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WEED CONTROL EFFECTS ON THE WHEAT-PEA INTERCROPPING

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Abstract

A cereal with legumes intercropping is a popular cultural technique and is useful for soil conservation, weed control and getting higher crop yield. To cope with and then find out remedies for many problems, field study entitled "weed control effects on the wheat-pea intercropping" was conducted at Research Farm, The University of Agriculture, Peshawar, Pakistan during Rabi season 2010. Randomized complete block (RCB) design was used with split plot arrangements. There were two main plots each having eight treatments. One main plot was kept weed free while the second was kept weed infested throughout the crop season. The details of wheat and pea combinations (treatments) was; (1) sole wheat (8 rows), (2) sole pea (8 rows), (3) wheat (1 row) + pea (1 row), (4) wheat (2 rows) + pea (1 row), (5) wheat (3 rows) + pea (1 row), (6) wheat (2 rows) + pea (2 rows), (7) wheat (3 rows) + pea (2 rows) and (8) wheat (3 rows) + pea (3 rows). Statistical analysis of the data revealed that weeding significantly decreased the weed density at 120 days after sowing (DAS), fresh and dry weed biomass. Weeds related parameters like weed density, fresh and dry weed biomass was significantly decreased by intercropping of peas in wheat. Weeds removal significantly increased spike length and grain yield of wheat. Weeds removal as well as intercropping of wheat and pea significantly affected the green pods yield of pea where maximum pods were recorded under weed free conditions. Sole pea produced higher yield of pods as compared to intercropped plots. Therefore in light of the instant studies it could be concluded that pea should be intercropped in wheat. However, further studies are suggested to study the possibility of wheat-pea intercropping at various densities for getting higher net returns.

Introduction

Wheat is an important cereal crop of the world and especially in Pakistan. Wheat is a rich source of protein and total food supply and the country's food supply is directly or indirectly dependent on the wheat production. Like wheat, pea is an important nutritious leguminous vegetable that is widely cultivated throughout the world. As a cool season crop, it is grown mainly in temperate zone. Pea is a rich source of protein, amino acids, sugars, carbohydrate, vitamins A and C, calcium and phosphorus. Pea also contains a small quantity of iron and is mainly grown for green pods, but the plant biomass is also useful as s source of nitrogen (Tripolskaja *et al.,* 2008). The total area under cultivation of pea during 2009 in Pakistan was 96.9 thousand hectares with the total production of 60.4 thousand tons (Anon., 2009).

Weeds in wheat as well as pea greatly decreased the yield of both the crops. Among various factors for the low yield of crop, weed infestation is the most important (Hussain *et al.,* 2012) as weeds have harmful effects on crop quality as well as quantity (Memon *et al.,* 2013). All weed species use soil nutrients, available moisture, and compete for space and light with crop plants, which results in yield reduction and quality deterioration of the agricultural products (Khan *et al.,* 2002). Many weeds are hosts for pathogens and insects pests. It has been reported that weed infestation can cause yield reduction by more than 80% (Karlen *et al.,* 2003). Sole pea is poorly competitive against weeds compared with cereal crops. This might be due to the small canopy and slow growth rate of pea. Among other cultural technique, increasing seed density as well as intercropping can also suppress the weeds significantly. Wheat and pea are usually grown separately in winter and farmers are reluctant to intercrop pea in wheat due to harvesting problem and lack of agriculture education.

In Pakistan, wheat and pea are grown as sole crops and there are no published reports that address the intercropping of wheat with pea. Both being winter crops, seems to provide opportunities of extensive research for intercropping. Intercropping suppresses weeds and soil resources are effectively utilized under organic farming systems (Jensen *et al.,* 2005). In the last few years, farmers are trying to get organic grains and suppress weeds through intercropping (Entz *et al.,* 2001). Intercrops of pea and barley have been shown to use available growth resources more efficiently than their corresponding sole crops. 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). It has been observed that two different plant species planted as intercropped usually do not compete for the exactly the same resource niche and thus there is some degree of resource complementary. Intercropping of cereals and clover offers a opportunity to provide nitrogen to the crops while growing a cereal crop (Anil *et al.,* 1998).

Wheat as well as pea are both winter crops and are extensively used by subsistence farmers in our country. As wheat as well as pea and the biomass of these crop species is the need of nearly all the farmers therefore growing both these crops as intercropped should be studied. Wheat straw and dried pea plants are used for different purposes. Such cropping systems are acceptable to the farming community as both crops will not be in direct competition with each other due to their canopy coverage, root system and morphology. Due to different morphology they are usually not in direct competition with each other. Therefore there is resource distribution among the pea and wheat plants. Due to resource distribution and different niche the weeds are suppressed. Both these crops are seriously affected by the weed competition therefore the instant studies were conducted to judge the possibility of intercropping of wheat and pea under weed free and weed infested conditions. Such studies will be helpful for researchers and farming community to grow more than two crops for economizing the resources and getting higher yield. As majority of the farmers in our country are subsistence and rely on the produce of the farms, therefore the instant proposal is one such approach. Pea is a cash crop therefore selling the pods in the market can assist the farmers to purchase inputs for the wheat crop. This will further support farmers in increasing the grain yield of wheat.

In light of the above discussion, it seems that intercropping provides unlimited opportunities to economize the resources and get higher yield of crops. Thus keeping in view the importance of wheat, pea and weed infestation of both these winter crops, field experiment was conducted to see the possibility of intercroping under weed free and weed infested conditions.

Materials and Methods

The present study entitled "weed control effects on the wheat-pea intercropping" was conducted at Research farm, The University of Agriculture Peshawar, Pakistan during rabi season 2010. The experiment was laid out in randomized complete block (RCB) design with split plot arrangement having three replications. There were two main plots each having eight treatments. One main plot was kept weed free throughout the crop season while the second was kept weed infested throughout the crop season. The treatment size was variable depending on the nature of the treatment. Field was irrigated and seedbed was prepared at proper moisture condition by ploughing twice and finally harrowing and leveling. Recommended doses of nitrogen and phosphorus (120:60 kg ha^{-1}) were applied to the experimental field during the seedbed preparation. Full dose of phosphorus and half dose of nitrogen were applied at seedbed preparation and the remaining nitrogen was applied during second irrigation of wheat. The crop was irrigated with the nearby canal whenever needed. Urea and DAP were used as a source of nitrogen and phosphorus. Variety of wheat "Saleem-2000" and pea variety "climax" were used in the experiment. Sowing of both crops was done using hand hoe. The seeds of both the species were manually cleaned before sowing and all other weed seeds and other materials were removed. Wheat seed rate was 120 kg ha^{-1} while pea seed rate was 60 kg ha^{-1}. Crop was irrigated as per requirement and all other agronomic practices were kept uniform for all the treatments.

The details of wheat and pea combination (treatments) was as under;

T1: Only wheat (8 rows)
T2: Only pea (8 rows)
T3: Wheat (1 rows) + pea (1 row)
T4: Wheat (2 rows) + pea (1 row)
T5: Wheat (3 rows) + pea (1 row)
T6: Wheat (2 rows) + pea (2 rows)
T7: Wheat (3 rows) + pea (2 rows)
T8: Wheat (3 rows) + pea (3 rows)

Parameters studied and data recording procedure for each trait was as under. Weed density m^{-2} was recorded at 120 days after sowing to observe the effect on weed density with the passage of time. A quadrate of size of 30 x 30 cm was placed randomly three times in each treatment and the weeds inside were counted. Means were computed and the data were subsequently converted into m^2.

Data of fresh weed biomass was recorded at 120 days after sowing (DAS). Weeds present inside a quadrate of size 33 cm x 33 cm in each treatment were harvested and their fresh weight was recorded by using an electric balance. Subsequently the data were converted into kg ha^{-1}.

To collect the dry weed biomass (kg ha^{-1}) data the fresh samples were kept in oven at 65^{0}C for 48 hrs and then the dry weight was recorded, averaged and subsequently converted into kg ha^{-1}.

Spike length (cm) was recorded by measuring the length of ten randomly selected spikes from each wheat plot and then the values were averaged.

The plants harvested in each treatment were threshed individually and then grain yield was recorded, and the values were converted to kg ha^{-1} by using the following formula:

$$\text{Grain yield (kg ha}^{1}) = \frac{\text{Weight of sample (kg) x 10000}}{\text{Area harvested (m}^{2})}$$

For data on pod yield of pea, pods from the whole plots containing pea were picked on weekly basis and total fresh weight was calculated, recorded and averaged. The data collected were converted into pod yield (kg ha^{-1}).

Statistical analysis

All the recorded data were analyzed using Analysis of Variance (ANOVA) and the means were separated by Least Significant Difference (LSD) test (Jan *et al*., 2009). Statistical computer software, MSTATC (Michigan State University, USA) was applied for computing both the ANOVA and LSD.

Results and Discussion

Weed density (m^{-2}): Data presented in Table 1 indicated that weeding had non-significant effect on the weed density (m^{-2}) at 120 DAS. This might be probably due to the fact that many weeds had completed their life cycles and thus had dried and decayed as weeds have usually shorter life cycle than crop plants. Intercropping of peas and wheat had significant ($p \leq 0.05$) effect on the weed density. It was noted that minimum weed density m^{-2} (222) was recorded in sole wheat (T1) followed by T3 (256) and T6 (256). While maximum weed density m^{-2} (307) was recorded in T8 (307) followed by T4 (283). Interaction of intercropping and weeding was non-significant. Overall data indicated that closer rows of wheat were more effective in decreasing the weed density as compared to wider rows due to intercropping of pea. Bilalis *et al*., (2009) reported that maize-legume intercropping system prevent the sunlight to reach to the weeds therefore the weed density is decreased. Therefore it is suggested that weeds could be suppressed by intercropping legume in wheat with closer row spacing.

Fresh weed biomass (kg ha^{-1}): Perusal of the data presented in Table 2 regarding the fresh weed biomass showed that weeding, intercropping as well as their interaction significantly ($p \leq 0.05$) affected the fresh weed biomass at 120 DAS. Weed free produced statistically lower fresh weed biomass (297 kg ha^{-1}) as compared to weed infested that produced 970 kg ha^{-1}. Due to rainy weather and irrigation of the crop, weeding with regular interval was difficult. Therefore some weeds got chance to grow up to some extent and thus produced biomass. Means o the intercropping showed that sole wheat was competitive enough to decrease the fresh weed biomass as compared to intercropping of wheat with pea. Different intercropping treatments produced different fresh weed biomass where minimum fresh weed biomass was recorded in sole wheat (460 kg ha^{-1}) followed by sole pea (536 kg ha^{-1}). Maximum fresh weed biomass of 726 and 711 kg ha^{-1} was recorded in T7 and T8 probably due to availability of more space for the weeds to grow vegetatively. The present findings revealed that sole stand of either crop was more effective in decreasing the fresh weed biomass as compared to intercropped. This is probably due to the smothering effect of the two species. However, other researchers (Rashid *et al*., 2011; Lelei *et al*., 2009) clearly demonstrated beneficial effects of maize–legume intercrops on weed suppression and crop growth. In interaction maximum fresh weed biomass was observed in T5-T8 where the values ranged from 1077–1062 kg ha^{-1}. While minimum values were recorded in T1 and T2. The values were 219 and 240 kg ha^{-1}, respectively.

Table 1. Effect of weeding and pea-wheat intercropping on weed density (m^{-2}) at 120 DAS.

Treatments	Weeding		Means
	Weeds free	Weeds infested	
T1: Wheat (Sole)	216	228	222 c
T2: Pea (Sole)	201	333	267 abc
T3: Wheat 1 row + Pea 1 row	177	336	256 bc
T4: Wheat 2 rows + Pea 1 row	171	396	283 ab
T5: Wheat 3 rows Pea 1 row	219	324	271 ab
T6: Wheat 2 rows Pea 2 rows	198	315	256 bc
T7: Wheat 3 rows Pea 2 rows	183	378	280 ab
T8: Wheat 3 rows Pea 3 rows	216	399	307 a
Means	**338**	**197**	

$LSD_{0.05}$ treatment = 81.120; $LSD_{0.05}$ weeding = NS, $LSD_{0.05}$ interaction = NS

Table 2. Effect of weeding and wheat-pea intercropping on fresh weed biomass (kg ha^{-1}).

Treatments	Weeding		Means
	Weeds free	Weeds infested	
T1: Wheat (Sole)	219 g	702 d	460 d
T2: Pea (Sole)	240 fg	813 c	526 c
T3: Wheat 1 row + Pea 1 row	288 efg	975 b	631 b
T4: Wheat 2 rows + Pea 1 row	312 ef	948 b	630 b
T5: Wheat 3 rows + Pea 1 row	303 ef	1077 a	690 a
T6: Wheat 2 rows + Pea 2 rows	300 ef	1095 a	697 a
T7: Wheat 3 rows + Pea 2 rows	357 e	1095 a	726 a
T8: Wheat 3 rows + Pea 3 rows	360 e	1062 a	711 a
Means	**297 b**	**970 a**	

$LSD_{0.05}$ treatment = 49.819; $LSD_{0.05}$ weeding = 23.307; $LSD_{0.05}$ interaction = 80.741

Dry weed biomass (kg ha^{-1}): Like fresh weed biomass, dry weed biomass was also significantly affected by weeding and intercropping of wheat and pea (Table 3). Means o the weeding indicated that dry weed biomass in weed infested plots was significantly higher than the weed free plots. Intercropping of pea in wheat also decreased the dry weed biomass significantly. Sole wheat produced minimum dry weed biomass (1332 kg ha^{-1}) as compared to the intercropped treatments. It was noted that in treatments where wheat rows were closer to each other, produced less dry weed biomass probably due to the canopy coverage of the wheat plants. While in pea intercropped treatments, weeds found plenty of sunlight to grow.

Spike length (cm) of wheat: Data presented in Table 4 regarding the spike length (cm) of wheat showed that weeding had significant ($p \leq 0.05$) effect while intercropping and their interaction had non-significant effect on the spike length (cm) of wheat. means of the data (Table 6) depicted that weed free plots produced statistically lengthy spike length of wheat (10 cm) as compared to weed infested that produced 9cm spike length. Means of the treatments (intercropping) showed that different intercropping treatments produced different spike lengths, where minimum value was recorded in T5 (9cm). While, the values for spike length in all other treatments were statistically and numerically the same. Although many researchers like Khan *et al*., (2002) reported that weed control significantly increase the spike length of wheat, but in our findings no such results were noted. Interaction of intercropping of pea and weeding showed non-significant regarding the spike length of wheat. The present findings depicted that the competition between pea and wheat was no so severe therefore the spike length was non-significantly affected. Spike length is an important yield component of wheat and thus greatly affects the grin yield of wheat. But in our study the spike length was non-significantly affected.

Grain yield (kg ha^{-1}) of wheat: Analysis of variance (ANOVA) indicated that weeding and intercropping had significant effect on grain yield of wheat while interaction was non-significant (Appendix-12). Data presented in Table 5 depicted that grain yield in weed free plot 3200 kg ha^{-1}) was significantly ($p<0.05$) higher than the weed infested plots (2329 kg ha^{-1}). In a weeds related studies, Khan *et al*., 2002 reported that weed control significantly increased the grain yield of crop as compared to weed infested conditions. Intercropping of wheat and pea did not affect the grain yield. Similarly, interaction was also non-significant regarding grain yield of wheat. Other researchers have also reported similar results. Polthanee and Trelo-ges (2003) found that grain yield and yield components of crop was unaffected by intercropping system. As grain yield is the economic yield that is the objective of the farmers. Therefore the instant results showed that intercropping had positive effect on grain yield of wheat. Thus intercropping of pea in wheat should be encouraged in the wheat growing belt.

Table 3. Effect of weeding and wheat-pea intercropping on dry weed biomass (kg ha^{-1}).

Treatments	Weeding		Means
	Weeds free	Weeds infested	
T1: Wheat (Sole)	105 de	159 bcd	132 d
T2: Pea (Sole)	102 de	186 ab	144 cd
T3: Wheat 1 row + Pea 1 row	96 e	183 abc	139 d
T4: Wheat 2 rows + Pea 1 row	114 de	189 ab	151 bcd
T5: Wheat 3 rows + Pea 1 row	126 cde	183 abc	154 abcd
T6: Wheat 2 rows + Pea 2 rows	144 bcde	234 a	189 a
T7: Wheat 3 rows + Pea 2 rows	141 bcde	219 a	180 ab
T8: Wheat 3 rows + Pea 3 rows	141 bcde	216 a	178 abc
Means	**121.13 b**	**196 a**	

$LSD_{0.05}$ treatment = 35.020; $LSD_{0.05}$ weeding = 13.228; $LSD_{0.05}$ interaction = 56.755

Table 4. Effect of weeding and wheat-pea intercropping on spike length (cm) of wheat.

Treatments	Weeding		Means
	Weeds free	Weeds infested	
T1: Wheat (Sole)	10	9	10
T2 : Wheat 1 row + Pea 1 row	11	9	10
T3: Wheat 2 rows + Pea 1 row	10	9	10
T4: Wheat 3 rows + Pea 1 row	11	9	10
T5: Wheat 2 rows + Pea 2 rows	10	9	9
T6: Wheat 3 rows + Pea 2 rows	11	9	10
T7: Wheat 3 rows + Pea 3 rows	11	9	10
Means	**10 a**	**9 b**	

$LSD_{0.05}$ treatment = NS; $LSD_{0.05}$ weeding = 1.1248; $LSD_{0.05}$ interaction = NS

Table 5. Effect of weeding and wheat-pea intercropping on grain yield (kg ha^{-1}) of wheat.

Treatments	Weeding		Means
	Weeds free	Weeds infested	
T1: Wheat (Sole)	3267	2300	2783
T2: Wheat 1 row + Pea 1 row	3133	2067	2600
T3: Wheat 2 rows + Pea 1 row	3100	2500	2867
T4: Wheat 3 rows + Pea 1 row	3100	2233	2667
T5: Wheat 2 rows + Pea 2 rows	3367	2433	2900
T6: Wheat 3 rows + Pea 2 rows	2867	2233	2550
T7: Wheat 3 rows + Pea 3 rows	3433	2533	2983
Means	**3200 a**	**2329 b**	

$LSD_{0.05}$ treatment = NS; $LSD_{0.05}$ weeding = 0.4099; $LSD_{0.05}$ interaction = 1.1327

Pod yield (kg ha^{-1}) of pea: Data presented in Table 6 depicted that weeding significantly ($P \leq 0.05$) affected the green pods yield of pea. Means of the data showed that weed free plots produced more yield of pods (1465 kg ha^{-1}) as compared to weed infested plots. As pea has slow growth rate as compared to many weeds therefore the pods yield of pea was greatly affected by weed competition. Means of the treatments showed that pod yield of pea was different in different combinations of intercropping. Maximum pod yield of 1671 kg ha^{-1} was recorded in sole pea while minimum pod yield was observed in T4 (970 kg ha^{-1}). Interaction of intercropping and weeding was non-significant. In an intercropping study, it was noted that intercropping was superior in term of forage quality and thus was suggested as alternative options for forage production (Lithourgidisa *et al*., 2011). Al-Johani *et al.,* (2012) reported that one of the main problems that agricultural production faces is weeds that interfere with crop growth and production. As green pod yield is the major objective of the farmers therefore it is suggested that pea should be intercropped in wheat at various seeding rate to investigate the potential of pods yield of pea.

Land equivalent ratio (LER): The judgment of profitability of an intercropping is usually measured by calculating the land quivalent ratio (LER). The value of LER greater than one is considered as advantageous. In the present study LER values indicated that all the possible combinations of intercropping treatments gave values that were greater than one. Therefore all combinations are considered as advantageous (Table 7). In a similar study, Haymes and Lee (1999) found that higher values of land equivalent ratios were achieved in an intercropping system compared with sole crops of either species. Similarly, Dahmardeh *et al*., (2010) claimed that land equivalent ratio values were greater in all intercropping systems. In light of the above results and previous reports it could be concluded that intercropping is profitable and hence this concept should be popularized in the developing countries like Pakistan. As intercropping of pea in wheat will cause no additional burden on the farmers for purchasing additional inputs therefore this concept should be popularized and encouraged across the countries. As there was no additional agronomic practice except the fixing support for pea plants therefore intercropping of pea with wheat showed results that are encouraging and desirable.

Table 6. Effect of weeding and wheat-pea intercropping on pods yield (kg ha^{-1}) of pea.

Treatments	Weeding		Means
	Weeds free	Weeds infested	
T1: Pea (Sole)	2108	1234	1671 a
T2: Wheat 1 row + Pea 1 row	1051	637	844 f
T3: Wheat 2 rows + Pea 1 row	1127	817	972 e
T4: Wheat 3 rows + Pea 1 row	1132	809	970 e
T5: Wheat 2 rows + Pea 2 rows	1301	935	1118 d
T6: Wheat 3 rows + Pea 2 rows	1640	1089	1365 c
T7: Wheat 3 rows + Pea 3 rows	1899	1262	1580 b
Means	**1465 a**	**969 b**	

$LSD_{0.05}$ weeding = 41.507

Table 7. Land Equivalent Ratio (LER) of wheat and pea intercropping.

Treatments	Wheat	Pea	LER
Wheat 1 row + Pea 1 row	0.51	0.93	1.44
Wheat 2 rows + Pea 1 row	0.93	1.03	1.61
Wheat 3 rows + Pea 1 row	0.58	0.96	1.54
Wheat 2 rows + Pea 2 rows	0.69	1.04	1.73
Wheat 3 rows + Pea 2 rows	0.82	0.92	1.74
Wheat 3 rows + Pea 3 rows	0.96	1.07	2.03

Conclusion

Wheat being taller and exhausting crop, was able to suppress the weeds more effectively as compared to pea. Like wheat, weeding also significantly increased the biomass and pods yield of pea. Similarly, pure stand of pea produced higher pod yield as compared to intercropped pea. In light of the results it could be concluded from the results that pea as well as wheat should be kept weed free during the growing seasons for getting higher yield. However, it seems that harvesting of wheat will be difficult due to intercropping in pea therefore pea intercropping in wheat is recommended for the farmers having small land holdings. As agriculture in our country is partially mechanized therefore special machinery like wheat thresher and combine harvester can not be used in wheat and pea intercropping due to harvesting problem. However, subsistence farmers usually harvest the crop manually therefore such intercropping is not a problem for harvesting the wheat crop.

References

Al-Johani, N.S., A. A. Aytah and T. Boutraa. 2012. Allelopathic impact of two weeds, chenopodium murale and *Malva parviflora* on growth and photosynthesis of barley (*Hordeum vulgare* L.). *Pak. J. Bot.,* 44(6): 1865-1872.

Andersen, T., P.J. Faerovig and D.O. Hessen. 2007. Zooplankton carrying capacity as related to quality and quantity of food. *Limnol. Oceanogr*., 52: 2128-2134.

Anil, L., R. Park, R.H. Phipps and F.A. Miller. 1998. Temperate intercropping of cereals for forage: a review of the potential for growth and utilization with particular reference to the UK. *Grass Forage Sci*., 53: 301-317.

Anonymous. 2009. Agricultural Statistics of Pakistan 2008-09. Ministry of Food and Agriculture (Economic Wing) MINFA. Islamabad.

Bilalis, D., A. Karkanis, A. Efhimiadou, A.R. Konstantas and V. Triantafyllidis. 2009. Effects of irrigation system and green manure on yield and nicotine content of Virginia (Flue-cured) Organic tobacco (*Nicotiana tabaccum*), under Mediterranean conditions. *Ind. Crops Prod*., 29: 388-394.

Dahmardeh, M., A. Ghanbari, B.A. Syahsar, and M. Ramrodi. 2010. The role of intercropping maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata* L.) on yield and soil chemical properties. *African J. Agricul. Res.*, 5(8), 631-636.

Entz, M., J.W. Hoeppner, L. Wilson, M. Tenuta, K.C. Bamford and N. Holliday. 2001. Influence of organic management with different crop rotations on selected productivity parameters in a long-term Canadian field study. www.isofar.org. retrieved on 28.2.2013.

Haymes, R. and H.C. Lee. 1999. Competition between autumn and spring planted grain intercrops of wheat (*Triticum aestivum*) and field bean (*Vicia faba*). *Field Crops Res*., 62: 167-176.

Hussain, S., M. A. Nadeem, A. Tanveer and R. Ullah. 2012. Determining critical weed competition period in maize (*Zea mays* L.) sown under different tillage intensities. *Pak. J. Weed Sci. Res.*, 18(4): 461-474.

Jan, M.T., P. Shah, P.A. Hollington, M.J. Khan and Q. Sohail. 2009. Agriculture Research: Design and Analysis, A Monograph. NWFP Agric. Univ. Pesh. Pak.

Jensen, E.S., H.H. Nielsen, J. Kinane, M.K. Andersen and B. Jornsgaard. 2005. Intercropping – The practical application of diversity, competition and facilitation in arable organic cropping systems. In: *Researching Sustainable Systems*. (Eds.): U. Köpke, U. Niggli, D. Neuhoff, W. Lockeretz and H. Willer. *Proc. 1st Sci. Conf. Intl. Soc. Organic Agric. Res. (ISOFAR), Bonn, Germany*, pp. 22-25.

Karlen, D.L., S.S. Andrews, B.J. Weinhold and J.W. Doran. 2003. Soil quality: humankind's foundation for survival. *J. Soil Water Conserv*., 58(4): 171-179.

Khan, M.A., B. Gul and D.J. Weber. 2002. Improving seed germination of Salicornia rubra. (Chenopodiaceae) under saline conditions using germination regulating chemicals. *Western North American Naturalist*, 62: 101-105.

Lelei, J.J., R.N. Onwonga and B. Freyer. 2009. Organic based nutrient management strategies: effect on soil nutrient availability and maize performance in Njoro, Kenya. *Afric. J. Agric. Res*., 4(2): 92-99.

Lithourgidisa, A.S., D.N. Vlachostergiosb, C.A. Dordasc and C.A. Damalasd. 2011. Dry matter yield, nitrogen content, and competition in pea–cereal intercropping systems. *Europ. J. Agron*., 34(4): 287-294.

Memon, R.A., G. R. Bhatti, S. Khalid, A. Mallah and S. Ahmed. 2013. Illustrated weed flora of wheat crop of Khairpur district, Sindh. *Pak. J. Bot.*, 45(1): 39-47.

Polthanee, A. and V. Treloges. 2003. Growth, yield and land use efficiency of corn and legumes grown under intercropping systems. *Plant Prod. Sci*., 6(2): 139-146.

Rashid, S., Z.I. Ahmed, M. Ashraf, M. Arif, M.A. Malik, M. Munir and M.A. Khan. 2011. Response of maize-legume intercropping system to different fertility sources under rainfed conditions. *Sarhad J. Agric*., 27(4): 503-511.

Tripolskaja, L., D. Romanovskaja and A. Slepetiene. 2008. The effect of various soil and crop management practices on the humus status in sandy loam. *Haplic Luvisol. Agric*., 95(4): 3-18.

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