The science behind Res+

The breakdown/degradation of crop residues is a complex process that begins as soon as harvest is complete. The quick and efficient breakdown of crop residues allows for the return of key nutrients back into the soil, leads to an increase in microbial activity, and leads to enhanced planting for the following crop year. To accomplish this feat in the shortest amount of time, Res+ was developed to expedite the process.

All crop residues left in the field are broken down by a combination of both degradative microbes, called saprobes, and their degradative enzymes that they produce to attack and break down residues into smaller digestible particles. These saprobes need several key ingredients to expedite this process, and Res+ enhances many of these attributes.

1. **Temperature:** The warmer the temperature, the greater the microbial growth rate is on the crop residue and the quicker the degradation can occur. Colder climates have a shortened window in which to break down residue, and this can lead to residue buildup from year to year. Applications of Res+ are most effective applied soon after harvest, or in the spring as the soils are warming up prior to planting.
2. **Moisture:** Microbes need moisture to both spread from the soil to the stalks, but also to colonise (coat) the residue with the microbes. This coating of the residue with living microbes places the microbes in close vicinity with the nutrients in the stalk, and allows the enzymes that they create to directly act on the residue. Res+ contains a humectant, which attracts water to the crop residue and holds it there, maximizing both the growth and spread of residue-degrading saprobes.
3. **Essential Nutrients:** Microbes require a variety of low abundance minerals for growth, including potassium, phosphorous, calcium, iron, boron, and copper. The macronutrients carbon and nitrogen are predominantly taken from the crop residue as a nutrient source. Res+ contains the most prevalent and most needed micronutrients for enhancing microbial growth, including magnesium, boron, copper, manganese, molybdenum, and zinc, in highly available chelated forms.

Optimal crop residue breakdown is also dependent on the type of residue and the conditions that speed up its degradation. The crop residue is predominantly made up of carbon, which is made up of three major materials: cellulose, hemicellulose, and lignin. A breakdown of the lignin, cellulose, hemicellulose, nitrogen, and ash content of major residue types are provided below (sourced from Cornell University).

Table 1. Breakdown of carbon and nitrogen sources from various crop residues

Material	Lignin %	Cellulose %	Hemicellulose %	Nitrogen %	Ash %
Wheat stubble	7-18	30-42	27-31	0.5-1.5	1.3-11
Barley stubble	11	48	21	0.68	7
Corn residue	11	28	28	1.05	7
Rice stubble	12	32.1	24	Not assayed	17.5
Soy stubble	16	38	16	0.83	6
Bagasse - sugarcane	11-18.9	33-38	30-34	1.42	10

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Cell Wall Constituents

Cellulose is a polysaccharide made up of long chains of glucose molecules, a preferred carbon nutrient for many microbes. The simplicity of the long glucose chains means that only a small number of selective enzymes are required for its breakdown. Res+ contains cell wall degrading enzyme that can break down cellulose and allows for expedited access for microbes to more cellulose and other carbon sources listed below.

In addition to cellulose, hemicelluloses serve as a major source of carbon for residue degrading microbes. Hemicelluloses consist of a mix of sugar structures, which besides glucose can comprise xylose, arabinose, galactose and mannose. They act as a reinforcing structural bridge between individual cellulose bundles as well as between cellulose bundles and the lignin molecules described below. The complexing of hemicelluloses, cellulose and lignin complicates how they breakdown in the field (Ladisch et al., 1983; Lynch, 1992). The enzyme in Res+ synergistically helps hemicellulose breakdown by weakening of the cellulose-hemicellulose network due to cellulose degradation, thus allowing quicker access for the soil microbes' own hemicellulose utilizing enzymes to attack.

Lignin is the last and most difficult carbon source for breakdown in residue. Lignin is made up of complex phenylpropane units, which are crosslinked to provide structural rigidity. Despite its resistant strucuture, some fungal microbes specialise in its breakdown, most common among them is the white rot fungi. These white rot fungi attack the lignin with enzymes similarly other residue degrading microbes attack the cellulose and hemicellulose fractions of the residue in the field. (Kirk and Farrell, 1987, Van Soest, 1994). The presence of higher levels of lignin reduces the overall surface area available for degradative enzymes, and also restricts access to the cellulose and hemicellulose fractions of the residue. (Haug, 1993).

Despite the resistant nature of lignin, there are proven methods of enhancing its breakdown and therefore breakdown of the residual residue in the field. The addition of nitrogen sources to woody materials, such as straw and stalks residue, has been shown to increase lignin breakdown (Yang et al., 1980). Res+ has 5.6% available nitrogen that allows for increased breakdown of lignin by lignin degrading microbes present in the field.

A number of other pre-treatments have been shown to affect the breakdown potential of residue and lignin. The addition of acidic material and both ammonia and urea components have been shown to speed up woody lignocellulosic degradation (Grethelin, 1985, Basaglia et al., 1992; Van Soest, 1994). Res+ contains significant ammonia, urea, and acidic components that each contribute to the enhanced breakdown of residue through cracking of the structural components, increasing surface area, and gaining access to the various buried carbon sources by microbial-produced enzymes.

Taken together, the breakdown of crop residue in the field is a complex process that entails optimizing and coordinating a microbial attack of the residue by enzymes. The addition of Res+ to residue gives the microbes everything they need to expedite their growth on the residue and speed up their attack of the residue with their enzymes (micronutrients, moisture, optimal carbon/nitrogen ratios). In addition, Res+ adds its own patent pending enzyme that helps facilitate the initial breakdown of the residue and quicker establishment of the microbes on the residue, as well as Res+ components that pretreat the residue to make it more amenable to breakdown (ammonia, urea, acidic components).

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