Investigating the Effect of Intercropping on Crop Yield and Yield Stability

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Key Definitions

Intercropping: Intercropping is the practice of growing two or more crops in proximity. Although there are multiple variants of this practice, including row intercropping or mixed intercropping, the method is generally thought to increase crop yields and profits by improving efficiency in the use of nutrients, radiation, and water, improving the results and stability of agricultural production.

Monocropping: Monocropping is an agricultural growth method of growing a single crop year after year on the same land, a more traditional practice that has been widely regarded as being environmentally damaging and less lucrative

Yield Stability: Although yield stability has been described in many different terms, the most generally accepted definition, given by *Penn State*, refers to how stable the yield of an agricultural system is over time from one year to another (Penn State)

Introduction

This report seeks to compare yield and yield stability in an intercropping set up, as opposed to a monocropping setup, by considering a range of different papers written on the subject – consolidating information from numerous extensive studies. Most of these studies performed one of three types of experimentation; (1) comparing the yield or yield stability as a result of intercropping to that of monocropping, (2) comparing the soil erosion/degradation between different agricultural methods or (3) comparing different intercropping setups to observe which arrangement produced the best results. This indicates that most were considering yield and land efficiency as key metrics to value the success of intercropping. Building from that, this paper will look at similarities or differences across multiple experiments to provide an analysis of the workings of intercropping. The papers chosen were mostly focussed on the southwestern Mediterranean region or coastal regions and, accordingly, provide adequate means for comparison. Two factors, yield and yield stability, will be considered from an analytical lens to see how the practice of intercropping has affected each one

The Effect of Intercropping on Yield

Multiple surveys have tried to measure the impact of yield on intercropping. In Gou et al, an increase of 40% was observed in yield through the intercropping system as compared to monocropping in coastal China. They found that, compared with the current land use, if all farmers replaced wheat-corn intercropping with a monocropping set up, yield would be reduced by a percentage up to 44%. This rise was substantiated by a paper written by Song, Zhang and Shultz, with one paper noting a 7 to 24% enhancement and another measuring an average RYT

(relative total yield) of 1.14 in an intercropping setup. Within the context of the paper, this meant that since the relative total yield is on average greater than 1, more than 1 hectare of a monocropping setup was required to equal 1 hectare of polyculture, or intercropping yield.

Additionally, many of these papers also measured the land efficiency both the methods result in, an improvement upon which would naturally result in higher yield. One paper mentioned that in a relay intercropping agricultural arrangement, the land use efficiency is 22% higher than that of the corresponding single crop (Gou et. al). In another, land use efficiency was increased by 40% through an intercropping system and an increment of 27% for maize-repe and 42% for maize-pea versus sole crops were obtained (Khanal, Slott). Furthermore, in the paper (Huang, 2019), the author noted that intercropping had a higher land and nutrient use efficiency and lower pest and disease incidence as compared to sole crops. (Although according to the data, there was a decrease in the production of intercropping as compared to monocropping).

Intercropping also proved to be better suited to more extreme climates. Both tropical and temperate areas support intercropping. In Central Africa, corn, sorghum, or millet is grown with pumpkin, cowpeas, pigeon peas, or beans (Faris). The logic behind the adaptability of crops in an intercropping setup was elaborated on by one source claiming that *"crops need crops that benefit from each other, not compete with each other. We need to choose them according to the depth their roots can reach, and the amount of sunlight, nutrients and water they need"* (Schultz). Such studies have shown that polycultures give greater productivity and economic profitability than monocultures. On the other hand, monocropping drains the ripeness (fertility) of the soil, making it less fertile over time. Additionally, continuous monocropping may prompt the speedier development of pests and diseases. While there were instances of a decrease in the production of intercropping as compared to monocropping in papers like Huang and Faris, this yield decrease was largely due to competitive interactions with other areas of the field, making them outliers in comparing data.

The Effect of Intercropping on Yield Stability

Although yield is an important metric to see how successful an agricultural arrangement is, yield stability might be a more telling value. The importance of measuring this was highlighted by one paper by Raseduzzaman: *"An agricultural system with high yield stability will output about the same amount of food each year. An agricultural system with low yield stability will output very different amounts of food each year."* Therefore, while environmental benefits and yield increment are important considerations, yield stability is likely the best metric for judging the success of intercropping.

After analysing 33 articles, intercropping was generally seen to improve the stability of agricultural production in the face of seasonal and climate changes (Khanal). One particularly

telling paper found that, in a replacement design to the monocropping system, intercropping had significantly ($P < 0.05$) higher yield stability than respective cereal and legume sole crops. Another paper again measured that an intercropping setup was more stable than the monocropping yield in an additive design system. Intercropping in all climatic zones showed higher yield stability than most sole crops. Therefore, increasing crop diversification through intercropping can improve yield stability and food security, and make important contributions to the ecological function, ecology, or sustainable intensification of global food production (Raseduzzaman).

This was also measured mathematically by an article considering ‘disasters’ or failures each set of crops goes through in one year of growth. On the basis of 94 experiments conducted, it was concluded that intercropping had greater stability than solo cropping. An example of the experiments conducted included measuring crops in a sole pigeonpea and sorghum system, both variants of the traditional intercropping arrangement. For a particular disaster, sole pigeonpea would fail one year in five, sole sorghum one year in eight, but intercropping only one year in thirty-six. The yield stability of the overall intercropping system was then inspected by ascertaining coefficients of variation, by computing regressions of yield against a natural record, and by assessing the likelihood of financial returns falling underneath given 'calamity' levels, all which showed a clear bias in favour of an intercropping setup (Rao).

Conclusion

After clearly analysing all the papers, it becomes apparent that intercropping provides better results, both in terms of yield and yield stability. The average rise in yield was around 30-40% with a polyculture setup as opposed to a monoculture one, showing the impact intercropping can have. Additionally, a rise in yield stability corroborates the fact that, not only is there a greater yield, but it is likely to be a stable one in the long run. This information, while telling, is unlikely to be true across the world. The sample size of papers used for experimentation was relatively large, but a drop in the ocean compared to all the research done on this subject – with this report only consolidating sources available at the time. Furthermore, most of the sources restricted their area of growth as well as the time period they were considering while measuring yield stability. Both these factors could be altered in further experimentation to provide a more comprehensive view of the topic in the future.

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