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Competitive dynamic effects of wheat-*Brassica* intercropping: A review

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Abstract

Intercropping depicts the growing of two or more crops at the same time in the same piece of land. Moreover it enhances the crop production per unit area and time with efficient use of resources especially for small land holders. Sowing time of oilseed crops belongs to *Brassica* species coincides with the wheat so these can be intercropped in wheat to get maximum land utilization. Various oilseeds like canola and lentil intercropped in wheat affects the yield and yield components, growth attributes, competitive indices as well as yield advantages. Farmers are reluctant to sacrifice wheat crop but intercropping oilseeds with wheat can be proved beneficial in terms of land equivalent ratio, aggressivity value, and yield advantages. Various intercropping types can be adopted to enhance net income of farm land. However, this review overviews the different aspects of intercropping as it may inhibit or enhances total productivity of the land as well as the key examples from the literature that favors its importance in agriculture.

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Introduction

Intercropping establishes a beneficial relationship between components crops, increasing grain yield, stability and efficient resource utilization hence causes the weed suppression (Khan *et al.,* 2012; Singh *et al.,* 2014). It is a mixed cropping or polyculture technique in which two or more crops are grown at the same time in the same field (Andrews and Kassam, 1976; Ofori and Stern, 1987). Many studies have been focused on the intercropping of wheat as main crop to increase per unit benefits. In intercropping the component crops must neither necessarily be sown nor harvested at the same time but they must be grown at the same time for most of their growing season. Usually, in intercropping there is one main crop that is of prime economic importance than other crops that may be one or more. Dakora (1996) revealed that intercropping has been practiced in different areas of Africa as a traditional farming system because of reduced lands and increased food security threats.

Various types of intercropping systems have been practiced from centuries. Intercropping renders some more services such as soil conservation, insurance against complete crop failure, improvement of soil fertility, improvement in forage quality, resistance against lodging of crops, reduction in pest and disease incidence and promotion of on-farm biodiversity (Lithourgidis *et al.,* 2011). Jensen *et al.* (2005) revealed that intercropping provides benefits like effective weed control as well as use of natural resources under organic farming systems. Altieri (1999) and Malezieux *et al.* (2009) described that intercropping, cover crops and crop rotations enhanced the biodiversity in agro-ecosystems in time and space. Many researchers, policy makers and farmers worldwide have paid great focus on sustainable agriculture which can provide a self-sustaining, minimal input and energy efficient system of crop production (Altieri *et al.,* 1999).

Intercropping offers farmers the opportunity to deal with the nature's principle of diversity at their farms (Ghosh, 2004). It has been reported that the competitive ability and interactions of different plant species in intercropping may vary due to time and environmental conditions (Andersen *et al.,* 2007). Fig. 1 is the schematic diagram to show the positive and negative effects of intercropping on biodiversity (Bavec and Bavec, 2011).

Intercropping system consists of two or more crops planted in the same field as compared with monocropping. It can be done annually with annual plants intercropping, annual with perennial ones; perennial plants with perennials intercrop (Eskandari *et al.,* 2009).

Moreover, there is a need to consider some important aspects for successful intercropping. Intercropping also has detrimental effects on the vegetative and reproductive growth of component crops (Silwana and Lucas, 2002). Compatible crops should be chosen so as to minimize competition for growth resources by spatial arrangement (Maluleke *et al.,* 2005). While using two or more crops in an intercropping system, their peak period for growth resource utilization should not coincide to avoid competition. Plant population must be optimized by reducing seed rate from the recommended sole crops as more or less population affects greatly to the grain yield of individual crops (Jeyakumaran and Seran, 2007). Time of planting of associated crops in intercropping is also crucial decision that it may also be planted at same time as of the main crop or at different time according to compatibility among component crops. Furthermore, component crops should have different feeding area for nutrients when they are sown at the same time (Amede and Nigatu, 2001).

Farmers are appealing to adopt intercropping mainly because of its economic benefits (Bhatti *et al.,* 2006). In the present situation, interest of farmers in intercropping is enhancing, mainly due to less farm income from sole cropping and their diversified needs. In modern agriculture, intercropping is considered to be the most effective way to get huge farm income and production per unit area. In order to meet the diversified needs of the people there is a dire need to plant more than one crop in a season. Ali *et al.* (2000) stated that intercropping is a potential way to increase production per unit area particularly for small land holders.

In previous studies intercropping was done in order to get enhanced benefits but no one emphasized on the reason of ignorance of the farmers for oilseed crops as well as their use in providing edible oil for household and commercial use. The objectives of this review are to interpret these issues so as to enhance the net income for farmers as well as reducing the import of edible oil of the country. Moreover, this review illustrates the dynamic effects of intercropping on the various attributes. Future studies should emphasize to enhance the yield of the intercrops in order to minimize the threat of food security as well to compensate the lower farm income.

Effects of intercropping

Positive effects of intercropping

Enhanced yield benefits

Intercropping provides various benefits as it enhanced the overall yield of the cropping system. Tsubo *et al.* (2001) reported that intercropping enhanced yield advantages because the growth resources such as light, water as well as nutrients absorbed completely and converted into plant biomass over time and space. It occurs as a consequence of differences among the crops for growth resources that exploit the difference of mixed crop in canopy development rates, canopy size and rooting depth.

Soil conservation

Among the merits intercropping also conserves the soil. El-Swaify *et al.* (1988) reported that intercropping controls the soil erosion and sustained the crop production by using the legumes as an intercrop. Those areas where cropping systems leave the soil bare for longer period of time with excessive rainfall leads to soil erosion and runoff resulting in infertile soil for crop production. Intercropping also provides space for microorganisms such as earthworm which enhances the fertility of the farmers land without expenditures.

Limited insect and disease occurrence

Another important aspect of intercropping system is its ability to minimize the incidence of pests and diseases. Langer *et al.* (2007) reported that the addition of plants to the cropping system can affect herbivores in different ways as compared to monocropping. Among these ways firstly the environment of the host plants is changed e.g. adjacent plants and microclimatic conditions and secondly, the quality of the host plant is changed e.g. morphology and chemical content. Bukovinszky *et al.* (2004) revealed that the instantaneous effect on both the environment and the quality may complicate assessments among systems as various mechanisms can affect herbivorous insects. Szumigalski and Van Acker (2005) reported that intercropping systems such as wheat-canola and wheat-canola-pea tended to provide higher weed suppression (as it helps in pest incidence) in comparison with each component crop grown alone which indicates a kind of synergism among crops within intercrops with regard to weed suppression.

Negative effects of intercropping

Intercropping also has several demerits. One of the disadvantages of intercropping is the difficulty in practical management of the field, especially when the crops have different requirements for fertilizer, pesticide, herbicide or when higher degree of mechanization is needed. Other disadvantages of intercropping are expenditures for mixed grain separation as well as their marketing, harvesting problems and grain loss during harvesting. Some other demerits are described as follows:

Competition for resources

In intercropping system component crops compete for resources. Baldwin and Tinker (1972) revealed that in relay intercropping competition for water and nutrients affected the repressed crop in different ways such as the roots of the repressed crops are less developed and they are likely to show higher root: shoot ratio as compared to dominant crop.

International rice research institute (IRRI) (1972) reported that under an intercropping system shallow rooted crops may trigger the neighboring crops to develop deeper rooting system that inquires the soil matrix more comprehensively as compared to monoculture. Competition exists when two plants compete for the same resources such as water and nutrient requirement at the same place and one of the plants receives less than it requires. Wanki *et al.* (1982) reported the reduction in the yield of crops which overlaps in space and time with each other because of the competition of limited resources among them.

Growing combination of intercrop

Growing combinations of crops in intercropping system also pose threats to the growth and yield of the prevailing crops. It is suggested that proper planning is required for the selection of the crops, their available cultivars as well as the existing environmental conditions of the area. Moreover, those crops must be selected that have no competition with each other for physical space, nutrients, water, or sunlight. For examples, planting a deep rooted crop with a shallow-rooted crop, or planting a tall crop with a short crop that requires only partial shade. Roberts *et al.* (1989) reported that wheat (*Triticum aestivum* L.) is the most suitable cereal for intercropping.

Wheat-Brassica intercropping

Wheat-*Brassica* intercropping has been practiced for centuries. In this intercropping practice wheat remains as a major crop and other crop belongs to *Brassica* species such as canola, linola, rapeseed etc. are intercropped in wheat. There have been several reports about yield stability and economic benefits of wheat intercropping (Naeem *et al.* 2012). This kind of intercropping has different effects on crop attributes like growth parameters, competitive indices and yield advantages which are as follows:

Growth attributes

A crop yield is the attribute of physiological processes and morphological manifestations with the interaction of crop and environment. Growth attributes of crops are measured basically in term of growth rate (dry matter production) and area covered by crop canopy. Growth analysis techniques were developed by Watson (1952) and he identified that difference in crops productivity is due to difference in leaf area index (LAI) and in this regard early canopy closure is the most damaging to dry matter production.

Plant population, plant height

Plant population in intercropping field is disturbed so as to adjust a suitable combination. The disturbance in plant population of associated crops should be well established to harvest greater net benefits. Wang *et al.* (2008) reported that in wheat-oilseed rape intercropping the population density of *Sitobion avenae* L. was considerably lower than that in wheat monoculture fields. Plant height of the component crops is usually affected by intercropping (Naeem *et al.,* 2012). Plant height of wheat was recorded significantly higher in wheat-gram intercropping (Khan *et al.,* 2005). Ahmad *et al.* (2001) gave the contrasting results that the plant height of wheat was not disturbed due to 7:1 row combination of wheat-mustard and wheat-methra intercropping. Moreover, reduction in plant height of wheat was reported when intercropped with rapeseed (Ahmed and Qureshi, 2001).

Leaf area index (LAI), leaf area duration (LAD)

LAI is the basic attribute that gave information about assimilatory surface of the system and amount of light interception in canopy (Mandal and Sinha, 2004). Effect of intercropping on LAI of component crops in an intercropping combination is well established and studied for many crops (Amini *et al.,* 2013). LAI of main crop was reduced in intercropping as compared to sole planting. There was reduction in leaf area expansion as light interception by canopy was reduced by individual plants in dense stand and competition for growth resources had increased (Tahir, 2002). Leaf area duration (LAD) specifies the period for which a certain canopy size is retained in the field. It is a combined quantity between leaf area and time. It also shows the total chance for radiation interception by a crop canopy. Watson (1952) also concluded that LAD is a major factor that determines the yield differences in varieties of agronomic traits rather than NAR. LAD was also reduced in intercropping patterns as it is directly related with leaf area of component crops in intercropping systems (Tahir, 2002). LAD of sole crop is more than intercropping combinations (Bhatti, 2005). In addition to that reduction in LAD was ascribed to low LAI due to less leaf expansion because of competition between the component crops for different growth factors (Bhatti, 2005).

Crop growth rate (CGR), net assimilation rate (NAR)

Hocking *et al.* (1997) conducted an experiment in Australia on brassica and canola which showed higher growth rates (10-15 g /m^2 /day) during the period between anthesis and maturity. Crop growth rate (CGR) of component crops in an intercropping combination was reduced as there was a competition for growth resources, as well as light interception had also been reduced and leaf area was not able to flourish to the extent as in sole stand (Gill *et al.,* 2009). Net assimilation rate also decreases in intercropping patterns as NAR is directly related to LAI which is also affected by intercropping, however, greater the leaf area, higher will be the assimilates production. Competition for growth resources between component crops in intercropping also decreases the assimilation rate than sole planting. It highly depends upon the persistence of photosynthetic machinery and time for which it remains productive. Dry matter accumulation in intercropped wheat is low because of the competition between component crops for growth resources such as water, nutrients, etc. that results in slow CGR, less LAI and LAD (Das *et al.,* 2012). Furthermore, Singh *et al.* (2014) concluded that dry matter production of wheat was reduced when it was grown in combination with non-legumes.

Yield and yield components

Component crops in an intercropping combination were characterized to reduce the yield attributes. All the yield supporting characters of crops were affected due to competition for available growth resources such as light, water, nutrients etc. (Khan *et al.,* 2005). Growth resources becomes limited as in intercropping combinations resource utilization per unit area is increased and ample amount of resources should be provided for greater output.

Fertile tillers, spike length, spikelet per spike and grains per spike

Sharar *et al.* (1991) reported that number of fertile tillers of wheat was reduced in wheat-methra intercropping combination. Reduction in number of fertile tillers may be due to inter row competition of wheat and exhaustive nature of associated crop because the nutrient uptake increases in intercropping systems (Lithourgidis *et al.,* 2011). Spike length, spikelet per spike and grains per spike are the important attributes of wheat that determine the final yield of crop. There was no significant difference among spike length and grain weight per spike when wheat intercropped with sugar beet on ridges or beds (Gadallah *et al.,* 2006). Intercropping also affects these important attributes of wheat to a variable extent (Khan *et al.,* 2012). Reduction in these attributes may be quoted to competition among component crops and their mutual shading.

1000-grain weight

The magnitude of grain development of wheat is mainly determined by 1000-grain weight. It is direct index that affects the final yield of a crop. Intercropping affects assimilates translocation in grain portion after the completion of vegetative stage. Competition for growth resources and space increases the plants interest for their survival as compared to their production. Test weight of component crops was reduced in intercropping patterns due to both inter and intra-specific competition. Khan (1984) revealed in an experiment on intercropping of linseed in wheat that plant height, number of grains per spike and grains weight per spike of wheat were not significantly affected by linseed intercropping, however 1000-grain weight affected significantly by the intercropping systems.

Oil contents

Seed oil content increased in canola-soybean intercropping as compared with sole cropping (Ayisi *et al.,* 1997). Valenzuela *et al.* (2002) checked out performance of twenty canola cultivars out of which three cultivars viz. Hyola 401, Hyola 42 and Rainbow, performed better. Contradictory relationship exists between oil and protein contents as cultivars containing high oil content usually have low protein contents. As the oil contents decreases, protein contents increases and vice versa.

During experiment on yield potential and oil contents of different canola cultivars, Cultivar Con-12 produced the maximum seed and oil yields due to highest number of pods per plant and seeds per pod whereas the cultivar Defender performed poorly and stayed at the bottom (Sana *et al.,* 2003). Oil contents in seed were higher in *Brassica napus* L. whereas the levels of erucic acid and glucosinolates were lower in *Brassica napus* L. than in *Brassica Juncea* L. (Iqbal *et al.,* 2008). Different intercropping systems responded differentially under intercropping of various crops (Table 1).

Table 1. Differential responses of various intercropping systems.

Main Crops	Intercrop	Findings	Type of intercropping	Experimental location	Reference
Wheat	Canola	Intercropping enhanced LER*, BCR*, however, sole crops gave higher economic yields	Row and mixed intercropping	Faisalabad (Pakistan)	Naeem *et al.* (2013)
Wheat	Wheat (3 cultivars Kohdasht, Tajan and Zagros)	Treatments have no significant effect on yield and maximum yield was obtained from the ratios of Tajan-Zagros cultivars (50:50) and had LER more than 1.25.	Row intercropping	Gonbad (Iran)	Biabani (2008)
Lentil	Wheat	Lentil and wheat have produced maximum yields however, the intercropping treatments provided maximum net income.	Row intercropping	Multan (Pakistan)	Khaliq *et al.* (2001)
Wheat	*Brassicas* (3 genotypes 2 canola and 1 mustard)	Growth and P uptake of wheat was not improved by intercropping with *Brassicas* and also there is no indication that P mobilized by *Brassicas* is available to wheat	-	Eyre Peninsula (South Australia)	Wang *et al.* (2007)
Wheat	Oilseed rape	It was revealed that intercropping row ratio 8:3 and 12:4 had the highest yield and related components.	Row intercropping	Tabriz (Iran)	Mardfar *et al.* (2013)
Wheat	Lentil, Rapeseed, chickpea	Among intercropping ratios chickpea intercropping in 1:1 gave maximum yield however, lowest yield was obtained by 1:1of wheat-rapeseed.	Row intercropping	D. I. Khan (Pakistan)	Khan *et al.* (2005)
Wheat	Linseed	Wheat yield was reduced by intercropping linseed in the pattern of 4, 6 and 10 row strips however, intercropped treatments have provided better yield than monocropping.	Strip Intercropping	Faisalabad (Pakistan)	Nazir *et al.* (2006)
Wheat	Canola	Four rows of wheat plus four rows of canola gave maximum LER and net benefits followed by two rows of wheat plus canola.	Row intercropping	Faisalabad (Pakistan)	Naeem *et al.* (2012)
Wheat	Lentil, chickpea	Wheat-chickpea in 2:2 ratio gave maximum LER, IA*, SLER* and AYL* however, sole lentil gave highest BCR and under intercropping wheat-lentil in 1:1 gave maximum BCR.	Row intercropping	Salna (Gazipur)	Das *et al.* (2012)
Wheat	Canola, Methera	Wheat plus canola intercropping at 100 kg N ha^{-1} gave maximum net income with BCR of 4.03 followed by BCR of 2.97 from wheat alone with no fertilizer application.	Strip intercropping	Faisalabad (Pakistan)	Ahmad *et al.* (2002)
Canola	Wheat	Intercropping enhanced growth and yield components as well as net income, BCR and LER	Row intercropping	Faisalabad (Pakistan)	Ali *et al.* (2000)

*Intercropping advantages (IA), Staple land equivalent ratio (SLER), Actual yield loss (AYL), Benefit cost ratio (BCR), Land equivalent ratio (LER)

Grain yield, Biological yield, harvest index

Grain yield is the most important parameter that determines the overall output of the crop. In an experiment on wheat the grain yield of wheat was reduced however, other growth attributes and yield components show decline as compared to sole planting (Nazir *et al.,* 2006).

Ali *et al.* (2000) conducted an experiment on canola based wheat intercropping pattern with treatments as sole canola and wheat, canola plus one row of wheat, canola plus two rows of wheat and canola plus three rows of wheat. The yield and yield components of canola were significantly decreased with increasing number of rows in treatments. Among intercropping treatments highest canola seed yield (1217 kg/ha) was given by canola plus one row of wheat. Intercropping reduced the yield of component crops compared with respective pure stands. Overall yield of the crops in intercropping increased in comparison to the component crops. This increase in yield may be because of the possible benefits for intercropping which includes maximum yield and high net income (Yildirim and Guvence, 2005), as well as effective use of ecological resources (Eskandari and Ghanbari, 2009) by the corresponding effects of two or more crops grown at an identical time on the same piece of land.

A field study to examine the comparative productive efficiency and feasibility of different canola wheat intercropping patterns revealed that canola and one row of wheat intercropping appeared to be not only a productive practice but also highly profitable as compared to other intercropping patterns and sole cropping of component crop (Cheema *et al.,* 2000). In many studies intercrop yields are transitional to the sole crop or comparable to those of the highest yielding sole crop whereas in some cases productivity is increased in intercrops (Hauggaard *et al.,* 2001).

Biological yield is the index of total dry matter productivity of a system. It is the total biomass produced by the crop. Competition between component crops for growth resources has negative impact on growth of component crops (Lithourgidis, 2006). Moreover, Rehman (1984), Mandal and Mahapatra (1990) reported the reduction in biomass yield of base crop due to competitive effect of different intensities of intercrops.

Intercropping also affects the harvest index of the crops. It leads to reduce the harvest index of wheat due to the limited supply of assimilates to the sink. This reduction might be because of competition between the crops for moisture, nutrients, space and light most probably at grain formation stage (Nazir *et al.,* 1988).

Competitive indices

Competitive indices comprised of competitive ratio, relative crowding coefficient as well as aggressivity value.

Competitive ratio (CR)

CR value provides the correct degree of competition, by representing the number of times by which the main species is more competitive than the recessive species (Ghanbari, 2000). The highest CR was observed in wheat plus Egyptian clover intercropping system followed by wheat plus gram while wheat plus lentil had the lowest CR, suggesting less competitive ability of wheat with lentil compared to that with Egyptian clover and gram (Anjum, 1996). Previous findings of wheat based intercropping in different planting patterns and geometry suggests that wheat possessed higher value of CR when intercropped with rapeseed (Bora, 1999), canola (Khan *et al.,* 2012).

Relative crowding coefficient (RCC), Aggressivity (AG) value

Each crop has its own RCC (relative crowding coefficient) value in an intercropping system (Willey, 1979). RCC value gives a real picture about the competitive indices of system. It has been reported that intercropping of wheat-Indian mustard (Singh and Gupta, 1994) have yield advantages in term of RCC. Wahla *et al.* (2009) reported that in barley based intercropping system, higher value of RCC has been observed for barley that showed its dominant behavior in that set of component crops.

Aggressivity (AG) value is an important tool to determine the competitive ability of a crop when grown in association with another crop. Zero AG value shows that component crops are equally competitive. Component crops have same numerical value but with opposite sign. Dominant species have positive sign while dominated species have negative sign (Ali, 1999; Sarkar *et al.,* 2001). Ali (1999) reported that rapeseed was dominant having positive AG values when grown in intercropping with wheat and also in linseed. Intercropping systems have significant effect on aggressivity value of various crops (Table 2).

Table 2. Effect of intercropping on Aggressivity value (AG) of intercropping systems.

Main Crop	Intercrop	AG value of the main crop	Trend	References
Wheat	Lentil	+1.73	Positive	Das *et al.* (2012)
Canola	Wheat	+0.06	Positive	Tahir *et al.* (2003)
Canola	Linseed	+0.11	Positive	Tahir *et al.* (2003)
Canola	Lentil	+0.14	Positive	Tahir *et al.* (2003)
Mustard	Wheat	+0.15	Positive	Singh *et al.* (2014)
Mustard	Lentil	+0.13	Positive	Singh *et al.* (2014)
Barley	Canola	+0.49	Positive	Wahla *et al.* (2009)

Yield advantages

Yield advantages in an intercropping combination are assessed in terms of land equivalent ratio, area time equivalent ratio (ATER) and seed yield equivalent ratio (SYER).

Land equivalent ratio (LER)

LER is the index mainly used for the judgment of profitability of an intercropping system. It depicts the biological efficiency of an intercropping system and units of area of sole crop that should be required to get the same advantage as produced in an intercropping system (Wahla *et al.,* 2009). LER is almost higher in different intercropping system which depicts its feasibility compared with mono-cropping. Many researchers and intercropping scientists revealed in their studies that there is always yield advantage in terms of LER. Nazir *et al.* (2006) and Das *et al.* (2012) reported higher LER value in an intercropping system than sole planting. Singh *et al.* (2014) concluded that LER value was greater in wheat-mustard as compared with wheat-lentil intercropping and in both cases, it was greater than one compared with monocropping of wheat, mustard and lentil.

Intercropping of wheat with brassica seems to be a promising technique as there are multi-dimensional assistances in that system of cropping. Yield per unit area is increased with better use of available resources and better use of land is achieved as concluded in results of LER and agronomic advantages of intercropping. Wheat and canola intercropping as matched with all sole plots significantly yielded maximum overall profit, LER, marginal net income, profit: expenditure ratio (Khan *et al.,* 2012) (Table 3).

Table 3. Effects of intercropping on Land Equivalent Ratio (LER) of intercropping systems.

Main Crop	Intercrop	LER	References
Wheat	Canola	1.37	Naeem *et al.* (2013)
Wheat	Cotton	1.39	Zhang *et al.* (2007)
Canola	Wheat	1.17	Ali *et al.* (2000)
Canola	Wheat	1.05	Ali *et al.* (2000)
Barley	Lentil	2.61	Dahmardeh (2013)
Barley	Lentil	1.45	Nazir *et al.* (1996)
Lentil	Wheat	1.52	Akter *et al.* (2004)

Seed yield equivalent ratio (SYER)

Wheat SYER is the seed yield of wheat plus yield of intercrop transferred into seed yield of wheat based on the existing market price of intercrop. It is also a good criterion to assess the superiority of intercropping over monocropping (Das *et al.,* 2012). Many researchers have given inference about wheat SYER that the trend was alleviated in intercropping combinations (Sonani *et al.,* 2001). Intercropping reduced the yield of component crops compared with respective pure stands. Khan *et al.* (2009) reported that highest wheat seed yield was produced when 3 rows of wheat intercropped with 2 rows of oilseed rape.

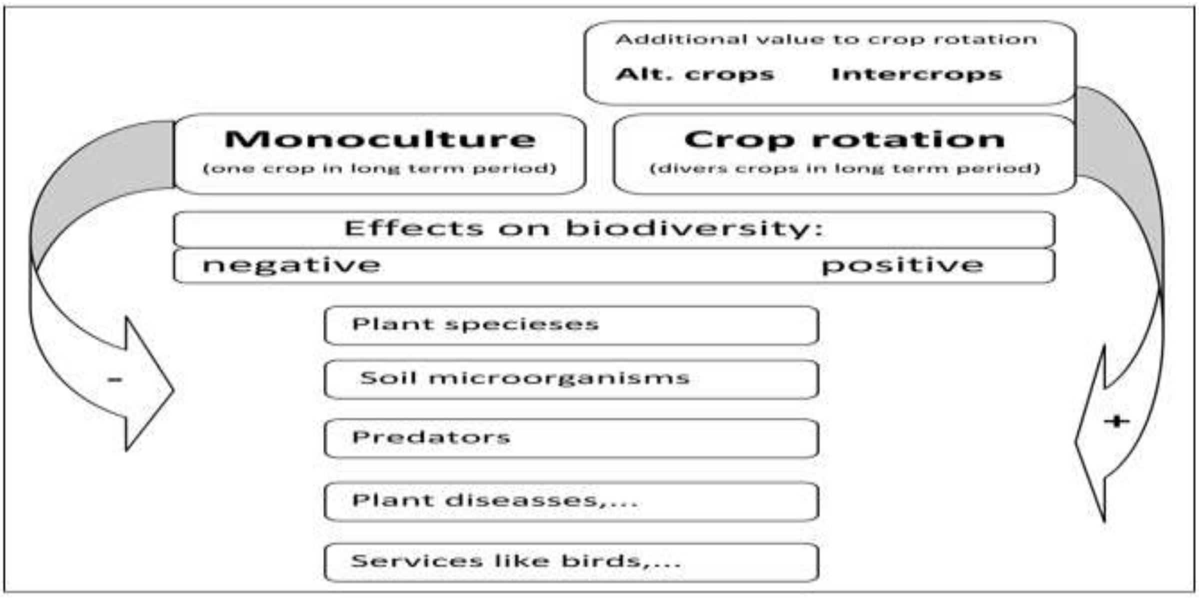

Fig. 1. Comparison of negative effects of monoculture and positive effects of crop rotation, alternative crops and intercrops on biodiversity parameters (Bavec and Bavec, 2011).

Area time equivalent ratio (ATER)

ATER specifies more convincing comparison of the yield benefit of intercropping than pure stand in terms of difference in time taken by the component crops of dissimilar intercropping systems (Hiebsch, 1980). Khan *et al.* (2012) reported the similar trend that ATER value was higher in intercropping combinations as compared to sole planting. Single row of wheat intercropped in canola proved to be more beneficial as it provides maximum LER, ATER and high profit as compared to other intercropping systems as well as sole plantation of canola (Tahir *et al.,* 2003a).

Conclusion and future trends

On the basis of above review, it can be concluded that wheat-*Brassica* intercropping has many advantages such as yield stability, efficient resource utilization, sufficient weed control, increased output per unit of land. Although, the yield and yield components of component crops are significantly affected due to increased resource competition but land equivalent ratio, grain yield, economic benefit and per unit productivity enhanced. Thus, wheat-*Brassica* intercropping is an advantageous approach to get better use of available resources and fulfill the local requirement of oilseeds of the community. In addition to that intercropping provides suitable ways to get maximum outcome within minimum time and use of resources.

It can be inferred that intercropping of two or more crops could be a beneficial approach to get a reasonable farm income especially for small land holders. Although it affects the physiological, yield and growth parameters but these effects are beneficial to some extent. Most of the time farmers grow wheat as a sole crop and do not sacrifice their main crop as they feel danger regarding the crop failure. But they should adopt intercropping practices by growing other crops along with wheat so that their main crop also remains there along with minor crop and they could get more income at the end of season as compared to sole cropping. In future programs intercropping must be adopted to get maximum benefits per unit land area as it yields maximum net benefits and land equivalent ratio. It could provide better environment for resource utilization as well as for greater biodiversity. Keeping in view the intercropping system the farmers should adopt this intercultural practice so that they can get reasonable amount of edible seeds for their household use as well as for getting huge income.

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