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PUBLICADO EN

ANALES DE EDAFOLOGIA Y AGROBIOLOGIA

TOMO XLII, NUMS. 1-2 – MADRID, 1983

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SUMMARY

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Under greenhouse conditions the P uptake by wheat is studied and soil P extracted by three laboratory tests is compared.

In these soils the critical level of available P depends on the laboratory method used. Thus for the Burriel-Hernando extracting solution, it is 80 ppm while the method of Olsen gives a value of 60 ppm; the lowest concentration being obtained by the procedure of van der Paaw-Sissingh 40 ppm.

The regressions of plant yield on soil P extracted are studied to the critical level and equations are obtained which help to determine the amount to be applied to the soil. Differences are found in these relations for Brown Soil despite the same value of critical concentration.

INTRODUCTION

Initially it was thought that the more a solution extracted, the better would be the status of a nutrient in the soil. Experience showed successes and failures, and other ideas or procedures by which the nutrient uptake by a plant could be predicted had to be considered.

This has given rise to a great number of extracting solutions, some of universal selection (Morgan, Spurway), others selective only for phosphorus (Bray, Olsen, Burriel-Hernando).

The effectiveness of an extracting solution for a nutrient is based upon whether or not it reflects a plant response to added P. For this purpose, Bray (1944) used the concept of % yield which is recognized by Hartfields theories and developed terms like: «nutritional index, critical value and fertility index».

In fact any of these expressions will be valid, so long as the physicochemical soil properties are taken into amount, and soil samples plus P are incubated according to Waugh and Fitts (1966). In this way, it will be possible to relate the soil P extracted to the amount of P fertilizer to be applied, and these procedures of P extraction will be valid for the end in view.

The purpose of this study is to verify the evaluation of soil phosphorus by the methods of Olsen, Burriel-Hernando and van der Paaw-Sissingh, in soils of dry farming areas which have received different amounts of fertilizers in the past.

MATERIAL AND METHODS

The material consist of Brown Earths from Ateca and Calatorao (Zaragoza Prov. Spain); xerorendzines from Anzon and Brown Soils belonging to Pedrosas and Sos (Zaragoza Prov., Spain).

Each area has had two different histories of fertilizer use in the past, one well carried out and the other incorrect.

In table 1 the physico-chemical properties of these soils are shown, according to the methods described in (Eleizalde, 1976; Eleizalde and Fernández, 1982).

In order to predict the phosphorus requierements of a soil the methods of Olsen, Burriel-Hernando and van der Paaw-Sissingh are considered in this evaluation using the criterion of Waugh and Fitts (1966).

Each soil with the P treatment (0, 10, 50, 100, 150, 200, 250, 300, 350, 400 and 600 ppm P) as calcium diphosphate is incubated for two weeks with 3 replicates per treatment and soil. After this time, soil phosphorus is extracted according to the method under study (Díaz, Eleizalde and Fernández, 1982).

On the basis of this study the P quantities per soil to be applied in the greenhouse trial are determined. These can be seen in table 2.

The greenhouse assay consists of three replicates of P treatment per pot with soil and plant and two repetitions of P treatment per pot with soil but without plant.

The incubation of soil plus dihidrogen calcium phosphate continues for two weeks at water holding capacity. After this time the dwarf variety of Abadia wheat is sown at the rate of 10 plants per Kg of soil and supported by a complete nutrient solution minus P (Waugh and Fitts, 1966).

Five weeks after the emergence of the seedlings the plants in each pot are harvested, dry matter is weighed and the phosphorus analyzed according to the procedure used in the Aula Dei Experimental Station at Saragossa (Spain).

In the soil samples from pot without plants, the phosphorus is extracted by the methods of Burriel-Hernando, Olsen and van der Paaw-Sissingh, to ascertain the concentration of soil available P during this trial.

The P analysis of water and $NaHCO_3$ extracts is done by the method of ascorbic acid (Watanabe and Olsen, 1965).

TABLE 1

Physico-chemical features in soils with different fertilizer use in the past

Soil	Fertiliz. use in the past	pH		% $CaCO_3$		% OM.	% N	C/N	C.E. mmhos/cm	Soil particle size %		
		H_2O	KCl	Total	Active					Sand	Silt	Clay
Brown Earths at Ateca	Good	8.25	7.80	4.11	3.12	0.884	0.098	4.99	0.416	30.00	40.00	30.00
	Bad	8.20	7.90	11.76	5.94	0.620	0.075	1.79	0.146	30.00	50.00	20.00
Brown Earths at Calatorao ...	Good	8.30	7.70	9.86	9.81	0.724	0.061	6.88	0.580	44.92	29.87	24.71
	Bad	8.20	7.90	12.70	12.12	1.103	0.058	11.03	0.219	49.91	27.27	23.23
Xerorendzines	New	8.00	7.92	25.80	10.56	1.290	0.098	7.63	0.153	40.00	40.00	20.00
	Good	8.34	7.86	37.71	8.12	2.230	0.114	10.83	0.199	30.00	54.00	16.00
	Bad	8.70	7.92	35.11	11.25	0.950	0.075	7.34	0.236	35.50	35.50	29.00
Brown soils at Sos	Good	8.30	7.65	27.46	8.10	1.950	0.103	10.86	0.186	20.35	42.40	37.10
	Bad	8.30	7.60	35.36	12.76	0.860	0.053	9.34	0.208	22.28	49.42	28.08
Brown soils at Pedrosas	Good	8.25	7.60	32.76	12.94	1.706	0.123	8.04	0.480	20.00	30.00	50.00
	Bad	8.10	7.75	35.86	15.56	1.913	0.137	8.09	0.280	25.00	35.00	40.00

TABLE 2

The values and P treatments for soils with different fertilizer use in the past

Soils	Fertilizer use in the past	X value	P treatment (ppm)							
			T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Brown Earth at Ateca	Good	152	0	19	38	79	117	158	225	300
	Bad	250	0	38	79	150	225	300	—	—
Brown Earth at Calatorao	Good	152	0	19	38	79	117	158	225	300
	Bad	150	0	19	38	79	117	158	225	300
Xerorendzines	New	300	0	38	79	150	225	300	450	600
	Good	304	0	38	79	150	225	300	450	600
	Bad	304	0	38	79	150	225	300	450	600
Brown soils at Sos	Good	300	0	39	79	150	225	300	450	600
	Bad	300	0	39	79	150	225	300	450	600
Brown soils ad Pedrosas	Good	304	0	39	79	150	225	300	450	600
	Bad	304	0	39	79	150	225	300	445	600

RESULTS AND DISCUSSION

There was a positive response of Abadia variety wheat to phosphorus added to Brown Earths from the Ateca and Calatorao districts, of the dry-farming are of Saragossa Province, since there was an increase in dry matter production from P treatment to P treatment applied (Fig. 1A) (Eleizalde, Alvarez, Díaz and García, 1982).

It was also found that, the use of fertilizers in the past had and influence on the plant yield, because in the Ateca locality great differences were obtained between the curves of plant yield when soils with a good or bad fertilization management were compared (Fig. 1A).

This did not occur with Brown Earths of the Calatorao area.

In the xerorendzine Group with a high soil available P content a response of wheat to the added phosphorus was found. In this case also the influence of fertilizer use in the past on the amounts of dry matter production was noticed. The highest values were attained with a new soil and that well fertilized in the past (Eleizalde, Alvarez, Díaz and García, 1982) and (see in fig. 1B).

The response of wheat plants grown on Brown Soils of the Sos and Pedrosas areas, was different from P treatment to P treatment and was not influenced by the use of fertilizers in the past (Fig. 1C) because similar plant yield curves were obtained for soils well or badly fertilized in the past.

In table 3, can be seen the phosphorus content of Abadia variety wheat grown in these soils, there was an increase in % P content from phosphorus treatment to phosphorus treatment. It started at about (0.055 and 0.100) and continued until a value of 0.40 was reached.

Jones and Benson (1975) point out that the gramineous crops require a 0.43 to 0.40 (Eleizalde, Alvarez, Díaz and García, 1982). This means that under these conditions, the range of plant requirement was attained.

On the other hand, the evaluation of a laboratory procedure is based upon whether it reflects or not the phosphorus absorption by a crop and includes three fundamental aspects:

1. Critical soil phosphorus level for each procedure.
2. The study of the relation between plant yields and soil P extracted by each method.
3. P quantity to be applied according to soil P extracted by a laboratory test.

The methods of Burriel-Hernando, Olsen and van der Paaw-Sissingh will be studied according to these three aspects.

1. *Critical level*

There are several investigators (Bray, 1944; Waugh and Fitts, 1966) who consider it fundamental to know the critical level of soil phosphorus, which is defined as the value above which there is no plant response to the amount of phosphorus applied.

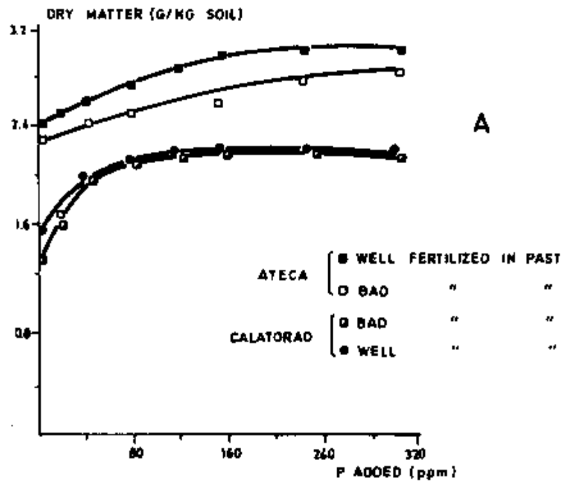

FIG. 1.—Relationship between dry matter production of Abadia wheat variety and Padded in Brown Earths.

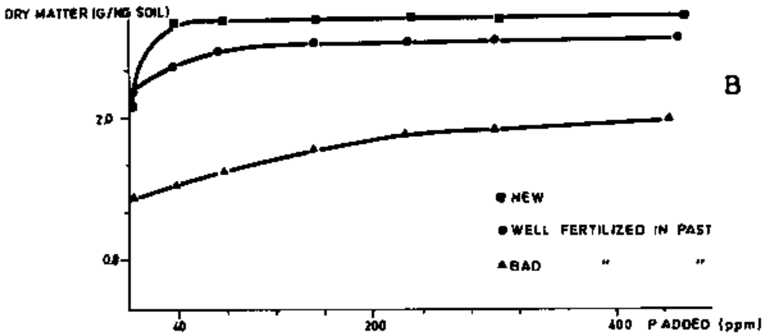

FIG. 1.—Relationship between dry matter production of Abadia wheat variety and Padded in xerorendzinas.

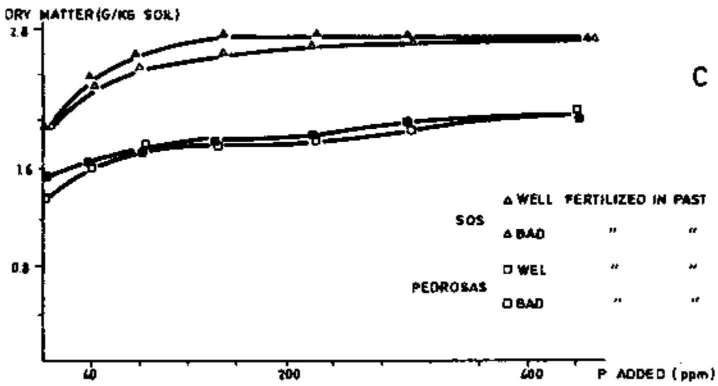

FIG. 1. Relationship between dry matter production of Abadia wheat variety and Padded in Brown soils.

TABLE 3

The Values and P treatments for soils with different fertilizer use in the past

Soils	Fertilizer use in the past	% P in plant material according to treatment							
		T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Brown Earth at Ateca	Good	0.073	0.120	0.130	0.210	0.280	0.350	0.410	—
	Bad	0.055	0.130	0.190	0.240	0.330	0.360	—	—
Brown Earth at Calatorao	Good	0.088	0.104	0.114	0.135	0.150	0.180	0.230	—
	Bad	0.079	0.113	0.125	0.153	0.221	0.250	0.320	—
Xerorendzines	New	0.055	0.146	0.232	0.321	0.430	0.480	0.490	0.520
	Good	0.093	0.156	0.224	0.260	0.325	0.386	0.497	540
	Bad	0.070	0.141	0.181	0.250	0.300	0.374	0.473	0.490
Brown soils at Sos	Good	0.067	0.124	0.164	0.313	0.350	0.450	0.474	0.550
	Bad	0.100	0.183	0.243	0.350	0.410	0.430	0.440	0.470
Brown soils ad Pedrosas	Good	0.087	0.150	0.230	0.334	0.421	0.430	0.440	0.480
	Bad	0.100	0.136	0.161	0.250	0.335	0.360	0.450	0.470

In order to find these critical values, these authors relate the % plant yield to the quantity of soil P extracted by an extracting solution.

This % plant yield is calculated as follow:

$$\% \text{ plant yield} = \frac{\text{plant yield at } T_0 \times 100}{\text{plant yield at any T}}$$

The method of Burriel-Hernando gives a critical level of 80 ppm for these soils (Fig. 2A). This value is lower than that found for calcareous soils of the Ebro Valley by Eleizalde (1983).

It is well known that this extracting solution has a good correlation with crop productions under a wide range of soil pH (4.9 to 7.2) (Eleizalde and van Diest, 1971; Cargue, 1953).

Again a good agreement was obtained between the plant yield results and soil P extracted data because the values falla with in the apropiate areas in the drawing seheme.

For the procedure of Olsen, a critical concentration of 60 ppm P was obtained (Fig. 2b) in the soils under study. This value was much lower than those value found by Mueller for Calcareous soils of Peru, Sta. Cruz *et al.* (1976) for those belonging to Murcia and Eleizalde (1983) for calcareous soils of the Ebro Valley.

In this case a good concordance was found between wheat yield data and soil P extracted results, because the values fall with in the appropiate areas of the drawing scheme (Fig. 2B).

The Sissingh-van der Paaw method was designed for Dutch soils which are predominantly non saline and have been receiving phosphorus fertilizer annually in relatively large quantities for several decades. It is interesting to note that this method, consisting of extraction of soils with mere water, migth also be applicable to soils with a higher level of salinity and with smaller reserves of potentially available soil phosphorus (Eleizalde and Van Diest, 1971) (Altares, Elizalde and Díaz, 1982).

The plant yield values plotted in relation to the soil P extracted by this procedure are shown in fig. (1C). It can be seen that the best concordance is obtained between both variables since all values fall with in the apropiate site of this drawing scheme areas.

A critical concentration of 40 ppm P was found by this laboratory method, this value being much lower than that reached by calcareous soils of the Ebro Valley reported by Eleizalde (1983).

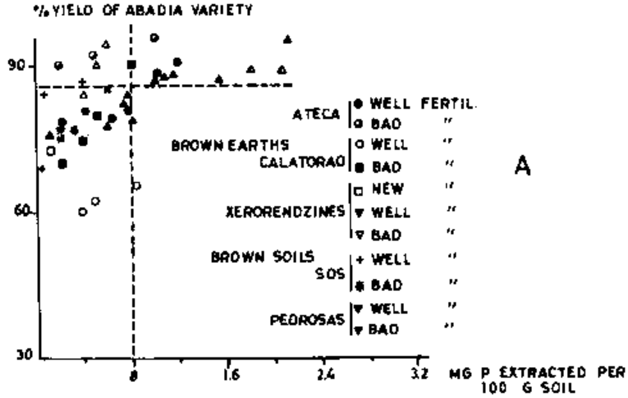

FIG. 2. Relation between % yield of Abadia variety and P soil extracted by method of Burriel-Hernando in Brown Earths Xerorendzines and Brown Soils.

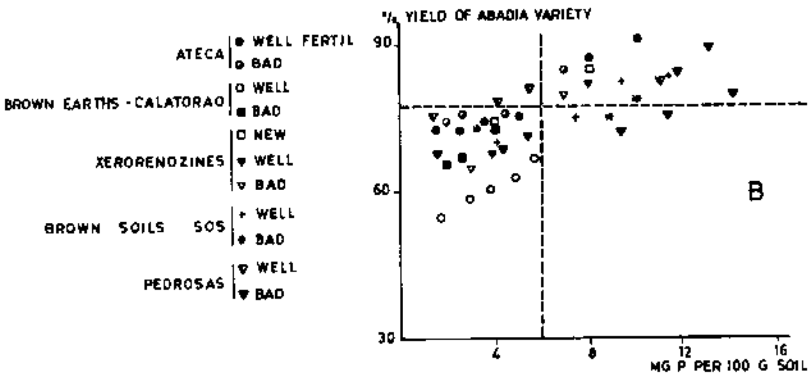

FIG. 2.- Relation between % yield of Abadia variety and P extracted by method of Van der Paw-Sissingh in Brown Earths Xerorendzines and Brown Soils.

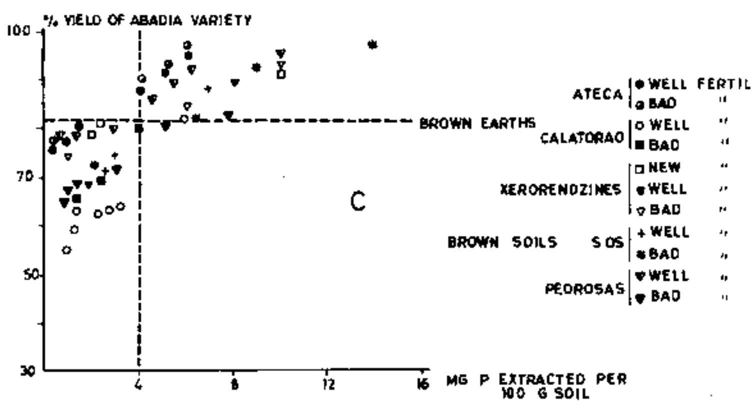

FIG. 2. Relationship between dry matter production of Abadia wheat variety and P added in Brown Soils.

2. *Relation between plant yield and soil P extracted by a laboratory test*

In order to have a wide view, an equation must be used which relates the soil P extracted to plant production provided that it is based upon the fact that a maximum yield of a crop (Fisher, 1974). This relation can be expressed as follows:

$$y = \frac{27x}{X} - \frac{7x^2}{X^2} \qquad (2) \quad \text{(Fisher, 1974)}$$

where:

y = observed yield.

x = soil P value that produces a yield.

X = soil P value at which maximum plant yield is obtained.

In these soils, the value X is that which produces 100 % plant yield, and is obtained at treatment 5.

These x values are the phosphorus contents from soil samples of pot without plant obtained by the methods of Olsen, Burriel-Hernando and van der Paaw-Sissingh.

In this way the values as a function of the known variables can be calculated the regression equations between x and y are calculated for yields and methods of soil available P extracted (table 4).

TABLE 4

Equations between % plant yield ans soil P extracted by methods of Burriel-Hernando, Olsen and van der Paaw-Sissingh

Laboratory test	Regression equations	
	Brown Earth + Xerorendizines	Brown Soils
Burriel-Hernando	$y = 24x - 1.56x^2$	$y = 16.7x - 0.69x^2$
Olsen	$y = 40x - 4x^2$	$y = 33x - 2.8x^2$
Van der Paaw-Sissingh	$y = 25x - 6.3x^2$	$y = 20x - 4x^2$

So, for each method these equations make it possible to ascertain, according to the yield needed, the available phosphorus in the soil.

3. *Quantity of P to be applied to each soil*

This section studies the relation between P added to the soil and P extracted from soil by two laboratory test.

In figs. (3A and 3B) the different relations between both variables due to

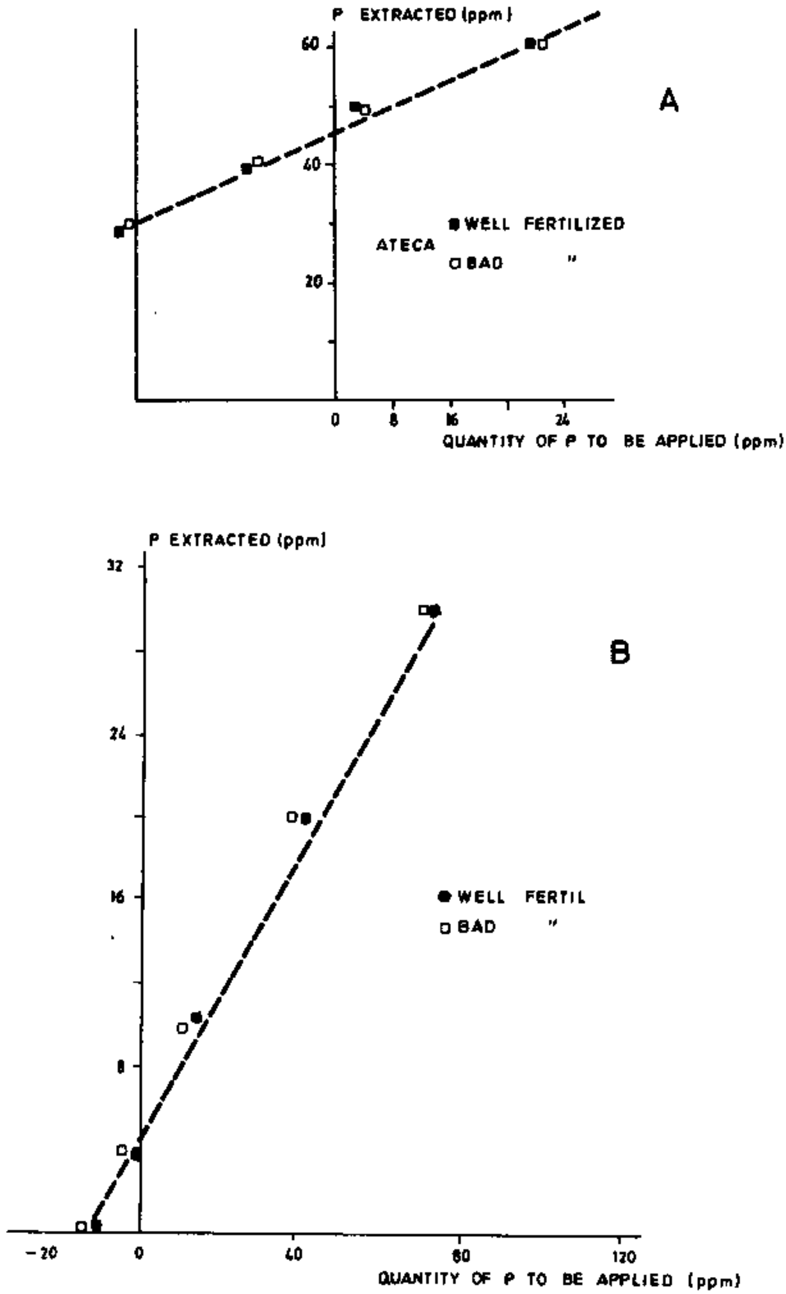

FIG. 3.—Relationship between P extracted by method of P to van der Paaw-Sissinah and quantity of P to be applied in Brown Earths from Ateca.

the nature of the laboratory procedure used can be seen. In the case of the Burriel-Hernando method (Fig. 3A) it is a mild extracting solution consisting of calcium and magnesium carbonates plus acetic acid, while in the procedure of van der Paaw-Sissingh it is merely water.

In both cases there are not differences as between soils with good and bad use of fertilizer in the past.

RESUMEN

Bajo condiciones de invernadero se estudia la absorción de P por el trigo, así como se compara la extracción del fósforo asimilable por tres métodos de laboratorio.

En estos suelos, la concentración crítica de fósforo asimilable a obtener depende del método a usar. Así para el Burriel-Hernando es de 80 ppm, en tanto que los métodos de Olsen y van der Paaw-Sissingh dan de 60 a 40 pp, respectivamente.

Se estudia la regresión entre los valores de rendimiento del cultivo y los del P extraído del suelo, esto permitirá establecer cantidades de P a aplicar.

RESUME

On a étudié dans serre l'absorption de P par le blé et l'extraction de P assimilable avec trois méthodes différents de laboratoire.

La concentration critique de P assimilable dans ces sols etant différent avee chaque méthode, on y a trouvé 80 ppm avec le methode Burriel-Hernando, 60 ppm avec Olsen et 40 ppm avec van der Paww-Sissingh.

La régression entre les rendements du blé et les valeurs des extractions de P donne une équation qui aide a établir les quantités des engrais phosphoriques a appliquer.

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Recibido para publicación 28-VI-82