



# Agricultural warfare

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BY **DAVE SAMMUT**

**Agricultural innovation was a precursor to terrible conflict in the 20th century.**

**W**ar is a terrible part of human existence. Early in the 20th century, the world was stunned by the scale and ferocity of a new conflict. Never before had so many nations gone to war with each other. Never before had so many people died, under conditions so horrendous, and with such rapid innovation in technologies for destruction. This was 'the war to end all wars'. How could it have come to this?

The 19th century had already set the scene of a world undergoing fundamental transition, at a pace neither imagined nor always welcome. Scientific advances, greater life expectancies and democracy had brought unexpected suffering through industrialisation, urbanisation, imperialism and nationalism.

As the century closed, political and industrial forces were coming together, leading inexorably to the first

global conflict. The mood of the day was captured in science fiction. Jules Verne's *Twenty thousand leagues under the sea* (1868) imagines a militarised submarine, captained by a fugitive prince seeking revenge against the British following the murder of his family during the Indian mutiny against the British East India Company in 1857. His 1870 novel *From Earth to the Moon* details the artillery science of gentlemen engineers, with the aim of colonisation, designing a cannon large enough to launch a projectile, complete with three men, two dogs, several chickens ... and no women.

While the development and use of chemical weapons during the Great War continues to live in infamy, I was interested to learn how developments in 19th-century agriculture (more specifically, fertiliser) contributed to the war – scientifically, industrially and politically.



Guano is widely reported to have been used by Andean populations for agriculture for over 1000 years, and the Incan empire had laws to restrict its use and mining (from small islands close to the Peruvian coast) to preserve the resource.

Alexander Von Humboldt began investigating guano's fertilising properties in 1802, and by 1840 the guano industry had taken off. Research in the era, including Justus von Liebig's 1840 text on organic chemistry, demonstrated the benefits of both nitrogen and phosphorus in fertiliser, for which guano was an outstanding natural source (up to 16% nitrogen, 12% phosphate and 3% potash). Liebig was particularly notable for applying chemistry to plant and animal physiology, where the prevailing theories firmly separated the two.

Guano was mined heavily from the Peruvian islands, as well as tropical islands around the world, from deposits sometimes 30–50 metres

deep. A very limited and non-renewable resource (at least over the short term), it quickly became subject to imperialist geopolitics. The Peruvian guano had particular advantages: the lack of rain on the islands allowed the accumulated droppings to bake in a dry atmosphere, better preserving the nitrates.

Britain was Peru's largest market for guano, with trade of about 20 million tonnes between 1840 and 1880. This period was one of substantial expansion and growth in the US, and the race to secure new sources was fierce. The US's 1856 *Guano Islands Act* declared exclusive rights to any American who found a new guano source on unclaimed islands. However, imprecision in navigation meant that many islands were mis-located, causing double-ups and counter-claims. The US claimed over 60 islands in total.

The human toll from this trade was enormous. Much of the mining was

performed by African slaves and Chinese labourers. Among the terrible conditions that they had to endure was ongoing exposure to airborne guano dust, which caused severe respiratory problems. Slavery was not abolished in Peru until 1854.

Within just 50 years, world guano reserves were substantially depleted. Industrial production turned to the heating of bone ash, and then to electric arc production from phosphate rock. By the turn of the century, the latter was the dominant source of phosphate fertiliser production.

Throughout the period, other sources of nitrogen and phosphate fertilisers were being developed. The Frank–Caro process for production of calcium cyanamide ( $\text{CaCN}_2$ ) from calcium carbide and nitrogen gas commenced industrial production from 1905. Other contemporaneous processes were put forward: electric arc production of nitric acid in the US, the Birkeland–Eyde process for nitrous



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Once a site of major economic activity in guano mining, the Ballestas Islands on the south coast of Peru are now a wildlife sanctuary. Bridges for loading guano onto ships are still in place.

oxide production in Norway, and the Pauling process in Germany and the US.

In one of the more interesting developments, a process was developed to dissolve coprolites (fossilised animal droppings) in East Anglia in sulfuric acid to make 'super phosphate'.

Together, the use of and competition for nitrogen and phosphorus formed a major undercurrent in the building wave of economic pressure around the world. The 19th century saw a boom in agriculture, driven by the widespread use of fertiliser, industrialisation of processes and better agricultural science.

I am no historian, but I find it interesting to consider just how much the growth in available food combined with the associated population explosion and international

competition for resources contributed to the global powder keg at the beginning of the 20th century. Equally interesting is how the massive industrial complex that had been established to serve these bucolic, ostensibly peaceable, purposes, were so easily turned to the machine of war.

Take the Haber process as an example. It was a breakthrough technology in 1905 for the catalysed production of ammonia from nitrogen and hydrogen at high pressure and temperature (around 450°C and 200 atm) – and therefore for fixation of nitrogen for fertiliser production. Developed by Fritz Haber, the technology was implemented on an industrial scale by Carl Bosch in 1913, and conversion of these facilities to explosives production is widely credited as having significantly contributed to prolonging Germany's war effort.

Haber's work was a driving force behind Germany's chemical weapons program during World War I. He was expelled from the country by Hitler for his Jewish heritage, and died in Switzerland in 1934. Sadder still is that an insecticide (cyanide-based Zyklon B) invented by an assistant of Haber was then used to murder Haber's family members as part of Hitler's holocaust.

In a similar fashion, technology for the electrothermal production of fertiliser from phosphate rock (as a replacement for guano) yielded related processes for white phosphorus production, which became extensively used in matches during the later decades of the 19th century. Composed of a  $P_4$  ring, white phosphorus degrades to red phosphorus (a polymeric structure) on exposure to heat and light, so that the common grades of material are

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typically yellow. It is highly toxic, and the exposure of workers in match factories caused severe necrosis of the bones of the jaw (called 'phossy jaw').

White phosphorus found a range of uses during World War I, including the production of smoke to obscure battlefields, tracer and incendiary bullets, and chemical weapon shells. Its uses in World War II were even more sinister, including as a major weapon in the incendiary bombing of Hamburg, the city in which it was originally identified in the 18th century. White phosphorus sticks to whatever it touches, and although it burns with a relatively low heat, it is very difficult to extinguish. Even if doused by water, it will re-ignite once exposed again to air. Phosphorus wounds must be thoroughly washed with a non-polar, non-flammable solvent before the burn can be treated.

Tracer bullets are a branch of the same technology tree. Towards the start of World War I, a shooter could only determine the accuracy of his shot by watching for the strike, which isn't possible at night. Moreover, this wasn't much use during aerial combat,

where a bullet that missed its target had no impact point. Britain's first tracer bullets were deemed to contravene the Hague Convention because they exploded on impact.

White phosphorus was added to bullets to create smoke during flight, and hence the early versions were called 'smoke tracers'. Later versions used a mixture of barium peroxide and magnesium. In flight, they burned with an intensity that was readily visible even in full sunlight, and although they burned only for a few seconds, this was still sufficient to follow the flight for a considerable distance – half a kilometre or more from the muzzle. However, the tracer bullets had a poor range. As the bullet lost mass during flight, its path became erratic.

Tracers were inserted as every fifth or so round in the magazine feed to a machine gun. A US report on the development of its own version from British and French technology stated:

*The tracer bullet consisted of a cupronickel shell, the nose of which contained a leaden core to balance the bullet properly. The rear chamber of the*



Fritz Haber (1868–1934), sketched in 1911 by W. Luntz

*bullet held a cup containing the mixture of barium peroxide and magnesium. The rear end of the bullet was left slightly open, and through this opening the mixture was ignited by the hot flame of the propelling powder charge.*

**America's Munitions 1917–1918: Report of Benedict Crowell, the Assistant Secretary of War, Director of Munitions, United States War Department, Government Printing Office 1919**

A special form of incendiary bullet was developed and used to shoot down hydrogen-filled zeppelins over Britain. Where conventional bullets just caused a slow leak, an incendiary bullet would cause a catastrophic ignition of the hydrogen.

During the 20th century, the pressures of conflict resulted in rapid advances in chemistry and technology. The use of tanks, air and chemical warfare all emerged during World War I. I have found it sobering to consider how the wider context of these developments helped set the scene for the war in the first place.

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