A new race of *Globodera pallida* attacking potatoes in Peru

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SUMMARY

The reproductive behaviour of potato cyst nematode (PCN) *Globodera pallida* " selfed populations " of races P_4A, P_5A, the new P_6A and their hyrids were studied on three potato clones with different levels of resistance to PCN. Crosses between PCN races included all possible combinations. Results of reciprocal crosses indicated no occurrence of maternal inheritance. Partial and full resistance to races P_4A and P_5A of *G. pallida* were confirmed in the cv. Maria Huanca and the clone 280090.10; however, with the new race P_6A both cultivars were susceptible. These results, and those obtained with the hybrid populations of PCN races, indicate a greater effect of P_5A and P_6A virulence genes since these were expressed as higher percentages of female formation on the potato clones used in this study. The existence of different virulence genes was more apparent when clone 280090.10 (resistant to P_4A and P_5A races) was used. The identification of this new race necessitates a search for new genes for resistance and their utilization in a potato breeding program to develop commercial cultivars with resistance to race P_6A of *G. pallida.*

RÉSUMÉ

Une nouvelle race de Globodera pallida *attaquant la pomme de terre au Pérou*

La présente étude concerne la reproduction de races pures (P_4A, P_5A et nouvelle race P_6A) de *Globodera pallida* et de leurs hybrides sur différents clones de pomme de terre présentant des niveaux variés de résistance au nématode. Toutes les combinaisons possibles de croisements entre races ont été effectuées. Les résultats des croisements réciproques ne montrent aucune évidence d'hérédité maternelle. La résistance partielle et complète du cv. Maria Huanca et du clone 280090.10 envers les races P_4A et P_5A est confirmée; l'un et l'autre cultivars sont cependant sensibles à la race P_6A. Ces résultats, et ceux obtenus avec les populations hybrides de races, démontrent une action plus forte des gènes de virulence des races P_5A et P_6A, comme indiqué par un pourcentage plus élevé de femelles formées sur les clones de pomme de terre utilisés dans cette étude. L'existence de différents gènes de virulence est plus évidente lorsque c'est le clone 280090.10 — résistant aux races P_4A et P_5A — qui est utilisé. L'identification de la nouvelle race implique la recherche de nouveaux gènes de résistance et leur utilisation dans un programme d'amélioration génétique de la pomme de terre, programme ayant pour but la mise au point de cultivars commercialisables résistant à la race P_6A de *G. pallida.*

The presence and nomination of a new race of *Globodera pallida* was recently proposed in Peru (Anon., 1986). The facts which were considered for this proposal resulted from a study with several potato cyst nematodes (= PCN) populations collected in the northern part of Peru (La Libertad Department). This new group multiplied very well on the clone $(VT^m)^2$ 62.33.3 and was identified as P_5A, since this reaction is the last option in the scheme developed by Canto and Scurrah (1977). As a result of testing PCN populations with the set of standard potato differentials (Franco, 1983), it was thought that the race P_5A of *G. pallida* was the most predominant one in this area. However, when an additional potato clone (280090.10) resistant to races P_4A and P_5A of *G. pallida* was introduced into the standard set of differentials, a new PCN population was detected because it was able to multiply on this potato clone.

As result of the proposal of this new race of *G. pallida*, the behaviour of " pure " lines of races P_4A, P_5A and P_6A and their hybrids on potato cultivars with different levels of resistance was studied.

Materials and methods

The potato clones utilized in this study were the fully susceptible cultivar Désirée with no known genes for resistance, the P_4A/P_5A partially resistant cultivar Maria Huanca and the full P_4A/P_5A resistant clone 280090.10, recently incorporated in the set of differential plants for identification of *G. pallida* races (Llontop & Franco, 1988). The populations of *G. pallida* races utilized to build up the hybrids and selfs were obtained from our cultures. The hybrids and selfed populations were obtained by crosses between females and males developed or collected from pieces of tubers grown in Petri

dishes containing water agar (2 %). The crosses between populations included all possible combinations and their reciprocals, to investigate the presence of a maternal or cytoplasmatic type of inheritance. Once the crosses were made, fertilized females were kept until cyst formation. Later on, cysts were collected and stored for two months at 15 °C to allow juveniles to develop inside their eggs and become ready for hatching.

Second stage juveniles for inoculation were obtained by incubation of cysts in potato root exudate collected from susceptible cultivars growing in pots. Inoculation of juveniles (J2) in cultivars Désirée, María Huanca and the clone 280090.10 followed the methods described for the Petri dish test (Mugniéry & Person, 1976). The nematode density per inoculation point on the roots was five J2 and the total number of J2 inoculated per cultivar was 80 due to the low number of crosses made. After 30 days, numbers of newly formed females were scored and the percentage of female formation was estimated. The normal approximation test — Z value — was used to compare the percentages. To establish if they were statistically different, this test considered the hypothesis that female percentages from crosses being compared were similar (Steel & Torrie, 1960).

Results and discussion

Results of reciprocal crosses between races did not show the occurrence of a maternal/cytoplasmatic inheritance although some differences were observed (Table 1). The resistant cv. María Huanca confirmed its partial resistance to races P_4A and P_5A of *G. pallida* and the full resistance of clone 280090.10 to both races. Both, the resistant potato cultivar and the clone behaved as susceptible to the new race P_6A (Fig. 1) showing its ability to overcome the genes for P_4A and P_5A resistance. So far, this group of nematodes represents the most virulent and aggresive race of *G. pallida* (Llontop, Franco & Scurrah, 1989). They are able to overcome all

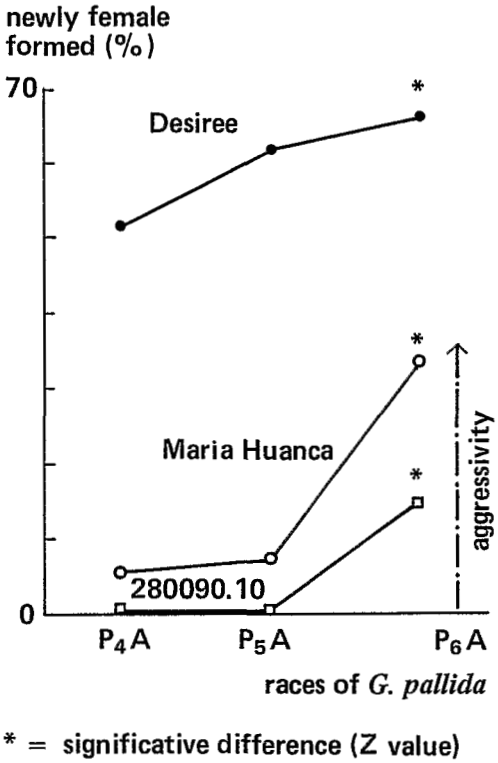

Fig. 1. Differences in aggressiveness between races of *G. pallida* (P4A, P5A and P6A) on two cultivars Désirée (● = susceptible) and María Huanca (○ = partially resistant to P4A and P5) and the clone 280090.10 (□ = resistant to P4A and P5A).

Table 1

Comparison of percentage of newly formed females of hybrids and their reciprocals on two potato cultivars and a clone with different levels of resistance by a normal approximation test.

Crosses	*Cultivars/clone**		
Hybrid vs *Reciprocal*	*Désirée*	*María Huanca*	*280090.10*
($P_4A \times P_5A$) *vs* ($P_5A \times P_4A$)	0.53 *vs* 0.53 (n.s)**	0.16 *vs* 0.19 (n.s)	0.01 *vs* 0.00 (n.s)
($P_4A \times P_6A$) *vs* ($P_6A \times P_4A$)	0.57 *vs* 0.48 (n.s)	0.22 *vs* 0.18 (n.s)	0.12 *vs* 0.09 (n.s)
($P_5A \times P_6A$) *vs* ($P_6A \times P_5A$)	0.61 *vs* 0.64 (n.s)	0.31 *vs* 0.26 (n.s)	0.16 *vs* 0.14 (n.s)

* Désirée (fully suceptible), María Huanca (partially resistant to races P_4A and P_5A) and 280090.10 (fully resistant to P_4A and P_5A).
** Calculated " Z " coefficient smaller than 1.645 for each pair are not significantly different.

the known genes for resistance present in the series of differential plants and they show a high rate of multiplication on susceptible cultivars (no genes for resistance or resistance genes to other races of *G. pallida*).

Results of hybrid nematode populations inoculated onto Désirée, María Huanca and 280090.10 are shown in Figure 2. When progenies from P_4A females (Fig. 2 *a*) crossed with males of the same race or P_5A and P_6A were inoculated onto Désirée (no genes for resistance) no differences were found in the percentage of newly formed females. However, when these progenies were inoculated on cv. María Huanca (partially resistant to P_4A and P_5A races), the hybrids $P_4A \times P_5A$ and $P_4A \times P_6A$ showed a significant difference with its self $P_4A \times P_4A$, indicating an effect of P_5A and P_6A virulence genes which were expressed by higher percentages of female formation. The existence of different virulence gene(s) is more clear with the clone 280090.10 (resistant to P_4A and P_5A races), where the selfed P_4A population and the hybrid population with P_5A males did not multiply, in contrast with hybrids with P_6A males, which did.

When progenies between P_5A females and other male races were tested on the same plants (Fig. 2 *b*), no differences in female formation were found on Désirée but with cv. María Huanca the hybrids behaved slightly different. The selfed P_5A population multiplied (8 %) but a significant increasing multiplication was noticed with the hybrid populations $P_5A \times P_4A$ and $P_5A \times P_6A$ (19 and 31 %). On the clone 280090.10, the hybrid $P_5A \times P_6A$ was the only population able to multiply (16 %) in contrast with the other two populations (selfed P_5A and hybrid $P_5A \times P_4A$), supporting the fact of the P_6A genes for parasitism.

The last group of populations obtained from crosses between P_6A females and males of other races (Fig. 2 *c*) showed a similar trend although the P_6A selfed populations and the hybrids with P_5A males had the highest percentages of female formation on the cultivars, but without a significant difference between them. On the contrary, the hybrids with P_4A males gave a significant lower percentage of female formation on the cvs Désirée and María Huanca (48 and 18 % respectively). No significant differences were found on the clone 280090.10 where the selfed P_6A population and the hybrid populations with P_4A and P_5A male did multiply.

Therefore, considering that maternal inheritance does not influence (Tab. 1) the differences observed in the percentages of newly formed females of both, the selfed populations (Fig. 1) and their hybrids (Fig. 2) on the cvs Désirée and María Huanca, and the clone 280090.10, these would just represent differences in aggressivity of the P_4A, P_5A and P_6A populations. However, although some of these genes for aggressivity seem to be shared by all three populations, it is clear by the behaviour of the

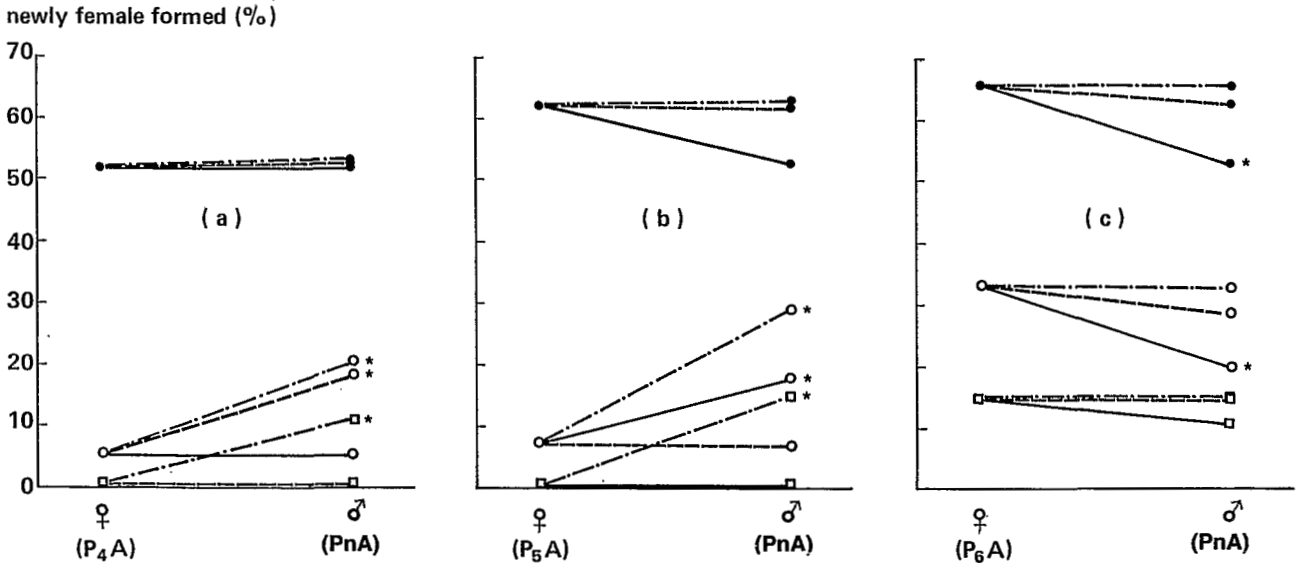

Fig. 2. Differences in percentage of female formation in the F1 of races P_4A (a), P_5A (b) and P_6A (c) of *G. pallida* and their hybrids on two potato cultivars and a clone with different levels of resistance : Désirée (●), susceptible, María Huanca (○) partially resistant to P_4A and P_5A, and 280090.10 (□), resistant to P_4A and P_5A.

P_6A hybrid populations that other genes are present which characterize this population.

The results indicated that this PCN population represents a new race of *G. pallida* which is able to multiply on all traditional standard differential clones utilized for identification of *G. pallida* races and on the new clone 280090.10 added to the set. The identification of this new race of *G. pallida* imposes the need to search for new genes for resistance and to use them in a breeding programme for the development of commercial cultivars with resistance to the race P_6A of *G. pallida*. Research with hybrid populations of PCN still continues in order to obtain further knowledge on the parasitic nature of the potato cyst nematode races.

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