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Review on: Role of Pulse Crop Intercropping with Bread wheat for hindering Rust Disease development and Improving Yield performance of Bread Wheat (*Triticum aestivum* L.)

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Abstract

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 maize 875 million tons and rice 718 million tons with a production of over 674 million tons on over 216 million ha, or 3.1t ha⁻¹ (FAO, 2013). 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 possible 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. 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 suggested that intercropping wheat with legumes is a desirable agronomic practice towards boosting of yield and prevention of disease incidence such as rust.

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Introduction

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 maize (*Zea mays* L.); 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 3.1 t ha⁻¹ (FAO, 2013). 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 (Sharma *et al.*, 2018).

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 (Spink *et al.*, 2009). 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 (Nasri *et al.*, 2014).

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 (Yayeh *et al.*, 2014). 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 (Bommarco *et al.*, 2013). 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 hazards 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 (Sharma *et al.*, 2018).

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 sever 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 (Jansen, 2006). Yayeh *et al.*, (2014) also point out that wheat intercropped with lupine has access to a larger pool of Phosphors, 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.

Objective of the review

To review the role of pulse crop intercropping with wheat for hindering rust disease development and improving yield performance of wheat.

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 (Sahota *et al.*, 2012).

Rust

Plant disease caused by more than 7,000 species of fungi of the phylum Basidiomycota. I 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 (Melissa, 2020).

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 microhezial association (Wahabi *et al.*, 2016). 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 (Ohyama, 2017).

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 (Kaul, 2015). 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, weed management, erosion control, and soil fertility amongst others (Ibrahim, 2011). Moreover, Zhang, (2019) 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 (Sharma *et al.*, 2018).

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 (Scalise *et al.*, 2015). Intercropping also increase N inputs to the plant-soil system, and the growth and yield of the intercropped cereal, by improving the efficiency of Microhizobial symbiosis (Betencourt *et al.*, 2012) for wheat-chickpea intercrops. Li *et al.*, (2001) 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, Cong *et al.*, (2015) 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 (Cong *et al.*, 2015). Particularly of intercropping legumes with low soil organic matter inputs (Tang *et al.*, 2014). 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 improve in the years following forage legume crops, which should encourage agricultural producers to include legumes in their crop rotations (Adrien *et al.*, 2015). Wang *et al.*, (2007) 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. Zhang, (2019) 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.

Role of pulse crop intercropping in hindering rust disease development on 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 (Duplessis *et al.*, 2012). 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. triticina* (Pt), respectively (Melania, 2018). Genetic resistance to rust infection has been identified as either race-specific (also known as seedling or qualitative resistance) or non-race-specific resistance (Periyannan *et al.*, 2017).

Reductions in plant diseases and pests have been recorded also for variety mixtures or intra-specific diversity of crops (Zhang, 2019). Zhu *et al.*, (2000)

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, Khan *et al.*, (2010) 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 (Zhang, 2019). 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 (Yayeh *et al.*, 2014).

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 (Fridley, 2001; Hinsinger *et al.*, 2011). Yayeh *et al.*, (2014) 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 Sharma *et al.*, (2018) 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. Akter *et al.*, (2004) 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 Hunady and

Hochma (2014) 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 (Zhang, 2019).

According to Zhang and Li (2003) 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, Bedoussac and Justes (2010) found that an increase in the protein grain content of wheat and pea concentrations in intercrop compared to the two monocrops.

Wahbi *et al.*, (2016) was conducted afield experiment aiming to estimate the two years impact practice on wheat yield and soil micrhohizal activates 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 micrhohizal functionalities. Wheat rapeseed intercropping with 6 rows of wheat+ 2 rows rapeseed could be an option to enhance yield benefits and rapeseed production (Ebrahimi *et al.*, 2017). Intercropping of wheat canola, (Khan *et al.*, 2012) 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.

Conclusion and recommendation are as follows:

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 conclude that, intercropping systems have the scope and potential to exceed the yields possible 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.

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 suggested that intercropping wheat with legumes is a desirable agronomic practice towards boosting of yield and prevention of disease incidence such as rust.

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