Behavior of Inc-Q Plasmids in Agrobacterium tumefaciens

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Inc-Q plasmids were introduced into Agrobacterium tumefaciens, by mobilization from Escherichia coli with an Inc-P plasmid, or by transformation with purified plasmid DNA. It was found that they were stably maintained. The presence of an Inc-Q plasmid did not influence tumorigenicity. These results suggest that these plasmids may be used in genetic complementation studies of Ti plasmid mutants in A. tumefaciens.

The Ti plasmid of Agrobacterium tumefaciens is essential for crown gall tumor formation (1-3). Part of the Ti plasmid, the T-DNA region, is transferred to the plant cell during tumor induction (4,5). Another segment of the Ti plasmid, distinct from the T-DNA region, was also found to be essential for tumorigenicity (6,7). This segment, the so-called Vir-region, was shown to be complementable in trans by R prime plasmids (8; J. Hille, I. Klasen, and R. Schilperoort, submitted for publication).

Detailed complementation studies of such Ti plasmid mutants might give information on the mechanism of tumor induction by the bacterium. To this end, we sought possible cloning vehicles that: (i) can replicate in A. tumefaciens, (ii) do not themselves influence tumorigenicity, (iii) have a suitable size and can be used for cloning with insertional inactivation, and (iv) most preferably can also replicate in Escherichia coli. A vector that fits these four conditions may be used in E. coli for cloning and can then subsequently be introduced in A. tumefaciens for complementation studies.

The wide host range Inc-Q plasmid pKT214, derived from RSF1010 and encoding resistance against tetracycline, streptomycin, and chloramphenicol (9), was chosen as a possible candidate, since it agrees well with points (iii) and (iv). It has a molecular weight of 10.5 Mdalton and contains unique sites for BglII and XbaI in the tetracycline resistance locus. This plasmid was transferred from E. coli to A. tumefaciens by mobilization with the Inc-P plasmid R772 (encoding kanamycin resistance). Transconjugants were obtained which carried R772 and pKT214, as well as transconjugants which carried pKT214 only (transfer of pKT214: 10^-3 per recipient). With the same frequency pKT214 was mobilized within A. tumefaciens C58 strains, and from A. tumefaciens to E. coli.

Purified pKT214 DNA, isolated from E. coli, was used to transform A. tumefaciens strain C58 by a freeze/thaw method (10). About 2000 Tc'Sm'Cm' transformants were obtained with 1 pg plasmid DNA and 10^9 bacteria. The transformation frequency was not influenced when the same plasmid, isolated from Agrobacterium, was used. This value is comparable to the frequency of transformation of small Ti plasmid derivatives (11), which indicates that pKT214 is not sensitive to any restriction/modification system of A. tumefaciens strain C58.

In order to obtain an extra selectable marker on pKT214, this plasmid was made linear with BamH1. A small Ti plasmid derivative, pAL2832 (11), was also digested with BamH1, which gives fragments of 0.9 and 1.6 Mdalton. The 0.9-Mdalton fragment carries the Ch resistance marker of transposon Tn1. These fragments were mixed,
ligated, and used to transform *A. tumefaciens* to Cb resistance. One out of forty transformants turned out to carry pKT214-Cb, the plasmid of which was named pRL220 (see Fig. 1).

To test for possible influence of an *Inc-Q* plasmid on the tumorigenicity of *Agrobacterium*, several different strains were transformed with pRL220 and thereafter tested for tumor-inducing capacity on two different plants (see Table 1). No influence on oncogenicity was observed. This is in contrast to *Inc-W* plasmids. It was reported that, in their presence, *Agrobacterium* strains failed to induce tumors (12).

We have shown that *Inc-Q* plasmids do conform to the conditions stated. They replicate in *E. coli* as well as in *A. tumefaciens*, they can be transferred reciprocally between these species by mobilization and transformation, and they do not influence the tumor-inducing capacity of *A. tumefaciens*. Furthermore, cloning with the use of insertional inactivation is possible in the unique sites for *Bgl*II and *XbaI* in the Tc resistance locus of pKT214 and pRL220.

These plasmids can be utilized for site-specific mutagenesis of Ti plasmids in the manner described by Ruvkun and Ausubel (13). Ti plasmid fragments, cloned on pKT214, can, e.g., be transposon mutagenized in *E. coli*. Mutagenized recombinant plasmids can be introduced into an *Agrobacterium* strain, carrying a Ti plasmid. Upon introduction of pRL220, the described recombinant plasmid is lost because of incompatibility. With a certain frequency the transposon is rescued by homologous recombination with the corresponding region in the Ti plasmid.

The unique *Bgl*II site of pRL220 can be applied for cloning the cos site of phage λ, which is conveniently located between *Bgl*II sites on the plasmid pHC79 (14). This per-

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**TABLE 1**

TUMOR-INDUCING CAPACITY OF STRAINS CARRYING pRL220

<table>
<thead>
<tr>
<th>Strain</th>
<th>Plasmid(s)</th>
<th>Tested on tomato</th>
<th>Tested on sunflower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without pRL220</td>
<td>In the presence of pRL220a</td>
</tr>
<tr>
<td>LBA288</td>
<td>Crypticb</td>
<td>-c</td>
<td>-</td>
</tr>
<tr>
<td>LBA677</td>
<td>Cryptic, pTi</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>LBA937</td>
<td>Cryptic, pTi, R772</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>LBA973</td>
<td>Cryptic, pAL969d</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>LBA958</td>
<td>Cryptic, pTi-C58</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

a Plasmid pRL220 was introduced into these strains by transformation.

b The cryptic plasmid in *A. tumefaciens* is described by Casse et al. (1979).

c (-) No tumor induction; (+) tumor induction.

d Plasmid pAL969 is an R772::Ti cointegrate plasmid.
mits the use of this plasmid for cosmid cloning in *E. coli*. Fragments of about 15 Mdalton can be cloned on such a plasmid. The possibility to do so will contribute to complementation studies with Ti plasmid mutants.

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**REFERENCES**


