence of the dose fertilizers it continues being not very significant in both seasons, exercising some more significant differences the sampling date in both seasons.

The relationships of nutrients extraction by the seeds was calculated by Depardon and Buron (1947). When comparing the relationships among N: P: K: Ca: Mg using the values of Depardon and Buron (1947) with the relationships obtained from the data of the Table 5, our values are high for N, K and Ca, and of the same order for Mg, and low levels in P motivated by the low contents of the soil. The phosphoric fertilization produces an increase in the contents of N and P although in a significant only in the first year for N and in both for P. Also, a significant descent took place in the potassic levels in the two years. Regarding the micronutrients it is prominent the significant increases found in Zn with the phosphoric dose in the two years.

In the Table 6 the medium chemical composition of the root system appears for both experimental seasons. The results were obtained dividing the root system in the two anatomical organs: rhizome and roots. In general, it is observed bigger contents for all the nutrients in the rhizome than in the roots except for the K that is of the same order in both. Comparing the contents with those described in the bibliography, they are considered normal in both seasons, in rhizomes and roots, in the case of N and Mg being similar to the levels described for Kaufmann and Kaufmann (1967), Hirsch (1985) and Hartmann and Hermann (1989). The P was low in both organs in the two years and the contents of K are considered normal in the rhizome, although they are something lower in the roots if we consider those proposed by Douglas et al. (1989) and Hartmann and Hermann (1989).

The contents of Ca are somewhat lower in the first season in both organs, and high in the second season. Regarding the Na, it is necessary to indicate the high requirements in

Lastly, as for the analyzed micronutrients and comparing the contents obtained with those from Douglas et al. (1989), it can be noted that the levels of Fe and Mn in the roots are high, while they are low in Zn and B.

In general, a good agreement exists among the low levels of the soil in P, Zn and B with those ones in the underground organs, which agree with the good correlations found between soil and underground organs by Hartmann and Hermann (1989). The statistical analysis indicates in a recurrent way in the two years, significant increases in the contents of Ca in the rhizomes, and increases of B in the roots although for this last it is only significant in the second year.

In order to study the influence of the phosphoric fertilization in the production of total dry matter and in the nutrients extractions, as well as to obtain an orientation of the nutrients supply that it is necessary to carry out in the annual fertilization, the necessary calculations for the nutrients extractions of the different experimental parcels.

Table 7 shows the productions of dry matter for hectare made for the different organs of the fern for the two experimental seasons showing the influence of the phosphoric fertilization in this production of dry matter, mainly for the second year. Also, in the Tables 8, 9, 10 and 11 are reflected the extractions of the different studied nutrients, made by the corresponding organs of the plant in two studied experimental seasons, finally the Table 12 reflects the total nutrients extractions of the different sites.

As shown in Table 12, the nutrients which the plant extracts in greater proportions are K and N, followed by Ca, P and Mg, which agrees with the order indicated by different authors (Brown and Carolus, 1965; Kaufmann and Kaufmann, 1967; Lubet et al., 1975; Hartmann et al., 1983; Espejo, 1991 and 1994). As for the Na, although there are few studies about their extractions, Espejo (1991 and 1994) indicates that they are of the same order that the Mg. Regarding the micronutrients, very few bibliographical dates that are about this topic exist. Of these we can mention Brown and Carolus (1965) and Espejo and Gonzalez (1992), although the first ones only study the extractions corresponding to the foliage (spears and ferns). Regarding the order of micronutrients extraction, both groups of authors coincide in the case of the cationics micronutrients, that is the Fe the is extracted in the first place, followed by the Mn, and lastly in same extraction order Cu and Zn. However, this authors, in the case of the B differ in the extraction order, being in the same extraction order that the Mn for Brown and Carolus (1965), and in the case of Espejo and Gonzalez (1992) in the same extraction order that Cu and Zn.

Regarding the level of extractions of each element, consulting the specialized bibliography, we find big oscillations in this extraction levels, justifiable for three questions: (to) to consider or not the participation of the underground system whose importance is showed in the work of Kaufmann and Kaufmann (1967), (b) the old age of the plantation, since the extraction relationship is modified N: P: K with the time (Abadia and Heras, 1969), and (c) the cultivation practices and variety of the asparagus. To this respect, it is necessary to indicate that most of the authors consulted in bibliography don't

expensive and at the same time difficult, since these organs participate in mature plant around 60-90 % in the formation of total dry matter (Kaufmann and Kaufmann, 1967).

Therefore, dry matter content of the underground system (rhizome and roots) was measured. This way, the participation of the dry matter of the underground system in the production of total dry matter, was considered the medium levels about 47 %, continued in importance by the ferns (37.6 %), and next for the spears (14.6 %) and seed berries (0.8 %) (Table 13).

This value of participation of the underground system in the total production of dry matter of the plant, is lower to the one proposed by other authors, since our experimental plantation is younger than the one studied by them. This influence of the production of dry matter at underground level is very marked with the age of the plantation according to that indicated by Kaufmann and Kaufmann (1967) that indicate a participation value around the 60 and 90 % in totally mature plants six seven years old, and in plants youths it hardly arrives to 50 %.

The nutrient and content and the dry matter produced by all the organs of the plant was used to calculate the total uptake of nutrients by the plant (Table 12). If we compare the total levels of extraction with the ones previous described, we find some discrepancies, mainly due to the rigor in the calculations of production of dry matter. In this sense, the extractions found by Kaufmann and Kaufmann (1967) are levels bigger than the ones in the present work, except for the Mg that it is of the same order. On the other hand, if we compare the data with those obtained by Anstett (1969), the levels in the present study are higher for the N, lower for the P and very similar for K. Also, it is compared, with other authors Jacob and Verkull, Knott and Penningfeld and Cold (mentioned by San Agustin, 1988), where in principle it is not known certainly if the participation of the underground system has been included in the calculations of total extractions, we found the same extraction orders for N, K, Ca and Mg that those of the present work, although for P they are clearly inferior in our case.

The comparison of nutrient uptake given by authors that didn't measure the underground system of the plant and the ratios of nutrient uptake by N: P: K: Ca: Mg, considering with P uptake equal to 1 were made. The earlier authors found the following ratios of N: P: K: Ca: and Mg:

- Depardon and Buron (1947): 3.71 :1: 3.80: 2.13: 0.41
 - BROWN and Carolus (1965): 4.39: 1: 5.33: 1.52: 0.36
 - Lubet et al. (1975): 4.47: 1: 4: 1.23: 0.18
 - Hartmann et al. (1983): 3.38: 1: 3.69: 4.92: 0.25
- and in our case the balance presented 5.89: 1: 6.57: 3.23: 0.49.

Of these relationships it is observed generally that the extractions of P in the present work are low in relation to N, K and Ca. On the other hand, the extraction of Mg seems high in our case in relation to these authors.

Everything suggests the low level P in the soil seems to induce some low extractions of this nutrient which is extracted in low proportion by this crop (Brown et al., 1961; Hartmann, 1985).

micronutrients of the air part (spears and ferns), with the suitable ones for Brown and Carolus (1965). It is important to mention first year had the lowest uptake for almost all the micronutrients relative to the second year. This fact is due to the biggest contribution in the extractions of these micronutrients for the first year as shown in the Tables 8 and 9.

Table 13 presents the relative importance of each organ of the plant studied in the extractions of macro and micronutrients of the soil. As you can observe, it is necessary to note the importance of the consideration of the underground system in the calculations of extractions for macro and micronutrients of the soil. So, for N, K and Na it is the radicular system the organ of more importance in the extractions, showing values next to 50 %, and for the case of the P and Mg, this organ is on the second place. Fern uptake of Ca, Mg and Na, occupied first place in the extractions, with the Na, an order of very similar importance that the root system. It is also necessary to indicate that in the case of the P, the spears are the organs that have the biggest participation in the uptake of this nutrient, ending up with about 50 % of the P taken up.

In what concerns to the implication of the different organs in the total extractions of micronutrients, it seems to be in this case that the participation of the underground system in the extractions, in general, is less important for the macronutrients. In this sense, the Fe, Mn and B are the nutrients extracted in greater proportion by the ferns, and Cu and Zn for the spears. This fact doesn't seem to miss in the case of this last one, due to the implications that this micronutrients seems to have in the development of the spear (Amaro Lopez et al., 1995).

On the other hand, they were carried out regression analysis among the total productions of dry matter of the different treatments fertilizers, with the corresponding nutrients extractions. The results appear in the Table 14. The best correlations between the production of dry matter and uptake of nutrients are: N ($R = 0.9729$, $p < 0.0001$), P ($R = 0.9554$, $p < 0.001$) and K ($R = 0.9778$, $p < 0.0001$). As for the micronutrients, although we cannot contrast the results of the present work with others of the bibliography due to the absence of the same ones, it is necessary to indicate it has obtained good correlations for Cu ($R = 0.924$, $p < 0.01$) and B ($R = 0.8833$, $p < 0.01$), and something inferior for Fe ($R = 0.8123$, $p < 0.05$). Everything comes it to confirm, on one hand the biggest importance of the macronutrients N, P and K in the nutrition and dry matter production of the asparagus.

The influence of the phosphoric fertilization on the production of dry matter and the extractions of total nutrients of the plant is shown in (Table 15) The influence of p on Dry matter seems more remarkable in the second year than in the first year, because of the postponed effect of the fertilization on the asparagus plant growth. In this sense, it is necessary to say that the production of matter dry total the second year increased in a significant way ($p < 0.01$) with the phosphorus applications, highlighting the remarkable decrease in the production of dry matter in the plants receiving the zero P applications, which showed a low development of the root mass fundamentally in the second year (Table 7). This result suggest the stimulating effect of the P of the soil, about the growth

which agrees Kaufmann and Kaufmann (1967) and also confirms Adler et al. (1984) finding that P fertilization exerts its effect fundamentally in the growth of all the underground organs.

Regarding to the influence of the phosphoric fertilization on the macronutrients extractions for the green asparagus, Espejo and Gonzalez (1992) described the positive relationship of the phosphoric dose and the extractions of N, P and K. In our case, a bigger extraction of P is appreciated with the increase of the dose, being a dependence in a significant way in the two years ($p < 0.05$), which suggest the improvement of the P in fertilization.

Phosphorus fertilization does not seem to effect the uptake of the micronutrients, no effects on the uptake of Fe or Zn, and doubtful on the Cu. There seems to exist a clear effect of increase of the uptake of B with the P applications, which confirms the possible synergism between the P and B in the assimilation B, which agrees with the results obtained by Warman (1991), who found an increase of the B in the ferns from the plant when increasing the phosphoric dose in the soil.

Nutrient uptake (Table 12), allows us to develop a nutrient application program for annual application to a plantation of green asparagus, in the upward phase of production (3rd to 4th year), being also considered that it is of the variety Plaverd, and that it is in a type of similar soil to the one studied. However, it is necessary to indicate that these orientations mark the minimum values of fertilizer doses occur because almost all volatilization processes (N), of retrogradation to insoluble forms (P, K, Mg, etc.) and lixiviation. According to the previously comment, and adjusting for excesses, the data about the medium of extraction of the Table 12, this work recommends the following minimum recommendations of nutrients per year to maintain the level of fertility of the soil, without considering the possible sources of mentioned losses: 110 kg N/ha, 8.8 kg P/ha, 104 kg K/ha, 60 kg Ca/ha, 10 kg Mg/ha, 10 kg Na/ha, 6 Kg Fe/ha, 0.5 kg Mn/ha, 0.1 Kg Cu/ha, 0.2 kg Zn/ha and 0.2 kg B/ha.

In these recommendations, nevertheless it is necessary to state that the uptake in the ferns at the end of the vegetative cycle are counted, since although, the incorporation of the fern in the soil would recycle some of the nutrients, it is also necessary to state that the incorporation is used most of the cases in a partial way, also, losses like volatilization, especially in the case of the N, shows that the recycling of the nutrients it is not 100 %.

If we compare these recommendations after carrying out the experiment, with the applications made at the beginning of the experiment and using the habitual practices of the study area, it is necessary to indicate that the application of N, can be considered excessive still keeping in mind a low use in this nutrient.

As for the other nutrients applied to the soil, it is necessary to indicate that the dose of P (11 Kg.ha⁻¹), apply with normality in the area can be enough to maintain the nutritious state of the soil, however due to the calcareous characteristics of the same one as well as to the biggest extraction in P for the spears, it is possible that the utilization of this nutrient is low, and that the dose to add should be higher. In this sense, other

Lastly, as for the application of K that was of 62.3 kg.ha^{-1} , it is necessary to say that it is considered quite low in front of the 99.6 kg.ha^{-1} extracted of this nutrient, and mainly keeping in mind the clayey characteristic of the soil, all that which indicates the necessity to increase the contributed dose of K above 99.6 Kg.ha^{-1} .

4. CONCLUSIONS

From the present study, we can suggest the following conclusions:

- the influence of the phosphoric dose in the production of dry matter of the plant, seems more remarkable in the second season than in the first, due to the released effect of the fertilization in this crop. On the other hand, of all the considered organs, it is in the radicular system where it showed a bigger formation of dry matter, around 47 % , followed by the ferns around 37.6 % , spears around 14.6 % and the seeds berries with values something lower to 0.8 % .

- considering the variety Plaverd, the age of the plantation, as well as the type of studied soil, the medium levels of annual extraction of nutrients expressed in kg.ha^{-1} , for a plantation with density of 15000 plants/ha can be evaluated in:

N	P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn	B
109.4	8.16	101.2	42.61	9.17	9.20	5.68	0.358	0.106	0.139	0.148

- the analysis of simple variance made on the extraction of nutrients, reveals a positive influence of the increase of the phosphoric dose in the nutrients extraction, accented in the second year. Also, this influence seems to be more marked in the case of P and B, and it is not manifested in the case of the Fe and Zn, not showing you conclusive influences .for the other elements.

- considering the levels of nutrients extractions before mentioned, where possible losses have not been evaluated by lixiviation, volatilization and immobilization, it can be considered that under the conditions of the experience, the used dose fertilizers are high in N, medium in P, and low in K.

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Table 1. Soil composition before to the experiment.

	pH (H ₂ O)	% CO ₃ ²⁻	% Sand	% Silt	% Clay	% O. M.	% C	% N	C/N	P available (mg/kg)	Specific conductivity (mS.cm ⁻¹)	Bulk density (g.cm ⁻³)
0-30 cm	7.9	24.3	26	22	52	1.65	0.96	0.06	16	3.70	0.550	1.35
30 cm	7.9	25.5	27	17	56	0.79	0.46	0.05	9	2.80	1.097	1.40

	Fe available (mg/kg)	Mn available (mg/kg)	Cu available (mg/kg)	Zn available (mg/kg)	B available (mg/kg)	Na +(* (*))	K ⁺ (*)	Ca ⁺⁺ (*)	Mg ⁺⁺ (*)	C.E.C. (*)	% V	P.E.S. (%)
0-30 cm	24.1	62.5	4.5	1.2	0.6	0.1	1.07	24.31	5.14	30.64	100	0.40
30 cm	21.9	72.5	7.2	1.0	0.6	0.5	0.63	25.46	4.91	31.58	100	1.80

(*) : meq/100 g soil P.E.S. : percentage of sodium exchanging

Table 2. Soil composition after the harvesting in the two years.

	0 kg P/ha				11 kg P/ha				22 kg P/ha			
	1 st year		2 nd year		1 st year		2 nd year		1 st year		2 nd year	
	0-30cm	30 cm	0-30cm	30 cm	0-30cm	30cm	0-30 cm	30 cm	0-30 cm	30 cm	0-30cm	30 cm
pH (H ₂ O)	7.6	8.1	7.4	7.7	7.8	8.1	7.4	7.7	7.6	8.0	7.4	7.7
% M.O.	1.57	0.28	0.86	--	1.14	0.53	0.66	--	1.40	0.62	0.88	--
% C	0.56	0.16	0.50	--	0.54	0.31	0.38	--	0.81	0.36	0.51	--
% N	0.05	0.01	0.07	0.03	0.07	0.07	0.07	0.04	0.12	0.07	0.09	0.04
C/N	11	16	7	--	8	5	5	--	7	5	6	--
P available (mg/kg)	5.30	2.44	5.30	2.44	10.13	3.07	10.77	8.93	10.70	9.70	17.70	2.70
Na ⁺ (meq/100 g suelo)	0.66	1.01	0.19	0.90	0.31	0.99	0.10	0.81	0.27	1.01	0.10	0.69
K ⁺ (meq/100 g suelo)	1.77	0.44	1.70	0.59	1.77	0.68	1.56	0.57	1.84	0.49	1.59	0.52
Ca ⁺⁺ (meq/100 g suelo)	28.08	47.51	30.38	32.64	27.19	26.55	26.56	28.04	25.53	26.49	25.86	31.55
Mg ⁺⁺ (meq/100g suelo)	4.58	4.95	4.77	4.61	4.86	5.51	4.00	4.88	4.86	5.22	4.77	4.27
Fe available (mg/kg)	20.1	24.1	--	--	22.8	23.8	--	--	21.3	22.9	--	--
Mn available (mg/kg)	55.4	49.1	--	--	52.9	45.8	--	--	52	42.8	--	--
Cu available (mg/kg)	5.4	5.3	--	--	6.3	6.1	--	--	5.2	5.1	--	--
Zn available (mg/kg)	0.6	0.6	--	--	0.9	0.8	--	--	1.3	1.2	--	--
B available (mg/kg)	0.4	0.4	--	--	0.6	0.5	--	--	0.8	0.3	--	--

Table 3. Average mineral composition of the spears (d. m.) in the two years and results of the multifactor analysis of variance.

	0 kg P/ha		11 kg P/ha		22 kg P/ha		F-ratio fertilizer dose		F-ratio date	
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
% N	3.61	3.07	3.76	3.14	3.77	3.04	0.800 ^{NS}	0.24 ^{NS}	3.03* (+)	2.79 ^{NS}
% P	0.33	0.43	0.35	0.44	0.36	0.46	1.373 ^{NS}	0.44 ^{NS}	60.12***** (+)	3.37* (+)
% K	2.47	3.42	2.45	4.14	2.41	3.96	0.295 ^{NS}	2.59 ^{NS}	5.14** (+)	2.19 ^{NS}
% Ca	0.16	0.22	0.20	0.23	0.16	0.25	3.238 ^{NS}	1.67 ^{NS}	24.99***** (+)	12.87** (+)
% Mg	0.10	0.13	0.10	0.12	0.10	0.11	1.714 ^{NS}	3.73 ^{NS}	5.54** (+)	1.08 ^{NS}
% Na	0.04	0.08	0.05	0.08	0.05	0.05	0.759 ^{NS}	2.33 ^{NS}	19.51***** (-)	5.49* (-)
Fe (mg/kg)	189	148	177	184	166	151	1.320 ^{NS}	0.34 ^{NS}	20.75*** (+)	22.27*** (+)
Mn (mg/kg)	47.8	27.9	50.8	33.3	46.4	28.9	1.727 ^{NS}	0.33 ^{NS}	20.14***** (+)	2.335 ^{NS}
Cu (mg/kg)	51.8	31.2	49.8	35.4	43.5	34.6	2.828 ^{NS}	0.15 ^{NS}	29.54***** (-)	1.39 ^{NS}
Zn (mg/kg)	70.5	33.2	74.5	34.0	71.5	34.5	1.893 ^{NS}	4.71* (+)	23.94***** (-)	4.134* (-)
B (mg/kg)	20.0	20.0	21.1	18.4	19.9	21.1	1.614 ^{NS}	0.800 ^{NS}	8.77*** (+)	1.92 ^{NS}

(-) The parameter decreases as the factor increases

(+) The parameter increases as the factor increases

^{NS} No significance *p<0.05 **p<0.01 ***p<0.001 *****p<0.0001

Table 4. Average mineral composition of asparagus cladodes and shoots (d. m.) in both years.

FIRST YEAR										
	0 kg P/ha		11 kg P/ha		22 kg P/ha		F-ratio fertilizer dose		F-ratio date	
	Cladodes	Shoots	Cladodes	Shoots	Cladodes	Shoots	Cladodes	Shoots	Cladodes	Shoots
% N	2.81	1.49	2.63	1.48	2.83	1.35	0.424 ^{Ni}	0.335 ^{NS}	12.979 ^{**(+)}	4.982 ^{*(-)}
% P	0.24	0.20	0.24	0.22	0.23	0.21	1.358 ^{Ni}	2.042 ^{NS}	102.246 ^{****}	166.187 ^{****}
% K	1.32	1.37	1.08	1.24	1.15	1.41	0.965 ^{Ni}	0.448 ^{NS}	7.886 ^{**(-)}	2.691 ^{NS}
% Ca	0.92	0.46	1.08	0.67	1.18	0.75	0.380 ^{Ni}	5.598 ^{*(+)}	0.749 ^{NS}	13.526 ^{**(+)}
% Mg	0.16	0.08	0.18	0.14	0.17	0.12	0.486 ^{Ni}	9.872 ^{**(+)}	2.597 ^{NS}	1.450 ^{NS}
% Na	0.06	0.06	0.05	0.05	0.02	0.02	12.708 ^{Ni}	14.021 ^{**(-)}	1.090 ^{NS}	1.191 ^{NS}
Fe (mg/kg)	399	209	383	226	387	164	0.067 ^{Ni}	2.373 ^{NS}	6.782 ^{*(-)}	4.046 ^{*(+)}
Mn (mg/kg)	118	77.4	132	67.5	115	81.2	2.499 ^{Ni}	0.243 ^{NS}	5.577 ^{*(-)}	6.072 ^{*(+)}
Cu (mg/kg)	26.4	23.6	33.9	23.6	26.0	20.1	2.828 ^{Ni}	0.042 ^{NS}	1.038 ^{NS}	0.652 ^{NS}
Zn (mg/kg)	51.8	36.6	50.4	29.2	49.1	31.2	0.771 ^{Ni}	1.293 ^{NS}	21.487 ^{***(-)}	2.564 ^{NS}
B (mg/kg)	74.9	41.4	61.5	42.1	77.2	49.5	11.858 [*]	4.114 ^{NS}	3.646 ^{NS}	1.100 ^{NS}
SECOND YEAR										
	0 kg P/ha		11 kg P/ha		22 kg P/ha		F-ratio fertilizer dose		F-ratio date	
	Cladodes	Shoots	Cladodes	Shoots	Cladodes	Shoots	Cladodes	Shoots	Cladodes	Shoots
% N	2.66	1.36	2.69	1.75	2.65	1.35	0.877 ^{Ni}	1.85 ^{NS}	21.84 ^{**(-)}	4.65 ^{NS}
% P	0.18	0.14	0.17	0.12	0.15	0.12	0.517 ^{Ni}	0.33 ^{NS}	9.87 ^{**(-)}	14.95 ^{**(-)}
% K	1.67	1.73	1.66	1.73	1.78	1.86	1.378 ^{Ni}	1.17 ^{NS}	119.15 ^{****(-)}	81.41 ^{****(-)}
% Ca	1.39	0.87	1.40	0.86	1.37	0.86	0.192 ^{Ni}	0.002 ^S	22.41 ^{**(+)}	14.50 ^{**(+)}
% Mg	0.27	0.20	0.30	0.23	0.25	0.21	1.929 ^{Ni}	1.47 ^{NS}	31.53 ^{***(+)}	2.32 ^{NS}
% Na	0.29	0.28	0.15	0.14	0.14	0.12	7.787 ^{Ni}	8.31 ^{*(-)}	9.12 ^{*(+)}	5.57 ^{*(+)}
Fe (mg/kg)	195	75.1	190	69.1	172	66.0	0.634 ^{Ni}	0.57 ^{NS}	6.86 ^{*(+)}	6.29 ^{*(-)}
Mn (mg/kg)	92.0	28.9	91.4	30.8	87.2	26.4	3.202 ^{Ni}	1.04 ^{NS}	106.76 ^{****(-)}	11.37 ^{**(-)}
Cu (mg/kg)	17.0	15.3	16.0	14.3	14.7	14.6	1.056 ^{Ni}	0.15 ^{NS}	14.11 ^{**(-)}	16.91 ^{**(-)}
Zn (mg/kg)	19.2	21.6	20.4	18.8	18.6	19.3	0.939 ^{Ni}	3.36 ^{NS}	25.27 ^{***(-)}	7.66 ^{*(-)}
B (mg/kg)	55.1	38.2	52.2	37.1	55.6	45.4	0.671 ^{Ni}	2.21 ^{NS}	3.72 ^{NS}	0.57 ^{NS}

Table 5. Average mineral composition of asparagus cladodes and shoots (d. m.) in both years.

	0 kg P/ha		11 kg P/ha		22 kg P/ha		F-ratio fertilizer dose	
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
% N	1.70	1.68	1.74	1.72	1.80	1.72	7.46(+)	0.63 ^{NS}
% P	0.21	0.20	0.28	0.22	0.29	0.19	17.16**(+)	13.76*
% K	1.64	2.01	1.56	1.74	1.56	1.88	27.42**(-)	368.30****(-)
% Ca	0.02	0.11	0.02	0.12	0.02	0.12	1.00 ^{NS}	4.00 ^{NS}
% Mg	0.11	0.20	0.11	0.10	0.10	0.11	2.27 ^{NS}	3.52 ^{NS}
% Na	0.02	0.02	0.02	0.02	0.02	0.02	1.00 ^{NS}	2.84 ^{NS}
Fe (mg/kg)	163.4	33.3	173.6	38.1	99.4	39.0	2.39 ^{NS}	4.51 ^{NS}
Mn (mg/kg)	21.8	12.8	20.5	13.5	19.5	13.5	0.73 ^{NS}	35.61****(+)
Cu (mg/kg)	9.7	10.9	12.3	11.5	11.5	10.4	26.78**(+)	4.33 ^{NS}
Zn (mg/kg)	11.8	11.0	13.0	12.4	16.2	12.8	7.04*(+)	7.66*(+)
B (mg/kg)	10.9	11.1	11.6	10.5	11.2	12.6	3.56 ^S	3.18 ^{NS}

(-) The parameter decreases as the factor increases

(+) The parameter increases as the factor increases

^{NS} No significance * p < 0.05 ** p < 0.01 *** p < 0.001 **** p < 0.0001

Table 6. Average mineral composition of asparagus rhizomes and roots in both years and results of the multifactor analysis of variance.

	0 kg P/ha				11 kg P/ha				22 kg P/ha				F-ratio fertilizer dose			
	Roots		Rhizomes		Roots		Rhizomes		Root		Rhizomes		Roots		Rhizomes	
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year
% N	1.72	1.50	2.01	1.80	1.37	1.43	1.87	1.57	1.26	1.51	1.96	1.95	11** (-)	0.35 ^{NS}	15.7** (-)	21.2** (+)
% P	0.09	0.07	0.14	0.08	0.08	0.07	0.15	0.10	0.07	0.07	0.16	0.07	9* (-)	1.33 ^{NS}	1.03 ^{NS}	4.94 ^{NS}
% K	1.65	1.37	1.17	1.24	1.21	1.30	1.28	1.14	1.10	1.32	1.22	1.28	30.8** (-)	0.35 ^{NS}	3.00 ^{NS}	1.11 ^{NS}
% Ca	0.16	0.32	0.31	0.82	0.14	0.47	0.39	1.07	0.01	0.42	0.34	0.90	3.89 ^{NS}	1.21 ^{NS}	6.33* (+)	7.22* (+)
% Mg	0.12	0.10	0.12	0.14	0.08	0.11	0.13	0.16	0.09	0.10	0.13	0.17	7.92* (-)	1.67 ^{NS}	3.52 ^{NS}	4.06 ^{NS}
% Na	0.11	0.14	0.17	0.21	0.09	0.15	0.17	0.19	0.08	0.14	0.14	0.20	7* (-)	0.17 ^{NS}	0.96 ^{NS}	0.44 ^{NS}
Fe (mg/kg)	470	493	1080	1140	680	937	1537	2071	494	582	1190	1193	1.43 ^{NS}	4.44 ^{NS}	0.61 ^{NS}	8.58* (+)
Mn (mg/kg)	36.6	9.0	55.9	19.7	37.1	10.6	71.3	18.3	31.1	9.1	55.5	19.6	2.1 ^{NS}	4.1 ^{NS}	0.82 ^{NS}	18.6** (+)
Cu (mg/kg)	9.2	24.8	16.7	53.7	8.3	39.1	17.5	79.5	6.1	29.6	15.3	58.6	26.37* * (-)	3.1 ^{NS}	5.86* (-)	1.06 ^{NS}
Zn (mg/kg)	10.5	6.1	22.0	39.6	8.2	6.4	23.5	25.5	8.0	6.1	23.8	35.4	39.7** * (-)	0.18 ^{NS}	15.2** (+)	3.1 ^{NS}
B (mg/kg)	7.9	7.3	12.1	11.3	7.9	6.2	11.8	11.0	8.3	8.5	11.3	11.6	3.7 ^{NS}	9.2* (+)	0.73 ^{NS}	0.06 ^{NS}

Table 7. Formation of dry matter, in kg.ha⁻¹. (Calculations referred to 15000 plants/ha).

	Spears		Ferns		Seed berries		Radicular system		Total		Total mean
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	
0 kg P/ha	1023	833	2670	2430	80.6	--	2977	1515	6751	4778	5764
11 kg P/ha	980	1111	2550	2640	67.7	--	2798	4965	6396	8716	7556
22 kg P/ha	1029	900	2850	2940	78.5	--	3562	5790	7519	9630	8574
Mean	1011	948	2690	2670	75.6	--	3112	4090	6889	7708	7299

* It has been considered for the calculations, 50% of female plants for all the sites.

The crop of seed berries of 1991 has not been possible to evaluate due to an autumn storm that made that great part of the crop fell to the soil.

Table 8. Nutrients extraction, in kg.ha⁻¹, for spears. (Data referred to 15000 plants/ha).

	0 Kg P/ha		11 Kg P/ha		22 Kg P/ha		Mean		Total mean
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	
N	35.4	25.6	37.4	34.9	38	27.4	36.9	29.3	33.1
P	3.41	3.95	3.36	4.93	3.74	4.18	3.50	4.35	3.93
K	24.98	28.47	23.90	45.98	25.23	34.61	24.71	36.35	30.53
Ca	1.73	1.82	2.04	2.53	1.63	2.14	1.80	2.17	1.98
Mg	1.02	1.08	0.98	1.33	1.03	0.99	1.01	1.13	1.07
Na	0.41	0.67	0.49	0.89	0.51	0.45	0.47	0.67	0.57
Fe	0.19	0.12	0.18	0.20	0.18	0.14	0.18	0.15	0.17
Mn	0.051	0.023	0.05	0.037	0.048	0.026	0.05	0.029	0.039
Cu	0.055	0.043	0.051	0.039	0.044	0.031	0.05	0.038	0.044
Zn	0.068	0.028	0.071	0.038	0.073	0.031	0.071	0.032	0.052
B	0.02	0.017	0.021	0.02	0.021	0.019	0.021	0.019	0.02

Table 9. Nutrients extraction, in kg.ha⁻¹, for the ferns. (Data referred to 15000 plants/ha).

	0 Kg P/ha		11 Kg P/ha		22 Kg P/ha		Mean		Total mean
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	
N	22.2	17.2	23.2	19.0	27.1	15.9	24.17	17.37	20.77
P	0.81	1.23	1.28	1.33	1.72	1.19	1.27	1.25	1.26
K	22.41	19.67	34.69	10.79	29.38	22.08	28.83	17.51	23.17
Ca	20.95	26.27	21.3	35.36	18.11	43.81	20.11	35.15	27.63
Mg	4.00	3.64	4.08	5.02	3.70	5.59	3.93	4.75	4.34
Na	3.20	3.40	3.06	5.81	1.71	6.17	2.66	5.13	3.89
Fe	3.70	1.47	4.21	1.67	3.79	1.98	3.90	1.71	2.81
Mn	0.26	0.10	0.25	0.11	0.24	0.12	0.25	0.11	0.18
Cu	0.024	0.023	0.022	0.024	0.025	0.029	0.024	0.025	0.025
Zn	0.045	0.111	0.032	0.030	0.039	0.032	0.039	0.058	0.049
B	0.088	0.092	0.084	0.096	0.118	0.11	0.097	0.099	0.098

Table 10. Nutrients extraction, in kg.ha⁻¹, for the seed berries. (Data referred to 15000 plants/ha and 50% of female plants).

	0 Kg P/ha	11 Kg P/ha	22 Kg P/ha	Mean
N	1.37	1.18	1.41	1.32
P	0.17	0.19	0.23	0.20
K	1.32	1.05	1.22	1.20
Ca	0.016	0.013	0.016	0.015
Mg	0.089	0.074	0.078	0.080
Na	0.016	0.013	0.016	0.015
Fe	0.0132	0.0117	0.0078	0.0109
Mn	0.0018	0.0014	0.0015	0.0016
Cu	0.0008	0.0008	0.0009	0.0008
Zn	0.0009	0.0009	0.0013	0.0010
B	0.0009	0.0008	0.0009	0.0009

Table 11. Nutrients extraction, in kg.ha⁻¹, for the radicular system. (Data referred to 15000 plants/ha).

	0 Kg P/ha		11 Kg P/ha		22 Kg P/ha		Mean		Total mean
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	
N	52.4	24.4	40.6	71.5	47.9	92.2	46.97	62.7	54.84
P	2.92	1.13	2.58	3.62	2.91	4.09	2.80	2.95	2.88
K	47.1	20.0	34.2	64.0	21.0	76.0	40.31	53.34	46.83
Ca	5.37	7.65	5.02	25.32	5.18	29.36	5.19	20.77	12.98
Mg	3.57	1.74	2.46	5.64	3.38	6.55	3.14	4.64	3.89
Na	3.53	2.52	2.88	7.59	3.10	8.76	3.17	6.29	4.73
Fe	1.66	1.12	2.29	5.06	2.06	4.04	2.00	3.41	2.71
Mn	0.1172	0.054	0.1194	0.2086	0.1213	0.2032	0.1193	0.1553	0.1373
Cu	0.0306	0.0197	0.0273	0.0554	0.0257	0.0642	0.0279	0.0464	0.0372
Zn	0.0362	0.0284	0.0299	0.0387	0.0353	0.0674	0.0338	0.0448	0.0393
B	0.0253	0.0133	0.0239	0.0325	0.0309	0.0526	0.0267	0.0328	0.0298

Table 12. Total nutrients extraction, in kg.ha⁻¹. (Data referred to 15000 plants/ha).

	0 Kg P/ha		11 Kg P/ha		22 Kg P/ha		Mean		Total mean
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	
N	111.4	67.2	102.4	125.4	114.4	135.5	109.4	109.4	109.4
P	7.30	6.31	7.41	9.83	8.6	9.46	7.77	8.54	8.16
K	95.78	68.14	93.79	120.8	95.53	132.7	95.04	107.2	101.8
Ca	28.05	35.78	28.33	63.26	24.92	75.33	27.10	58.13	42.6
Mg	8.68	6.46	7.59	11.99	7.16	13.13	7.81	10.53	9.17
Na	7.16	6.59	6.44	14.29	5.34	15.38	6.31	12.09	9.20
Fe	5.57	2.71	6.69	6.93	6.03	6.15	6.10	5.26	5.68
Mn	0.431	0.180	0.421	0.360	0.409	0.345	0.42	0.295	0.358
Cu	0.110	0.086	0.101	0.118	0.096	0.124	0.102	0.109	0.106
Zn	0.150	0.167	0.134	0.107	0.149	0.130	0.144	0.135	0.139
B	0.134	0.122	0.130	0.148	0.171	0.182	0.145	0.151	0.148

Table 13. Dry matter and percentage of the different organs of the plant in the total extraction of macro and micronutrients.

Nutrient	organ of the plant			
	% element extracted in spears	% element extracted in ferns	% element extracted in seed berries	% element extracted in the radicular system
Dry matter	14.60	37.60	0.80	47.00
N	30.08	18.87	1.20	49.85
P	47.52	15.27	2.40	34.81
K	30.01	22.78	1.17	46.04
Ca	4.65	64.85	0.03	30.47
Mg	11.41	46.27	0.85	41.47
Na	6.20	42.26	0.16	51.38
Fe	2.98	49.29	0.19	47.54
Mn	10.85	50.47	0.45	38.23
Cu	41.13	23.36	0.74	34.77
Zn	36.80	34.68	0.71	27.81
B	13.45	65.90	0.61	20.04

Table 14. Correlation degree and regression equation between the production of total dry matter and the nutrients.

Nutrient	Regression coefficient R	Significance p	Regression equation
N	0.9729	<0.0001	$Y=13.337X+11.815$
P	0.9554	<0.001	$Y=1.641X+6.584$
K	0.9778	<0.0001	$Y=14.207X+19.649$
Ca	0.6005	>0.05	$Y=8.773X-1.445$
Mg	0.7273	<0.05	$Y=0.914X+2.919$

Table 15. Analysis of simple variance of the influence of the phosphoric fertilization in the production of dry matter and in the extractions of total nutrients

FIRST YEAR												
	total dry matter	N	P	K	Ca	Mg	Na	Fe	Mn	Cu	Zn	B
Variance	2.768	1.153	6.521	3.264	5.981	11.25	22.00	3.572	19.43	21.43	2.731	6.548
reason						3	1		3	2		
Significance level	N.S.	N.S.	* (+)	N.S.	* (-)	** (-)	** (-)	N.S.	** (-)	** (-)	N.S.	* (+)
SECOND YEAR												
Variance	18.43	17.93	8.942	16.95	60.93	19.43	17.81	3.243	9.810	16.98	1.543	61.47
reason	2	4		4	2	2	2			7		3
Significance level	** (+)	** (+)	* (+)	** (+)	*** (+)	** (+)	** (+)	N.S.	* (+)	** (+)	N.S.	*** (+)

N.S.= No significance * p< 0.05 ** p<0.01 *** p<0.001 ***** p<0.0001

(+) (-) Increase or decrease of dry matter and nutrients extraction with phosphoric doses.

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