

## Rake & Trail

I'VE HAD SEVERAL requests to cover this subject, so I'll try to do it justice in a page. But even if you already understand the concept, perhaps I can shed some light on how tire and suspension adjustments affect trail, and how to use that knowledge to your benefit.

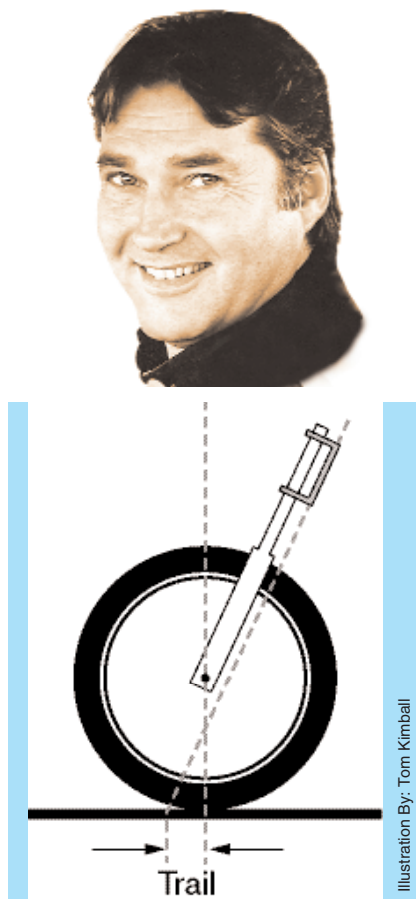
What we call trail is the distance between the center of the front tire's contact patch and the axis of the fork pivot (see the illustration). It isn't obvious when you look at a motorcycle from the side, but it's invariably true: The contact patch always trails the pivot point.

Rake refers to the angle of the fork, which typically varies between 23°–31°; sportbikes with the least, custom cruisers with the most. Offset in the triple clamp (the distance between the center of the pivot shaft and the center plane of the fork tubes) or an angle, can be used to give any amount of trail, regardless of rake. But once the design is produced, any increase in rake created by tire or suspension changes will increase trail and vice versa.

The actual amount of trail built into the front end geometry varies considerably from bike to bike, typically within a range of 3.5"–7.5"; again sportbikes on the short end and cruisers with the longer numbers. With such a wide variation, you might imagine that the exact distance isn't particularly crucial, but you'd be wrong. In fact, for the best handling, it needs to be almost millimeter-perfect. And if you'd ever seen the number of custom triple clamps with fractionally different offsets inside the transporters of factory roadrace teams, you'd despair of ever getting your own sportbike to handle properly.

How do you know if your bike has too little or too much trail? Because trail adds stability, and not enough trail will make a bike feel nervous and unstable, most manufacturers will err on the side of too much rather than too little. If your bike doesn't give you complete confidence in its front end grip, if it resists mid-corner directional changes or wants to run wide at the end of a corner, it probably has more trail than it needs. If it feels unstable, nervous and squirrely, it probably has too little. If it's just right, it feels like you can read the road surface through your handlebars and you have great confidence in your front tire grip, so you can enter turns rapidly, knowing everything is under control.

Unfortunately, we tend to think that if another rider goes more quickly than we feel comfortable riding, it's because we aren't sufficiently talented or bold, which



can have tragic consequences when the bike's handling is the real issue.

For the most part, only sportbikes and naked bikes come close to achieving ideal steering geometry, because sport riding is their reason for being. And they often have fully adjustable suspension that allows tiny tweaks to the standard setup in order to fine-tune their handling.

Adjustments that raise the rear of the bike are often described as adding more weight to the front end for better handling. But in fact, if you put the bike on scales, such changes do almost nothing to shift weight. What they really do is to change the rake and thus the trail. Remember, less rake = less trail and vice versa.

Tires make a big difference. The diameter of the tire, a function of its nominal size and aspect ratio, will vary from manufacturer to manufacturer even when listed as the same size, and slight diameter differences, especially on the front, will alter trail. The fork tubes can be lifted in the triple clamps to compensate for a taller tire, and 5 or 10mm will create noticeable changes. If you are very happy with your bike's handling, but want to try different tires, it would be a good idea to measure their circumference before purchasing.

For every 6.28mm (¼") greater circumference, the axle will be raised 1mm, which will add a little more than 1mm to trail.

Tire pressures also make a big difference, as the tread's compression will alter trail. Less pressure reduces trail. While most tires will easily tolerate pressures reduced 4 psi from stock to add footprint for aggressive riding, some won't, and the CB1000R tested this month, which has excellent steering feel in stock form, was adversely affected by dropping its front tire pressure just 2 psi.

It's also worth knowing that the rake and trail figures given by the manufacturers cannot be entirely trusted, as they may have been derived by different methods. If they are determined from blueprints, with the suspension fully extended and no weight on the tires, the trail number will appear longer than if the measurements are made on the ground, with the suspension and tires compressed.

Sometimes, we will find that a new bike will steer better with more rear preload, which raises the rear end, reducing trail. And oftentimes the improvement in steering feel will be more valuable than spoiling its otherwise balanced ride quality. Also, as the increased rear preload will make the rear suspension more prone to top-out cresting bumps, adding rebound damping will help reduce this response.

Some bikes don't offer sufficient rear end adjustments, but they can still be improved. Sliding the forks up through the triple clamps will do the same thing to reduce trail, but takes more effort.

Notice that hard braking causes front end dive, which dramatically shortens trail at the same time. But because the stability created by trail is a function of the pull exerted on the steering by the contact patch, which rises during braking, this works to your advantage. Note, too, that tire designs affect the stability created by trail, and knobby tires don't offer the same consistent contact patch as a street tire.

If you decide to make changes, keep careful records so you can go the other way if you don't find improvements. Don't change tire pressure by more than 4 psi unless an expert knowledgeable about your bike says otherwise. Test on familiar roads only when traffic is light, bring tools to try changes back-to-back, wear full gear and be cautious as you gain experience.

*DAVE SEARLE*

—Dave Searle  
Editor