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The Math Behind Biointensive Agriculture: Companion Planting Calculator

Biointensive agriculture (BIA) is the set of techniques practiced by small-scale sustainable farmers who want to make the most efficient use of limited renewable resources. When considering what to plant, BIA suggests a high-density mixed planting system for maximum efficiency. This means planting beds with two or more plant species spaced relatively close together. Contrast this with conventional monoculture farming practices, which can produce high yields in the short term but are not sustainable in the long term. BIA farmers in the planning stages can access a highly beneficial resource online called the "Companion Plant Spacing Calculator"[1]. Dr. Michael Bomford, professor and researcher at Kentucky State University and the University of Kentucky, is the creator of this free resource. After experimenting with various planting distance strategies, Bomford has come up with a calculation that takes both area and plant proportion into account, something previous calculations were lacking.

One of Dr. Bomford's experiments, run from 2001 through 2002, tested the hypothesis that mixed planting makes more efficient use of land than single-planted "pure" beds. Using the three plants of tomatoes, basil, and Brussels sprouts, Bomford compared pure plantings of each crop with three mixed beds: tomatoes and basil, tomatoes and Brussels sprouts, and Brussels sprouts with basil. Since tomatoes and basil are well-known companions while brassicas are known to be antagonists to tomatoes, Bomford expected better efficiency with the companion plants versus the antagonists. After two trials of one-year growth monitoring, Bomford's results only supported the higher-efficiency of mixed planting hypothesis in 2002, a year that experienced higher temperatures and drier

[1] Bomford, Michael. "Companion Plant Spacing Calculator." *Companion Plant Spacing*. Kentucky State University, 05 June 2009. Web. 11 Mar. 2014. http://organic.kysu.edu/CompanionSpacing.shtml

climate. Neither did his results support the hypothesis that the "companion" planting of tomatoes and basil made more efficient use of land than the "antagonist" pairing of tomatoes and Brussels sprouts. The experiment was not at all a waste, however, since it led Bomford to create a new equation for calculating spacing for plantings containing two or more species.

One popular method for calculating efficient distance between companion plants can be found in John Jeavon's manual "How to Grow More Vegetables." One simply takes the mean of the suggested distances for each plant's pure planting. The example Bomford provides on his website is the mixture of corn and beets. Since a monocrop of corn has a plant spacing recommendation of 15" and beets have one of 4",

$(15+4)/2 = 9.5$

Thus, an efficient distance between each plant would be 9.5" in a hexagonal pattern.[2] There are two problems with this method, however, which Bomford realized after performing his experiment in 2001 and 2002. The first is that it does not take into account the proportion of crops in the mixture. The second is that it does not account for the square of plant spacing, which is the plant's available area. Bomford re-configured the equation to account for these missing factors:

$\sqrt{(ps_A + (1-p)s_B^2)}$

Here, p is the proportion of crop A in the planting (value between 0 and 1), s_A is the recommended spacing for a pure planting of crop A, and s_B is the recommended spacing for a pure planting of crop B. Bomford plugs in the equation with the values for corn and beets and reveals the new, shorter distance of 8.25" instead of 9.5".

Numerous studies have been done showing the benefits of mixed plantings over mono-crop systems. Bomford's results of his 2001-2002 experiment were skewed by a change in the uncontrollable variable of weather, but one year did show a benefit to the

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[2] Bomford, Michael. "Companion Plantspacing Calculator." *Companion Plant Spacing*. Kentucky State University, 05 June 2009. Web. 11 Mar. 2014. http://organic.kysu.edu/CompanionSpacing.shtml

mixed planting method over the pure plantings. Overall, mixed planting increases diversity, which is the ultimate goal of sustainable agriculture. In the National Center for Appropriate Technology's "Agronomy Systems Guide", Preston Sullivan outlines the reasons behind sustainable agriculture succinctly: "Since nature consistently integrates her plants and animals into a diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity. Nature is also efficient…By understanding these principles we can use them to reduce costs and increase profitability, while at the same time sustaining our land resource base."[3] Diversity can be increased via crop rotation, "farmscaping" (building habitat features like borders and windbreaks), and what they call "Intercropping", their term for mixed planting. According to Sullivan, numerous trials have proven that growing two or more crops together will "increase productivity per unit of land."[4] Another reason to plant mixed beds is that "There is overwhelming evidence that plant mixtures support lower numbers of pests than do pure stands"[5]. Another form of increasing biodiversity is using mixed cover crops during the off-season, which can reduce the amount of insecticide and fertilizer needed during the growing season.

The evidence may not be clear on specific companion plants, but years of farmers' observations and recent scientific studies in the laboratory have found that farmers can benefit from mixed planting methods. With increasingly dwindling natural resources and highly questionable weather changes in the future, biodiversity will reduce risk in the long-term, both financially as well as environmentally.

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[3] Sullivan, Preston. "Intercropping Principles and Production Practices". *National Sustainable Agriculture Information Service*. 2003. Web. 11 March. 2014. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=105

[4] Sullivan, Preston. "Intercropping Principles and Production Practices". *National Sustainable Agriculture Information Service*. 2003. p.4. Web. 11 March. 2014. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=105

[5] Sullivan, Preston. "Intercropping Principles and Production Practices". *National Sustainable Agriculture Information Service*. 2003. p. 8. Web. 11 March. 2014. https://attra.ncat.org/attra-pub/summaries/summary.php?pub=105