Spanish Journal of Agricultural Research (2003) 1 (2), 49-54

Organic seed production of leek *(Allium porrum* L.) in the northeastern of Buenos Aires. I. Yield components and quality

I. E. Paunero*[1], G. B. Corbino[1], O. Bazzigalupi[2] and R. Uviedo[1]

[1] *Estación Experimental Agropecuaria San Pedro. Instituto Nacional de Tecnología Agropecuaria. Ruta Nacional 9, km 170. 2930 San Pedro, Buenos Aires. Argentina*

[2] *Estación Experimental Agropecuaria Pergamino. Instituto Nacional de Tecnología Agropecuaria. Ex ruta 32, km 4,5. C.C. 31. 2700 Pergamino, Buenos Aires. Argentina*

Abstract

The objective of this study was to characterize the organic seed production of leek for a representative site of the northeastern of Buenos Aires. The Monstruoso de Carentán cultivar was studied in an Argiudol vertic soil, Ramallo series. The seed to seed method was used. Green manure and earthworm compost were used as fertilizers. Phenology, climatic parameters, seed yield components and quality were evaluated. Phenological records showed that conditions were appropriate for the seed to seed method. The leek vernalization requirements were met, and this contributed to good flowering (91%) and seed production. Seed yield was 78.4 g m^{-2} with 86% of seed germination (average of the 2000/01 and 2001/02 cycles). The results of this study show that the agroecological conditions of northeastern of Buenos Aires, can be considered as adequate for organic seed production of leek.

Key words: sustainable production systems, ecological conditions, Argentina.

Resumen

Producción orgánica de semillas de puerro *(Allium porrum* L.) en el nordeste de Buenos Aires. I. Componentes del rendimiento y calidad.

El objetivo de este estudio fue caracterizar la producción orgánica de semillas de puerro mediante algunos parámetros de rendimiento y calidad, en las condiciones agroecológicas del nordeste de Buenos Aires. El cultivar Monstruoso de Carentán fue sembrado en un suelo Argiudol vértico, serie Ramallo, utilizando el método semilla-semilla. Se fertilizó con lombricompuesto y abono verde. Se evaluó la fenología del cultivo, los parámetros climáticos, los componentes del rendimiento y la calidad. Los registros fenológicos estuvieron dentro de valores apropiados para el sistema de producción semilla-semilla. Los requerimientos de vernalización fueron cubiertos, lográndose el 91% de floración. Se obtuvieron 78,4 g m^{-2} de semillas, con una germinación del 86%, promedio de los ciclos 2000/01 y 2001/02, valores superiores a lo exigido por la normativa vigente. Los resultados de este estudio muestran que las condiciones agroecológicas del nordeste de la provincia de Buenos Aires pueden considerarse aptas para la producción de semilla orgánica de puerro.

Palabras clave: sistemas producción sostenible, condiciones agroecológicas, Argentina.

Introduction

The time of sowing for leek seed production (*Allium porrum* L.) using the seed to seed method must be brought forward so that the plants have sufficient time to get over the young plant stage, to become receptive to the cold stimulus, to vernalize and to flower during spring. In this way, the whole cycle is completed in 12-14 months (Jones and Man, 1963; George, 1989; Brewster, 1994). To flower, plants must accumulate a specific number of hours of cold, in an interval of 0-18ºC, with an optimum temperature of 5ºC (Wiebe, 1994). To be receptive to the cold stimulus the young plants must exceed 2 g in fresh weight and have more than 5 visible leaves (Wiebe, 1994), although there are differences between cultivars (Van der Meer and Hanelt, 1990). In unirrigated areas, water requirements must be satisfied, mainly by rainfall. New areas of crop and seed production

* Corresponding author: ipaunero@correo.inta.gov.ar
Received: 09-07-02; Accepted: 03-03-03.

must attend agroecological requirements of species and cultivars.

Early sowing and transplantation of young plants with more than five leaves increases flowering (Rusev and Buchvarov, 1974; Wurr *et al*., 1999). The increased drilling density augments seed production, with optimum values ranging from 50 to 60 plants per square metre (Gray and Steckel, 1991), the usual density being 15-18 plants per square metre (Jones and Man, 1963; George, 1989). Both the harvesting of mature seed and cultivation in plastic tunnels increase seed yield and quality (Gray and Steckel, 1986, 1991). In turn, these factors are also influenced by production system (Brewster, 1994; Brumfield *et al.*, 2000).

In the organic production system, crops must be grown with seeds of the same origin (Boletin Oficial, 1999). The consumer market for this kind of vegetable is increasing (Bazzigalupi, 1997; Thompson, 2000) and there are not sufficient seeds to satisfy the producers' demands.

In Argentina, the official area dedicated to this crop has increased five times in the past five years reaching a surface area of 2,880,149 hectares. The surface area dedicated to vegetable and salad crop production is around 1162 hectares, mainly in the provinces of Buenos Aires, Mendoza and Catamarca (Puppi and Ramirez, 2001).

The aim of this study was to characterise organic leek seed production by selected parameters of quality and yield in the agroecological conditions of northeastern of Buenos Aires, Argentina.

Material and methods

Trials were conducted in the San Pedro Agricultural Experimental Station (EEA) of the Instituto Nacional de Tecnología Agropecuaria (INTA) (33º 41' LS, 59º 41' LW) during the 2000/01 and 2001/02 cycles.

The cultivar used was Monstruoso de Carentán, which is widespread and well adapted in the area. The seed to seed method was used. Seeds were sown in the nursery in soils previously solarized the first year and not treated at all in the second. Hand irrigation was used. Plants were protected from intense rains by a plastic tunnel-shaped cover. They were uncovered at the end of each phenomenon.

In the second year, sowing was done one month earlier than in the first to favour growth of the young plants (Wurr *et al*., 1999). Transplantation in the first year was delayed because soil could not be suitably prepared owing to the rains. It was done in the 5-6 true leaf stage. In the second year, transplantation was done in the 3-4 leaf stage. In both years, transplantation was done in double rows in beds 0.80 m apart, with 0.10 m between plants. Density was 25 plants m^{-2}, slightly higher than in commercial use (George, 1989).

To control diseases, preventive measures based on copper oxychloride sprays and wettable sulphur were used. Insecticides were not used. Weeding was done manually. Approximately 50 mm of complementary sprinkler irrigation was used.

Experiments were conducted in an Argiudol Vertic soil, Ramallo series (INTA, 1973). In the first and second years, fertilization with earthworm composts were applied in doses of 20 and 40 t ha^{-1} respectively (Table 1).

Five samples of earthworm compost of approximately 1 kg were taken from different parts of the pile and were then mixed together to form one sample for analyses. Samplings were done following a similar procedure each time and were taken from a depth of 0-20 cm. Soils was analysed at the beginning, before adding fertiliser mixture, and at the end of the experiment, after the second year of harvest. Soil and compost analyses were done using routine laboratory methods for soil analysis of the San Pedro EEA, described by Chapman and Pratt (1973).

The following parameters were determined: pH, in water ratio 1:2.5; the organic matter (OM) by the wet combustion method (Walkley-Black); total N by the Kjeldal method; assimilable P by the Bray and Kurtz method 1; total concentrations of the elements K, Ca,

Table 1. Analitycal results of earthworm composts applied in each cycle, in the organic seed production of leek trials, in northeastern of Buenos Aires

Cycle	pH	OM (%)	Tot N (%)	Assim P (ppm)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Zn (ppm)	Mn (ppm)
2000/01	7.18	17.71	1.34	968	0.53	3.48	0.73	142	441	890
2001/02	7.06	10.98	0.71	1,221	0.5	2.63	0.56	157	877	671

OM: organic matter; Tot N: total nitrogen; Assim P: assimilable phosphorus.

Table 2. Results of initial and final soil analysis corresponding to organic seed production of leek trials in northeastern of Buenos Aires

Soil analysis	pH	OM (%)	Tot N (%)	P (ppm)	K (meq 100 g^{-1})	Ca (meq 100 g^{-1})	Mg (meq 100 g^{-1})
Initial	6.95	2.37	0.14	132	3.74	16.98	2.82
Final	7.10	2.68	0.16	167	2.58	16.64	2.62

OM: organic matter; Tot N: total nitrogen.

Mg, Cu, Zn and Mn by acid digestion (nitric/perchloric). The results are given as dry weight values.

The same tests were done for the initial and final analyses of soils except for K, Ca and Mg, in which ammonium acetate were used.

Between first and second leek crop broom sorghum (*Sorghum technicum* Koern.) was used as green manure. Dry matter provided by the sorghum (7,600 kg of dry matter ha^{-1}) was determined by heating in a furnace until reaching constant weight.

Phenological parameters (times of sowing, transplantation, harvest and crop cycle) and climatic factors (hours of cold and rain during the crop cycle) were recorded. Hours of cold (Sands *et al.,* 1979) and the temperature interval (Wiebe, 1994) were calculated.

One week before harvest, to prevent seed fall due to climatic contingencies (George, 1989), some parameters were counted (Paunero, 1999): a) number of fruits per umbel, in 5 umbels randomly selected from the edge of each sampling unit, and b) number of seeds per fruit, using seeds of 50 fruits from the previous measurement.

At harvest, the following parameters were measured in each sampling unit: height of floral scape (cm) of five plants, diameter of five umbels (cm), number of umbels, number of flowering plants and total number of plants. Height, diameter, number of fruit per umbel, mean number of seeds per fruit for the sampling unit, number of umbels per square metre, number of seeds per umbel (= no. of fruits $umbel^{-1}$ × no. seeds $fruit^{-1}$) and a percentage of flowering (= no. flowering plants × 100/ total no. of plants) were calculated.

Harvest was done when mature umbels showed a third of open fruit. The drying process of the umbels was naturally completed indoors. Threshing was done manually and cleaning was done using hand riddles.

Seed was cleaned and weighed and the yield was estimated (g m^{-2}). The seed weight and germination were determined according to the ISTA rules (1999).

The measurements of parameters were made in five plots, each one having four rows of plants 3 m long. The sampling unit was one linear metre from the centre of each plot. It was performed an analysis of variance and the interaction of the yield components between years was determined using the SAS statistical programme (1988).

Results

The results of the initial and final soil analysis (Table 2) show a slight rise in pH values (2.1%). Rises of 12% in the OM and total N and of 21% in P, give a positive balance between the inputs of the composts applied and the extraction made by the crop. In contrast, Ca and Mg reduced slightly, by 2% and 7% respectively, and K suffered a sharper decline (31%).

Phenological and climatic data are shown in Table 3.

In the second year, earlier sowing time did not affect the flowering percentage and yield (Table 4). Vernalization requirements to flowering were satisfied with 90% of plants with flowers without variation between years. In both seasons, the hours of cold and millimetres of rainfall (Table 3) were suitable to achieve normal crop development and seed yield.

In the first year, transplantation of young plants with a larger number of leaves did not have any influence either on the percentage flowering and the seed yields.

Bringing the sowing time forwards by 42 days resulted in a cycle 20 days longer. There were no differences in the number of days between sowing and

Table 3. Phenological and climatic data corresponding to the organic seed production of leek trials in northeastern of Buenos Aires during cycles 2000/01 and 2001/02

	2000/01	2001/02
Sowing date	24 April	12 March
Transplantation date	30 August	18 July
Harvesting date	9 March	14 February
Days from sowing to haverst (Cycle)	319	339
Number of cold hours	1,123	1,128
Rainfall (mm)	737	791

Table 4. Values of the yield components and qualities obtained in the organic seed production of leek experiment in northeastern of Buenos Aires during the cycles 2000/01 and 2001/02

Yield component	Cycle	Average	Standard deviation	Probability > F (between years)
Scape height (cm)	average*	91.94	4.87	0.832
Umbel diameter (cm)	2000/01	8.88	0.38	0.042
	2001/02	10.08	0.73	
No. fruits per umbel	2000/01	383.4	99.66	0.0039
	2001/02	726.20	86.56	
No. seeds per fruit	2000/01	3.71	0.23	0.047
	2001/02	4.2	0.32	
No. seeds per umbel	2000/01	1,430	409	0.0028
	2001/02	3,037	304	
No. umbels m^{-2}	average*	22.7	2.67	0.578
Percentage flowering	average*	91.03	10.56	0.547
Weight of 1,000 seeds (g)	average*	3.55	0.18	0.323
Germination (%)	average*	85.71	5.28	0.099
Seed yield (g m^{-2})	average*	78.40	9.67	0.339

* The average of two seasons is given since there were no statistically significant differences between them ($\alpha = 0.05$).

transplantation (128 days). The differences recorded were those accumulated between transplantation and harvest. This was started on the 9 March and the 14 February in the first and second year, respectively (Table 3). Crops were harvested three times over a relatively long period of 18 days.

Values for the yield components are recorded in Table 4. Interactions between years were given for some yield components: umbel diameter, number of fruit per umbel and number of seeds per fruit. In spite of significant differences between number of fruit per umbel, there was no difference in seed yield between years, probably because samples were extracted from different plants. The scape height, the number of umbels per square metre, flowering percentage and seed yields presented no significant differences between years. In the same way, there were no differences in quality parameters of seeds, weight and germination.

Discussion

Earthworm compost supplemented with sorghum as fertilizers are both in accordance with Argentinian organic legislation (Boletín Oficial, 1999), and maintained soil fertility (Tables 1 and 2). Both the rise in soil pH after application of compost and cultivation of crops indicates a slight salinization (Table 2). The increase of pH may be considered as a consequence of organic supplements (Souza, 1998). The sharp decline in K concentrations (31%) and to a lesser extent in Ca and Mg, could be due to the greater consumption of these elements in fruit and seed production although stabilisation of the levels of the different nutrients would be achieved after some years of organic crop management (Souza, 1998). It would be interesting to study the change in these parameters over more seasons.

Phenological records (Table 3) indicated that crop cycles were within suitable values for the 12-24 month seed to seed production system described by George (1989). Earlier sowing date and transplantation of young plants with more leaves did not affect flowering and yields. This does not agree with results of other authors (Rusev and Buchvarov, 1974; Wurr *et al.*, 1999), probably because the plants passed the five leaf stage early enough (Wiebe, 1994) and covered their vernalization requirements. Possibly, sowing date was not brought forward a sufficient number of days to produce differences described by other authors. Future works should test the effect of bringing sowing date forward a greater number of days.

The relatively long period of umbel harvesting agrees with that described by Gray and Steckel (1986). The period of leek seed maturation was longer than that recorded for other *Alliums* like onion (Brewster, 1994).

The hours of cold, rainfall and soil type are the main components that characterise an agroecological region (George, 1989). There are no references to the organic seed production of leek in the literature. But, it has been shown that organic management system affects crop yields in tomato (*Lycopersicon esculentum* Mill), pumpkin (*Cucurbita pepo* L.) and sweetcorn (*Zea mays* L. var. *saccharada*) (Brumfield *et al.,* 2000). In our case, the number of cold hours was sufficient to achieve flowering requirements in both years.

The number of seeds per umbel were slightly lower than those obtained by Gray and Steckel (1986) in crops grown in a plastic tunnel. The value of 3.75 g, obtained for the weight of 1,000 seeds was slightly lower than that obtained by George (1989). Seed germination greatly exceeded the current legal limits corresponding to a minimum value of 70% (Boletín Oficial, 1997).

In agreement with the works of Gray and Steckel (1986, 1991), seed quality was not affected by plant density.

Average yields of 78.4 g m^{-2} obtained in the experiment were higher than those reported by other authors. Hence, Jones and Man (1963) reported average yields of 50 g m^{-2}, while George (1989) mentioned 50-60 g m^{-2} using 15 to 18 plants per square metre, both working in field crops. Gray and Steckel (1991) on the other hand, in crops grown in a plastic tunnel, obtained yields of between 140-250 g m^{-2} using mineral fertilization and high density planting (50-60 plants m^{-2}).

Viability of seed production of leek was determined by the lack of yield components differences between years. Scape height, flowering percentage, number of umbels, seed weight and germination reflect all seed yield stability and quality confirming leek adaptation to organic seed production in northeastern of Buenos Aires.

The results obtained show that the agroecological conditions of northeastern of Buenos Aires province, can be considered to be suitable for organic seed production of leek.

Acknowledgments

We would like to thank the staff of the soil laboratories of the EEA San Pedro, for carrying out the soil analyses.

References

BAZZIGALUPI O., 1997. Semillas para la agricultura orgánica. SAGPyA, INTA, Argentina. Proyecto de Diversificación Productiva. Serie C, 15, p. 27.

BOLETÍN OFICIAL DE LA REPÚBLICA ARGENTINA, 1997. Resolución 306/1997 Secretaria de Agricultura, Ganadería, Pesca y Alimentación. Estándares de calidad para las semillas de especies hortícolas, legumbres, aromáticas. BO no. 28769, 17/12/1997.

BOLETÍN OFICIAL DE LA REPÚBLICA ARGENTINA, 1999. Ley 25127/1999 Producción ecológica, biológica u orgánica. BO no. 29228, 13/9/1999.

BREWSTER J.L., 1994. Onions and other vegetable alliums. CAB International. UK, 263 pp.

BRUMFIELD R.G., RIMAL A., REINERS S., 2000. Production and marketing reports. Comparative cost analyses of conventional, integrated crop management, and organic methods. HorTechnol 10 (4), 785-793.

CHAPMAN H.D., PRATT P.F., 1973. Métodos de análisis para suelos, aguas y plantas. Ed. Trillas, Mexico. 195 pp.

GEORGE R.A.T., 1989. Producción de semillas de plantas hortícolas. Ed Mundi-Prensa, 330 pp.

GRAY D., STECKEL J.R.A., 1986. The effects of several cultural factors on leek (*Allium porrum* L.) seed production. J Hortic Sci 61 (3), 307-313.

GRAY D., STECKEL J.R.A., 1991. Density and harvest date effects on leek seed yields and quality. Seed Sci Technol 19, 331-340.

INTA (INSTITUTO NACIONAL DE TECNOLOGÍA AGROPECUARIA), 1973. Carta de suelos de la República Argentina 19. Sheet 3360-33, Perez Millán. 78 pp.

ISTA (INTERNATIONAL SEED TESTING ASSOCIATION), 1999. International rules for seed testing. Seed Sci Technol 27 (Supplement), 1-333.

JONES H.A., MANN L.K., 1963. Onions and their allies. Ed Leonard Hill, London. 285 pp.

PAUNERO I.E., 1999. Optimización de la producción de semillas de cebolla (*Allium cepa* L.) por el método semilla-semilla, en la provincia de Catamarca. Thesis *Magister Scientiae*. Universidad Nacional de Cuyo, Mendoza, Argentina.

PUPPI N., RAMÍREZ J.C., 2001. Situación de la producción orgánica en la Argentina durante el año 2000. SENASA mayo, 31 pp.

RUSEV D., BUCHVAROV S., 1974. Studies on leek seed production II. The effect of seed plant age and planting date on seed productivity. Horticultural Abstracts 45, pp. 6472.

SANDS P.J., HACKETT C., NIX H.A., 1979. A model of the development and bulking of potatoes (*Solanum tuberosum* L.). I. Derivation from well-managed field crops. Field Crop Res 2, 309-331.

SAS INSTITUTE INC., 1988. SAS/STAT users's guide release 6.03. SAS Institute Inc. Cary, N.C.

SOUZA J.L. de, 2000. Estudo da fertilidade de solos submetidos a manejo organico ao longo de nove anos. Actas 40º Congreso Brasileiro de Olericultura, San Pedro, Brasil. pp. 390.

THOMPSON G., 2000. International consumer demand for organic foods. Hort Technology 10 (4), 663-674.

VAN DER MEER Q.P., HANELT P., 1990. Leek (*Allium ampeloprasum*). In: Onions and allied crops. (Brewster J.L., Rabinowitch H.D., eds), vol.III, pp. 179-196.

WIEBE H.J., 1994. Effects of temperature and day-length on bolting of leek (*Allium porrum* L.). Sci Hortic 59, 177-185.

WURR D.C.E., FELLOWS J.R., HAMBIDGE A.J., FULLER M.P., 1999. Growth, development and bolting of early leeks in the UK. J Hortic Sci Biotech 74 (1), 140-146.