

Review Article

Review on: Role of Pulse Intercropping for Hindering Rust Disease and Improving Yield of Wheat (*Triticum aestivum* L.)

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Abstract: Wheat is the third most produced cereal in the world after maize and rice. Due to ever increasing human population and decreased area under cultivation, there is a pressure on limited land resource to meet basic demands of increased population towards food, fodder, pulses, oilseeds etc. The potential to increase arable cropping area is severely limited without significant environmental implications; the way to solving the problem is a sustainable intensification through a re invigoration of yield improvement by either genetic progress or optimization of cropping systems. Having this idea in mind, it can be conclude that, intercropping systems have the scope and potential to exceed the yields impossible in monocultures of their component species and hindering variety of disease development such as rust. It provides a variety of returns from land and labour to the farmers, often increases the efficiency with which scarce resources are used and reduces the failure risk of a single crop that is susceptible to environmental and economic fluctuations. Cropping system based on carefully designed species mixtures reveal many potential advantages interims of enhancing crop productivity, reducing pest and disease, and enhancing ecological service. Therefore it can be recommended that intercropping wheat with pulse crop is a desirable agronomic practice towards boosting of yield and prevention of disease incidence such as rust.

Keywords: Intercropping, Rust Disease, Yield, Bread Wheat and Pulse

1. Introduction

1.1. Background of the Review

Among food-grains, wheat is the most important staple food grain crop and stands next only to rice at global level. Wheat is the third most produced cereal grain in the world after; 875 million tons and rice, (*Oryza sativa* L.; 718 million tons) with a production of over 674 million tons on over 216 million ha, or 3.1t ha⁻¹ [9]. Due to ever increasing human population and decreased area under cultivation, there is a pressure on limited land resource to meet basic demands of increased population towards food, fodder, pulses, oilseeds etc. Therefore, it was realized that there is a need not only to increase production of cereal crops, but also the ability to grow multiple crops with inclusion of oilseed and pulse in existing crops or cropping systems in same piece of land [25].

The potential to increase arable cropping area is severely limited without significant environmental implications; the route to solving the problem is a sustainable intensification through a re-invigoration of yield improvement by either genetic progress or optimization of cropping systems [26]. In these conditions, intercropping systems have the scope and potential to exceed the yields possible in monocultures of their component species. It provides a variety of returns from land and labour to the farmers, often increases the efficiency with which scarce resources are used and reduces the failure risk of a single crop that is susceptible to environmental and economic fluctuations [21].

Intercropping is the type of cropping system involving the growing of two or more crops in the same piece of land at the same time or relayed which could compute for growth resources for certain growth period. This farming practice is a popular crop production system used in subsistence tropical agriculture and is very common in the semi arid areas of

Africa. It is also cropping practices that possess the potential of providing valuable ecosystem services such as improved pest control, increased resource use efficiency. Lowered weed infestation levels, in crop livestock mixed farming system [32]. Intercropping provides a possible pathway for ecological intensification, achieving high crop yields and improving the environment by using ecological mechanisms to reduce anthropogenic inputs in agriculture [5]. Furthermore; Intercropping have some advantages e.g. better use of growth resources, control of weeds, pests and diseases and greater stability of yield in case of environmental hazard over the monoculture of the companion crops. The merits of intercropping have been maintained by; additional income from companion crop, insurance against failure of the main crop and, quick growth of companion crop tends to suppress severity of weeds and disease such as rust in wheat [25].

Wheat is often cultivated with pulse crops such as chickpea, lentil, faba bean, cowpea, pea and lupine as a companion crop and those are food crops often traditionally and in modern way grown in an intercropping form in the world. Intercropping lupine with cereals such as wheat is cultivated to a greater extent than before because of its adaptability, stability and feasibility of production under low soil fertility status and disease severe area. It is also an annual legume and non climbing growth habit and has high levels of protein. The tap root system of lupine could exploit water and nutrients from deeper soil layers than cereals [15]. [32] also point out that wheat intercropped with lupine has access to a larger pool of Phosphorus, Manganese and Nitrogen than sole cropped wheat. Production cereals in intercrop with lupine could also provide a rotational yield response to main season crops. However, management of cereals intercropped with lupine follows simple natural principles, and its practice is limited only by the imagination of farmers. They used less than 25% lupine seed rate with full cereal seed rate. Meantime the combined effect of those cropping system is highly crucial and results yield increment. Therefore reviewing and identifying the research gaps in the role of pulse crop intercropping with wheat for hindering rust disease development and improving yield performance of wheat is very important.

1.2. Objective of the Review

To review the role of pulse intercropping for hindering rust disease of wheat (*Triticum aestivum* L.).

2. Review of Literatures and Discussions

2.1. Definition of Terms

Intercropping: Intercropping generally refers to growing a mix of non-legume and legume crops. Intercropping could have several benefits, such as yield stability and reduced risk of crop failure due to crop diversity. Lower input costs due to less fertilizer and pesticide usage, improve grain yield and economic returns in cereal-legume [27].

Rust: Plant disease caused by more than 7,000 species of fungi of the phylum Basidiomycota. It affect many

economically important plant species and usually appear as yellow, orange, red, rust, brown, or black powdery pustules on leaves, young shoots, and fruits [29].

2.2. Role of Pulse Crop Intercropping with Wheat

Cropping system based on carefully designed species mixtures reveal many potential advantages interims of enhancing crop productivity, reducing pest and disease, and enhancing ecological service. Associating cereals and legume production through cropping system might be a relevant strategy of producing both types of crops while benefiting from combining nitrogen fixed by the legume through symbiotic association with nitrogen fixing bacteria and from better use of phosphorous and water through micorhezial association [30]. World population increases rapidly and global food production must be adapted to the requirements of human consumption. To increase the cultivated land area would be very difficult, so it is necessary to promote crop production or the efficient use of existing croplands [22].

Despite possible advantages; however, intercropping has traditionally been neglected in temperate climate agriculture with cropping systems based on agrochemicals because of its complexity and management difficulties, although there is an increasing interest in intercropping in temperate regions [16]. Intercropping, defined simply as the growing of two or more crops together simultaneously in the same piece of land has been shown to be beneficial in terms of yield stability, increase in total yield, pest and disease management, and weed management, erosion control, and soil fertility amongst others [14]. Moreover, [33] argued that intercrops have the capacity to make use of resources, specifically radiation more effectively than the sole crops which means that wheat might have used transmitted radiation to produce optimally, bean might have used direct irradiance to produce. Considering the impact of intensive agriculture on the environment and human health, as well as the many alternatives proposed, such as intercropping legume-cereal, it seems very interesting to know the impact of the intercropping cereal-legume on the symbiotic root nodulation, and to what extent this system would affect the activity of the rhizobial symbiosis in comparison with a legume sole crop [25].

Nutritional benefits and agro-ecological services of legumes may constitute an alternative agronomic practice for a better use of the growth resources, by integrating them into cropping systems either in intercropping or in rotating crops [24]. Intercropping also increase N inputs to the plant-soil system, and the growth and yield of the intercropped cereal, by improving the efficiency of Moicrohizobial symbiosis [4] for wheat-chickpea intercrops. [19] reported that a significant increase in the yield of wheat when it was grown in intercropping with soybean compared to their respective sole cropping. In a long-term experiment, [7] showed that both intercropping and rotating wheat and faba bean increased N uptake and productivity. Introducing cropping system practices such as cereals and legumes in agro ecosystems can improve soil C stocks [7]. Particularly of intercropping legumes with low soil organic matter inputs [28]. Under warm

climatic conditions, including forage legume crops in the rotation can provide a direct N contribution and indirect benefits to crops by improving soil fertility. Therefore grain crop yield and N nutrition are improved in the years following forage legume crops, which should encourage agricultural producers to include legumes in their crop rotations [1]. [31] worked on intercropping of wheat and chickpea and reported that the total intercrop seed yield was greater than yields of both wheat and chickpea sole crops. [33] also point out that the total intercrop yields was greater than yields of sole crops of maize and faba bean. These various investigations clearly indicate that it is possible to obtain greater total intercrop yield compared to the yields of the component sole crops.

2.2.1. Role of Pulse Crop Intercropping for Hindering Rust Disease Development of Wheat

Rust pathogens have hindered global wheat production since the domestication of the crop and continue to threaten the world wheat supply. It is estimated that global annual losses to wheat rust pathogens range between US\$ 4.3 to 5.0 billion. Rust fungi are obligate biotrophic organism that is completely dependent on nutritional resources obtained from living host cells for growth and reproduction. Rust species vary in their ability to infect certain hosts and this differential biology is reflected in the classification of the species. There are three wheat rust diseases, namely stem, stripe and leaf rust, all caused by members of the Basidiomycete family, genus *Puccinia*, named *P. graminis* f. sp. *tritici* (Pgt), *P. striiformis* f. sp. *tritici* (Pst) and *P. triticea* (Pt), respectively [20]. Genetic resistance to rust infection has been identified as either race-specific (also known as seedling or qualitative resistance) or non-race-specific resistance [23].

Reductions in plant diseases and pests have been recorded also for variety mixtures or intra-specific diversity of crops [33]. [34] reported that 94% reduction in plant disease in intercropping of two rice genotypes. Other studies on intercropping for disease control have usually achieved lower rates of disease suppression, but experiments assessing the plant disease reducing effect of species mixtures have never been synthesized quantitatively. There is a need for critical analysis of literature to synthesize the existing knowledge and ascertain the average levels of disease reduction attained in intercropping, its variability across studies, and factors affecting disease suppression.

However, [17] stated that the high biomass production of bean particularly when sown early could restrict the flow of air in the canopy and thereby favoring the development of diseases. Intercropping helped to control pests and diseases problems demonstrated that intercropping with sorghum produced a large reduction in the incidence of *Fusarium udum* (wilt) in pigeon pea (*Cajanus cajan*) by up to 55%. This is due to the host plants are more widely spread in intercrops, such that they are more difficult to locate. ii) One of the component crops might serve as a trap crop to deter the pest from finding the other crop. iii) One of the component crop species might serve as a repellent to the pest [33]. Lodging in wheat was often a result of the combined effects of diseased plant due to

rust but intercropping of wheat with lupine can limit the aggressiveness of disease in the wheat field [32].

2.2.2. Role of Pulse Crop Intercropping on Yield Performance of Wheat

The positive effects of species diversity in intercropping systems result from two main processes: complementarity and facilitation [10; 12]. [32] Reported that wheat intercropped with lupine, bean and pea produced significantly higher grain yield than wheat in sole crop. This due to nitrogen fixing ability of legumes and extensive root system of cereals. Similarly [25] also reported that the plant height, spike length, number of grains per spike and grain yield of wheat was higher with chickpea intercropping, while the effect on 1000 grain weight was non-significant. [2] added that higher yield of wheat and lentil was achieved when both crops were sown in lines of intercropping than broadcast systems. This increase in wheat productivity in intercropping has also been reported by [13] who found that grain yield of wheat was higher in intercropping with faba bean than in monocropping. However For wheat, under intercropping conditions with bean or other crops biomass yields are often substantially reduced largely due to intense competition between the two component crops [33].

According to [33] when durum wheat intercropped with cowpea, faba bean and soybean the protein content of wheat and faba bean grain was significantly higher for intercropping than for sole. Similarly, [3] found that an increase in the protein grain content of wheat and pea concentrations in intercrop compared to the two monocrops. [30] was conducted afield experiment aiming to estimate the two years impact practice on wheat yield and soil microhizal activities and he found that intercropping give better results interims of crop productivity than the rotation practice after the two rotation seasons. benefits results from inter crop should be highly linked with soil microhizal functionalities. Wheat rapeseed intercropping with 6 rows of wheat+ 2 rows rapeseed could be an option to enhance yield benefits and rapeseed production [8]. Intercropping of wheat with canola, [17] had significant effects on grain and relative yields of wheat and canola. Sole crops of wheat and hybrid canola had higher wheat and canola yield, whereas 4 rows of wheat and 2 rows of hybrid canola intercropping provided higher relative yields for both wheat and canola.

3. Conclusion and Recommendation

3.1. Conclusion

The potential to increase arable cropping area is severely limited without significant environmental implications; the route to solving the problem is a sustainable intensification through a re-invigoration of yield improvement by either genetic progress or optimization of cropping systems. Having this idea in mind, it can be concluded that, intercropping systems have the scope and potential to exceed the yields impossible in monocultures of their component species and hindering variety of disease development such as rust. It provides a variety of

returns from land and labour to the farmers, often increases the efficiency with which scarce resources are used and reduces the failure risk of a single crop that is susceptible to environmental and economic fluctuations.

3.2. Recommendation

Cropping system based on carefully designed species mixtures reveal many potential advantages interims of enhancing crop productivity, reducing pest and disease, and enhancing ecological service. Associating cereals and legume production through cropping system have a relevant strategy of producing both types of crops while benefiting from combining nitrogen fixed by the legume through symbiotic association with nitrogen fixing bacteria and from better use of phosphorous and water through michrohezial association. Therefore it can be recommended that intercropping wheat with pulse crop is a desirable agronomic practice towards boosting of yield and prevention of disease incidence such as rust.

References

- [1] Adrien N'Dayegamiye, Joann K. Whalen, Gilles Tremblay, Judith Nyiraneza Michèle Grenier, Anne Drapeau, and Marie Bipfubusa. The Benefits of Legume Crops on Corn and Wheat Yield, Nitrogen Nutrition, and Soil Properties Improvement. *Agronomy Journal*, Vol 1 07, 2015.
- [2] Akter, N., Alim, Md. A., Islam, M. M., Naher, Z., Rehman, M. and Iqbal Hossain, A. S. M. Evaluation of mixed and intercropping of lentil and wheat. *J. Agron.*, 3 (1), 2004, 48-51.
- [3] Bedoussac L., Justes E. The efficiency of a durum wheat winter pea intercrop to improve yield and wheat grain protein concentration depends on N availability during early growth. *Plant and Soil*, 330, 2020 19–35.
- [4] Betencourt E., Duputel M., Colomb B., Desclaux D., Hinsinger P. Intercropping promote the ability of durum wheat and chickpea to increase rhizosphere phosphorus availability in a low P soil. *Soil Biology and Biochemistry*, 46, 2012, 181–190.
- [5] Bommarco, R., Kleijn, D., & Potts, S. G. Ecological intensification: Harnessing ecosystem services for food security. *Trends in Ecology and Evolution*, 28 (4), 2013, 230–238.
- [6] Chaochun Zhang & Yan Dong & Li Tang & Yi Zheng & David Makowski & Yang Yu & Fusuo Zhang,(2019). Intercropping cereals with faba bean reduces plant disease incidence regardless of fertilizer input; a meta-analysis, *Eur J Plant Pathol*, 2019. <https://doi.org/10.1007/s10658-019-01711-4>.
- [7] Cong W. F., Hoffland E., Li L., Six J., Sun J. H., Bao X. G., Zhang F. S., Van Der Werf W. Intercropping enhances soil carbon and nitrogen. *Global Change Biology*, 21, 2015, 1715–1726.
- [8] E. Ebrahimi, H.-P. Kaul, R. W. Neugschwandtner, and A. Dabbagh Mohammadi Nassab. Productivity of wheat (*Triticum aestivum* L.) intercropped with rapeseed (*Brassica napus* L.), *Can. J. Plant Sci.* Vol. 97, 2017.
- [9] Food and Agriculture Organization of the United Nations- FAO stat: crops, 2013.
- [10] Fridley, J. D. The influence of species diversity on ecosystem productivity: how, where and why? *Oikos* 93, 2001, 514–526. doi: 10.1034/j.16000706.2001.930318.x.
- [11] Ghiles Kaci Didier Blave, Samia Benlahrech Ernest Kouakoua Petra Couderc Philippe Deleporte Dominique Desclaux Mourad Latati Marc Pansu Jean-Jacques Drevon Sidi Mohamed Ounane. The effect of intercropping on the efficiency of faba bean-rhizobial symbiosis and durum wheat soil-nitrogen acquisition in a Mediterranean agro ecosystem, *Journal of Plant Soil Environment*. Vol. 64, No. 3, 2018, 138–146.
- [12] Hinsinger, P., Bettencourt, E., Bernard, L., Brauman, A., Plassard, C., Shen, J. For two sharing a scarce resource: soil phosphorus acquisition in the rhizosphere of intercropped species. *Plant Physiol.* 156, 2011, 1075–1086. doi: 10.1104/pp.111.175331.
- [13] Hunady I., Hochman M.. Potential legume-cereal intercropping for increasing Yields and yield stability for self sufficiency with animal fodder in organic farming. *Czech Journal of Genetics and Plant Breeding*, 50, 2014, 185–194.
- [14] Ibrahim Yahuza,. Wheat /faba bean intercropping system in perspective, *ournal of Biodiversity and Environmental Sciences (JBES)*, Vol. 1, No. 6, 2011, p. 69-92.
- [15] Jansen PCM. *Lupines albus* L. In. Brink, M. & Belay, G. (Editors) *Prota (Plant Resources of Tropical Africa)* Wageningen, Netherlands.2006.
- [16] Kaul, H.-P. Sowing ratio and N fertilization affect yield and yield components of oat and pea in intercrops. *Field Crops Res.* 155, 2015, 159–163. doi: 10.1016/j.fcr.2013.09.010.
- [17] Khan HR, Paull JG, Siddique KHM, Stoddard FL. Faba bean breeding for drought-affected environments. A physiological and agronomic perspective. *Field Crops Research* 115, 2010, 279-286.
- [18] Khan, M. B., Khan, M., Hussain, M., Farooq, M., Jabran, K., and Lee, D.-J.. Bio-economic assessment of different wheat canola intercropping systems. *Int. J. Agric. Biol.* 14, 2012, 769–774.
- [19] Li L., Sun J. H., Zhang F. S., Li X. L., Yang S. C., Rengel Z.. Wheat/maize or wheat/soybean strip intercropping: I. Yield advantage and interspecific interactions on nutrients. *Field Crops Research*, 71, 2002, 123–137.
- [20] Melania Figueroa, Kime. Hammond-Kosack AND peter S. Solomon.. A review of wheat diseases-a field perspective, *Molecular Plant pathology* 19 (6), 2018, 1523–1536.
- [21] Nasri, R., Kashani, A., Barary, M., Paknejad, F. and Vazan, S. Nitrogen uptake and utilization efficiency and the productivity of wheat in double cropping system under different rates of nitrogen. *Internat. J. Biosciences (IJB)* 4 (4), 2014, 184-193.
- [22] Ohyama T. The role of legume-rhizobium symbiosis in sustainable agriculture. In: Sulieman S., Phan Tran L. S. (eds.): *Legume Nitrogen Fixation in Soils with Low Phosphorus Availability*. Cham, Springer, 2017, 1–20.
- [23] Periyannan, S., Milne, R. J., Figueroa, M., Lagudah, E. S. and Dodds, P. N. An overview of genetic rust resistance: from broad to specific mechanisms. *PLoS Pathog.* Vol 13, 2017.

- [24] Scalise A., Tortorella D., Pristeri A., Petrovicová B., Gelsomino A., Lindström K., Monti M. Legume-barley intercropping stimulates soil N supply and crop yield in the succeeding durum Wheat in a rotation under rainfed conditions. *Soil Biology and Biochemistry*, 89, 2015, 150–161.
- [25] Sharma, K. C., Parmar, P. S., Solanki, K. S., Singh, A. K. and Saiprasad, S. V. Inter/mixed cropping of lentil (*Lens culinaris*) in late sown Wheat (*Triticum aestivum* L.) for higher productivity and profitability of wheat in vertisols of Central India, *J. agric. Sci.*, 14 (1), 2018, 21-26.
- [26] Spink, J., Street, P., Sylvester bradley, R., and Berry, P. The potential to increase productivity of wheat and oilseed rape in the UK. Project Report HGCA, London, UK. 2009, pp. 131–136.
- [27] T. S. Sahota Sukhdev S. Malhi. Intercropping barley with pea for agronomic and economic considerations in northern Ontario, *Journal of Agricultural Sciences* Vol. 3, No. 7, 2012, pp 889-895.
- [28] Tang X. Y., Bernard L., Brauman A., Daufresne T., Deleporte P., Desclaux D., Souche G., Placella S. A., Hinsinger P. Increase in microbial biomass and phosphorus availability in the rhizosphere of intercropped cereal and legumes under field conditions. *Soil Biology and Biochemistry*, 75, 2014, 86–93.
- [29] Melissa petruzzello. Recent edition of Plant Pathology Books, 2020.
- [30] Wahbi S, Prin Y, Thioulouse J, Sanguin H, Baudoin E, Maghraoui T, Oufdou K, LeRoux C, Galiana A, Hafidi M and Duponnois R. Impact of wheat /faba bean mixed cropping or rotation systems on soil microbial functionalities. *Front. plant sci.* 7, 2016, 1364.
- [31] Wang D, Marschner P, Solaiman Z, Rengel Z.. Growth, P uptake and rhizosphere properties of intercropped wheat and chickpea in soil amended with iron phosphate or phytate. *Soil Biology and Biochemistry* 39, 2007, 249-256.
- [32] Yayeh Bitew Fetien Abayand Tadesse Dessalegn., Effect of lupine (*Lupinus* Spp.) intercropping and seed proportion on the yield and yield component of small cereals in North western Ethiopia, *African journal of research*, Vol. 9 (30), 2014, pp. 2287-2297.
- [33] Zhang F. S., Li L. Using competitive and facilitative interactions in intercropping Systems enhances crop productivity and nutrient-use efficiency. *Plant and Soil*, 248, 2003, 305–312.
- [34] Zhu, Y. Y., Chen, H. R., Fan, J. H., Wang, Y. Y., Li, Y., Chen, J. B., Fan, J. X., Yang, S. S., Hu, L. P., Leung, H., Mew, T. W., Teng, P. S., Wang, Z. H., & Mundt, C. C.. Genetic diversity and disease control in rice. *Nature*, 406, 2000, 718–722.