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RESEARCH PAPER

Growth, Yield and Yield Components of Wheat (*Triticum aestivum* L.), Chickpea and Wild mustard as Influenced by Intercropping in Different Row Proportions

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A B S T R A C T:

A field experiment was conducted at Grdarasha Experimental Farm / College of Agricultural Engineering Sciences / Salahaddin University – Erbil, located at (36.2^o N, 44.1^o E and elevation 470 m) during the winter season of (2016-2017) to study the performance of wheat (*Triticum aestivum* L.), chickpea (*Cicer arietinum* L.) and wild mustard (*Sinapis arvensis* L.) in intercropping. Seven treatments were initialized from combination of either single, double or triple (row: species) were arranged in a standard replacement series. Aiming to study growth, yield and yield component of wheat (A), chickpea (B) in the presence of the invading wild mustard weed (C), which is the common invader weed in the area. Wheat species possessed the highest significant mean values of plant height (123.0 cm), spike length (13.9 cm), grain yield (182.0 g plant^{-1}), straw yield (752.5 g plant^{-1}), while wild mustard showed superiority in all studied traits except in silique length and grain number. silique^{-1}.

KEY WORDS: Intercropping, Growth, Yield Components, Relative yield, Row: Species Ratio.
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1. INTRODUCTION

In the developing countries at tropic and sub tropic regions, lands are often utilized by a special method called intercropping where as two or more crops are grown simultaneously on the tract (Shaker and Nasrollahzadeh, 2014). Bybee-Finley and Ryan (2018) confirmed the legacy of traditional practice of the intercropping pattern throughout the history to increase yield then to insure optimal instinctive use of land in sustainable agriculture. Wheat (*Triticum aestivum* L.) is one of the most important crops in terms of cultivated area and productivity, due to the excellent control over weed invasion (Siyahpoosh *et al*., 2012).

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The mineral nutrition significantly contributed in increasing crop yields during the 20th century. (Khursheed and Mahammad, 2015). Chickpea (*Cicer arietinum* L.) is important pulses food, which is traditionally grown under rain-fed environmental conditions in most parts in the world and it is belong to the family Leguminaceae (Erdemci, 2018). Cicer arietinum L. is the main crops that have a role in fixed nitrogen in the nodules of the root, through its role in soil fertility (Qader, 2019). Wild mustard (*Sinapsis arvensis* L.) is an annual winter plant which belongs to *Brassicacea or Crusiferea* plant family it has indeterminate upright growth and may reach a height of more than two and a half meter. This weed proliferates extreme spreading through producing thousands of seeds, which are assisted by the valuable tropical and subtropical weather (Siyahpoosh *et al*., 2012). Weed-crop competition studies possessed many scenarios or experimental designs. Any one of them has a critical importance

(Rejmanek *et al*., 1989). Harper (1977), noted that the replacement design is an effective way particularity in the study of the interference between two species of plant crops. However, additive design is widely used to study the competition between the weeds and crops (Aziz, 1991; Wilcox, 1995; Ali, 2000; Bhan and Froud, 2005). In replacement series total plant density is kept fixed within a special care to plant geometry. Total density of all the crops involved in the design was constant. In other word, when the density of one crop components increases or decreases, the density of the other crops changes to maintain a constant total for all partial crop densities seeking for optimizing yield levels (Kaushik *et al*., 2016). Sharma *et al*., (1986) in the other hand detected significant effects of plant density on intercropped plants of wheat and mustard. Intercropping of wheat and mustard according to (Singh and Pal, 1994) reduces their seed yield comparing to their pure stands. Yield and yield components of wheat were significantly affected by intercropping of chickpea, lentil and rapeseed (Malik *et al*., 1998). Intercropping can increase the productivity of both yield and grain quality by integrating the use of water, fertilizer, space, and other resources (Thorsted *et al*., 2006; Lithourgidis *et al*., 2011). Selection of suitable cultivars and sowing time plays an important role in obtaining higher yields due to good utilizing of residual soil moisture and nutrients from the soil (Mandal *et al*., 1996; Sekhar *et al*., 2015; Kaushik *et al*., 2016). Cultivation of chickpea with cereal crops (barley, wheat, etc.) or oilseed (mustard, linseed, etc.) is well known to farmers of non-insured rain fed areas (Poddar *et al*., 2017). The importance of intercropping is the possibility of increasing the quantity and improving the quality not only by increasing production costs; but also by modifying farm management (Willey, 1979). Intercropping facilitates different resources of returns to the farmer from the same land, and reduces crop failure risk of a mono-cropping when susceptible to ecological and economical fluctuations. This approach was backed by (Khan *et al*., 2005). The objective of this study was to evaluate the effect of intercropping and row ratios on some growth parameters and yield components of wheat, chickpea and wild mustard.

2. MATERIALS AND METHODS

The experiment was carried out at Grdarasha Research Farm, College of Agricultural Engineering Sciences / Salahaddin University / in Erbil-Iraq (36.2º N, 44.1º E and elevation 470 m above the mean sea level). In single, double, and triple (row: species) arrangements were used in a standard replacement series to maintain a total number of 6 rows, which forms seven (row: ratio) consortia. Each group represents one intercropping mixture treatment. Combinations were repeated 3 times to form sixty three units of 2 m rows length and 0.2 m inter-row spacing forming an area of 4.8 m^2. Each treatment was duplicated to avoid any probable risk. The experiment was planned based on the Randomized Complete Block Design (RCBD). Wheat (A), chickpea (B) and wild mustard (C) were sown solely or in 1, 2, 3 rows out of 6 rows per each treatment. They form triple (row: crop) ratios named 1A:2B:3C, 1A:3B:2C, 2A:1B:3C, 2A:2B:2C, 2A:3B:1C, 3A:1B:2C and 3A:2B:1C, respectively plus three sole crops as control treatments. Data are represented by error bars with standard error labeled by (Duncan, 1975) letters for 5% significance. Samples were taken from air dried soil in the field at a depth (0 - 30 cm), and then analyzed for some physical and chemical properties as shown in (Table 1). The recorded rainfall during the growing period from (Nov. 2016 to May. 2017) was 218 mm. The seeds were sown in rows on November 26th 2016. Manual weed control repeated twice. Planting densities were chose based on the recommendations of the competent local agricultural authorities. However, wild mustard density was adopted according to its natural abundance in the region as 175, 63 and 38 plants/m^2 for wheat, chickpea and wild mustard respectively. Seeds of the competitor plant species were obtained from the Directorate of Agricultural Research Station, Erbil.

Table (1): Some selected properties of the soil at the experimental sites.

Soil properties		Unit	Available value
Particle size distribution	Sand	g/kg	128.0
	Silt	g/kg	521.4
	Clay	g/kg	350.6
Texture name			SiCL
Organic matter content		g/kg	9.3
ECe		g/kg	0.56
pH		g/kg	7.57
Calcium carbonate equivalent		g/kg	339.0

3. RESULTS AND DISCUSSION

3.1. Days to Flowering

The results of analysis of variance in figure (1) showed that chickpea plant had significant response to number of days to flowering. The highest number was recorded in the mix-consortium 2:3:1 (134.7 days), while 1:2:3 row consortia recorded lowest number of days (129.3). In addition wheat and mustard didn't obtain any significant differences among all treatments.

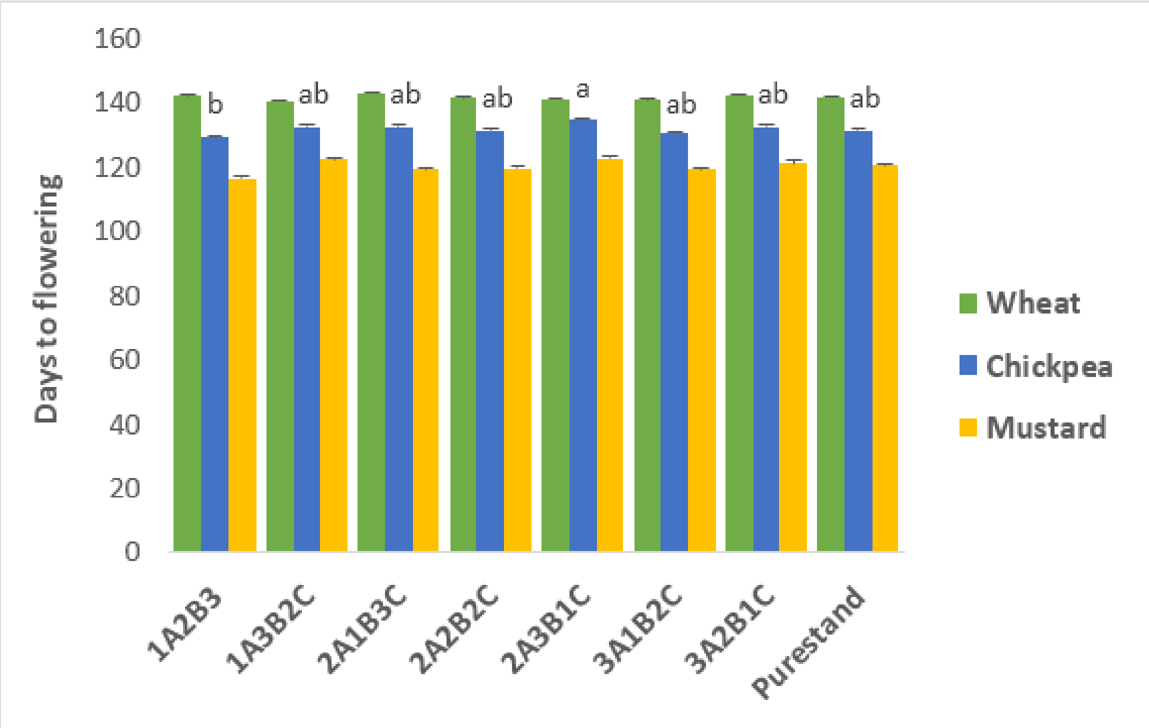

Figure 1: Effect of intercropped species on number of days to flowering.

3.2. Plant Height (cm)

Plant height is an important growth parameter that is affected by genetic and environmental variation. The result in figure (2) indicates the existence of significant differences among all studied factors. The greater plant height (123.0 cm) was showed in the treatments where chickpea and wild mustard was intercropped in 1:2:3 ratios. The wheat recorded minimum plant height of (110.2 cm) at pure stands. Chickpea possessed (77.7 cm) taller plant at 3:1:2 ratio, in addition wild mustard (130.2 cm) the highest mean when planted at 2:3:1 row species consortia. This result is in agreement with the findings of Mandal (1991), who noticed intercropping legume crops significantly increased wheat plant height.

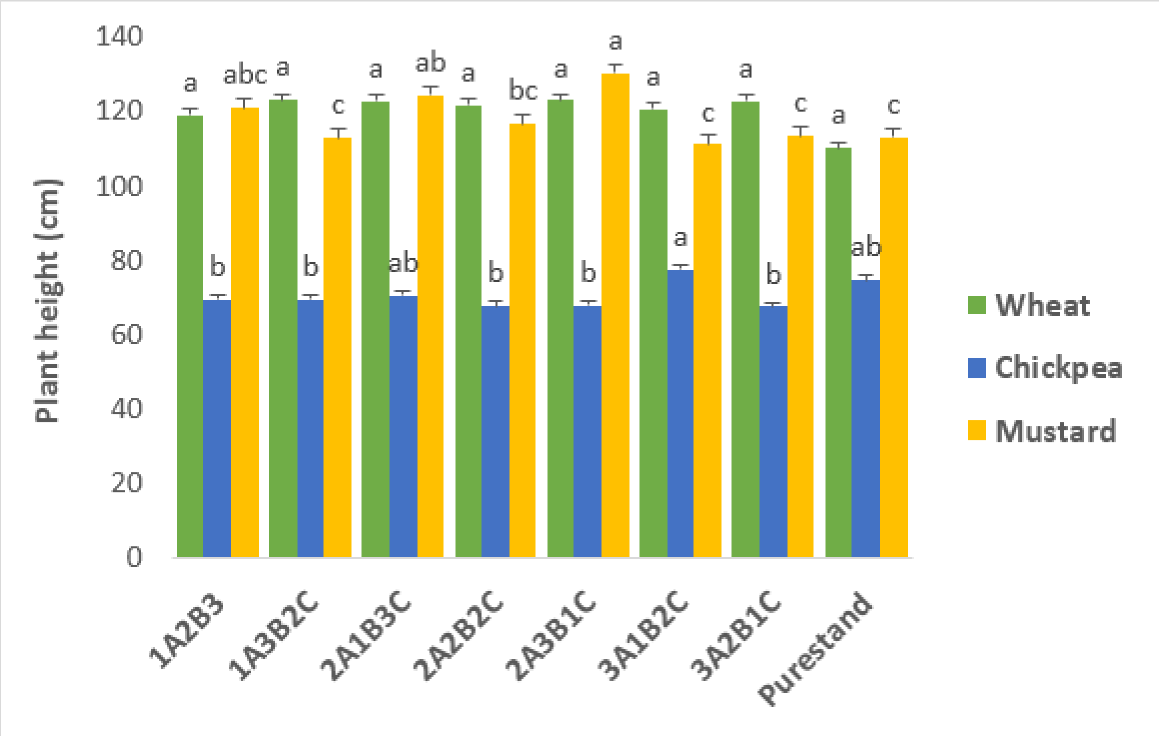

Figure 2: Effect of intercropped species on plant height (cm).

3.3. Number of tillers or branches plant $^{-1}$

Number of wheat tillers and mustard branches responded significantly to mix-culture as they produced (3.3 tillers. plant^{-1}) tiller for wheat and (17.7 branches. plant^{-1}) for mustard at consortia 1:2:3, 1:3:2 and 2:3:1 respectively superior to their pure stands, in addition chickpea obtained the highest mean value (6.0 branches. plant^{-1}) in pure stand, while the lowest value (3.7 branch. plant^{-1}) in mix-consortia 132 ratio (Figure 3). Lemerle *et al*., (2001), note that the number of tillers is the most important yield component in wheat, which reduced with increase competition of weeds. Armin *et al.* (2011) has reported that in condition of competition for nutrients, water and light availability, it will restrict the plant growth and reducing number of tiller per plant. Similar results also found by (Marof, 2008; Marof, 2013).

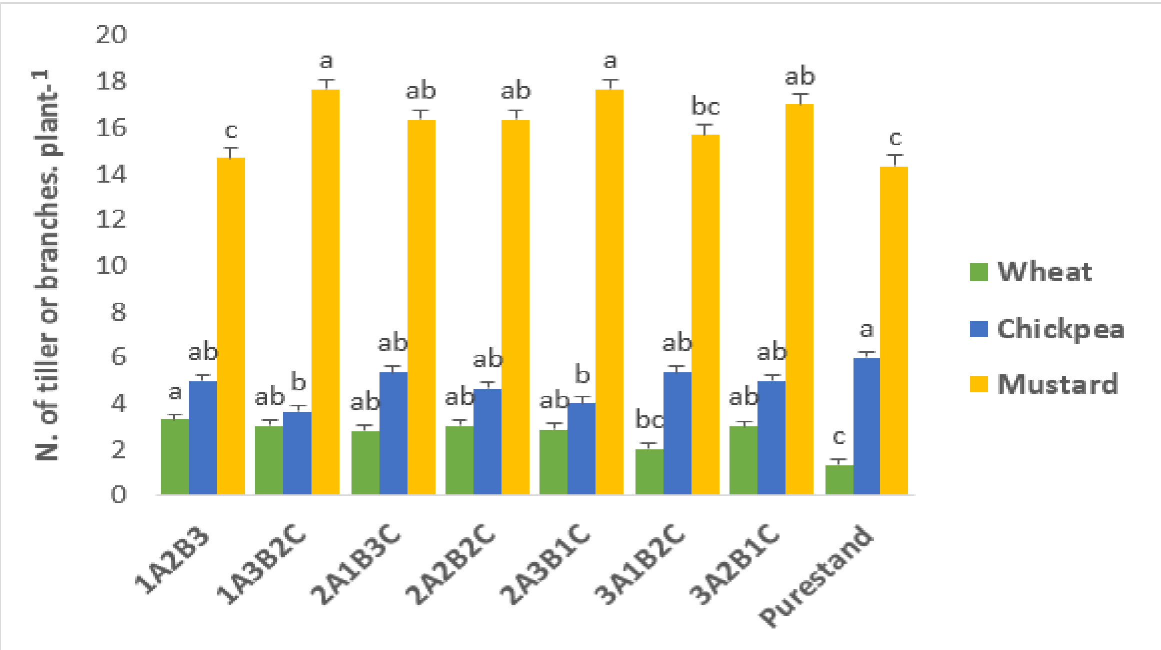

Figure 3: Effect of intercropped species on number of tiller or branch.plant^{-1}.

3.4. Spike or Pod Length (cm)

Statistical analysis of the data figure (4) revealed that chickpea shows non-significant affects in length of reproductive organs pods. However wheat plant recorded longest mean values of (13.9 cm) was possessed in the treatment where wheat was intercropped with chickpea and wild mustard in 1:3:2 ratio, while the smallest was (12.3 cm) planted at 1:2:3 mix consortia. Mustard recorded the longest silique length in the treatment 3:1:2 (2.7 cm), whereas the smallest mean was (2.3 cm) in the treatment 2:1:3 row ratio. Karim and Mamun (1988) reported that competition leads to reduced length of leaves which eventually caused the process of photosynthesis that provided less absorption than required to produce natural spike. These results are in agreement with the findings reported by (Nazir *et al*., 1988; Malik *et al*., 2002; Sinha *et al*., 2009).

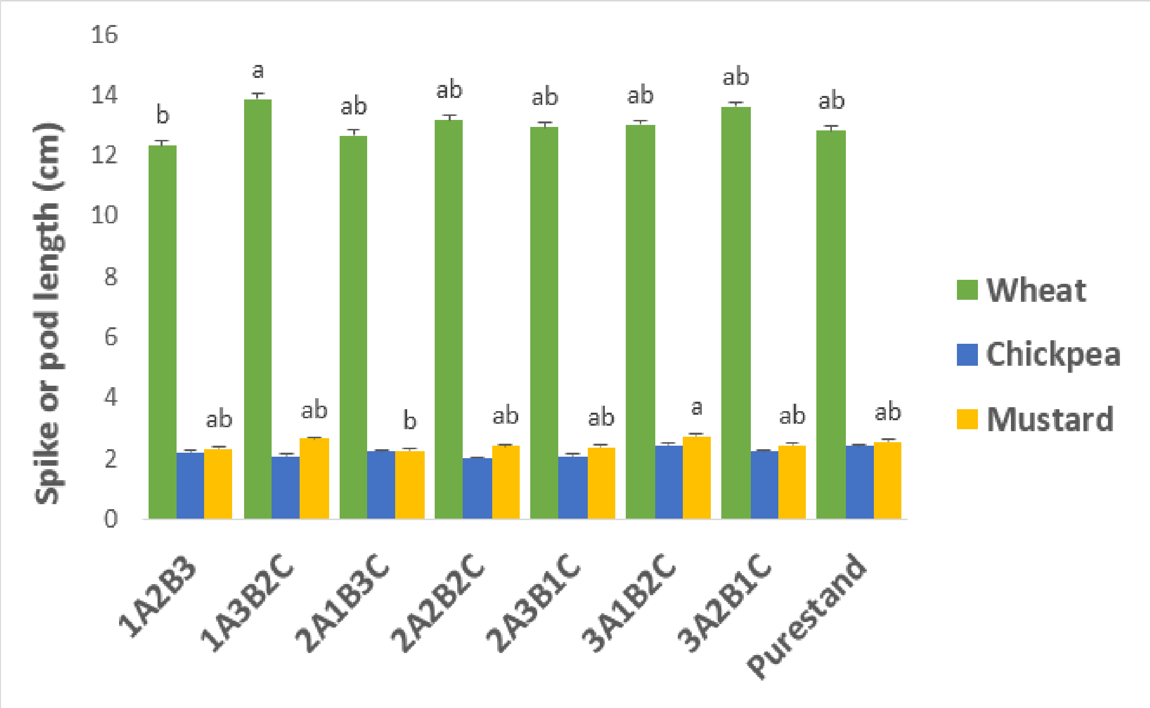

Figure 4: Effect of intercropped species on spike or pod length (cm).

3.5. Grain Number per Spike or Pod

All three competitor plant species in all mix and pure stands showed significant variation number of grain per spike or per pod and silique. The most number of grain was obtained of wheat plant (63.7) at 1:3:2, while the lower mean value was (52.3) in mix-consortia 3:1:2. Chickpea and wild mustard possessed the higher mean value (48.0 and 16.0) in the treatment 1:2:3 and 3:2:1 row ratio, followed by the lower mean was (37.0 and 12.3) in the mix-consortia 3:1:2 and 2:3:1 ratio (Figure 5).

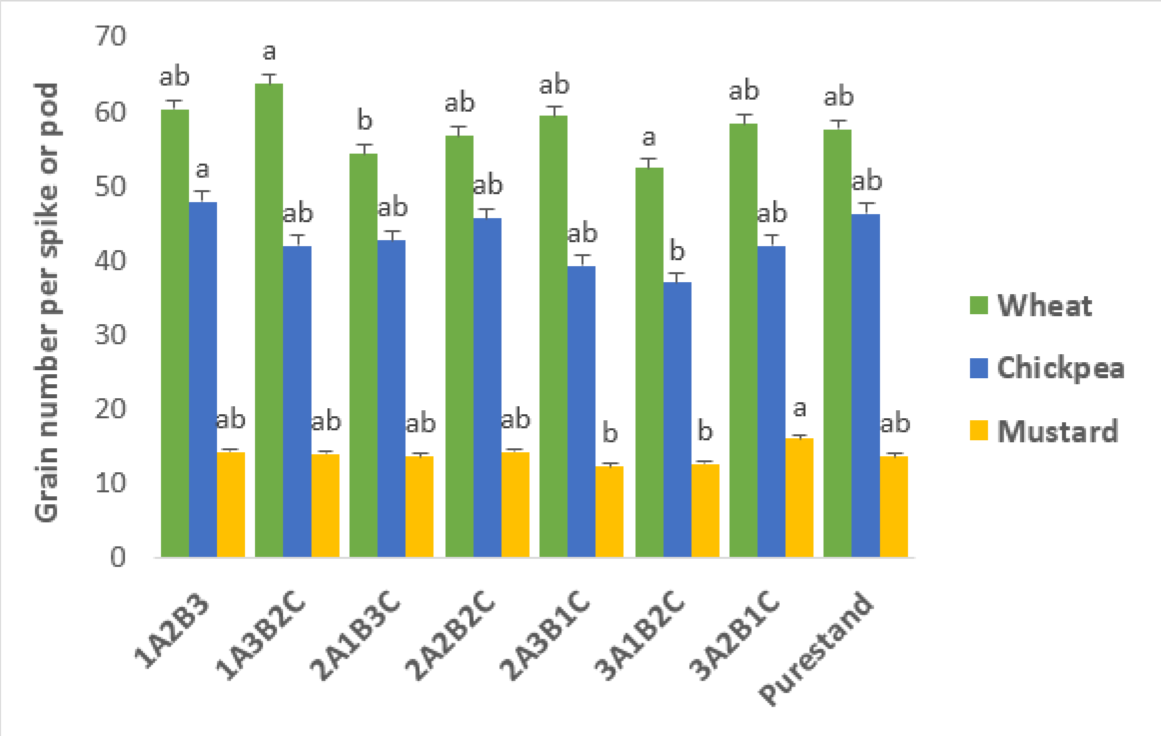

Figure 5: Effect of intercropped species on grain number per spike or pod.

3.6. Days to Maturity

The data Postulated in figure (6) confirm non-significant differences P ≥ 0.05 in the time period required to maturity in general. The highest number was (172.7) showed of wheat at 2:1:3 ratio, followed by mustard weed by (142.7) in 2:2:2 mix- consortium compared with pure stands. The decrease in the length of the plant cycle under rain conditions is one of the main effects of water deficits. (Thompson and Chase 1992), these results are also supported by (Naeem Khan *et al*., 2002; Hassani *et al*., 2006).

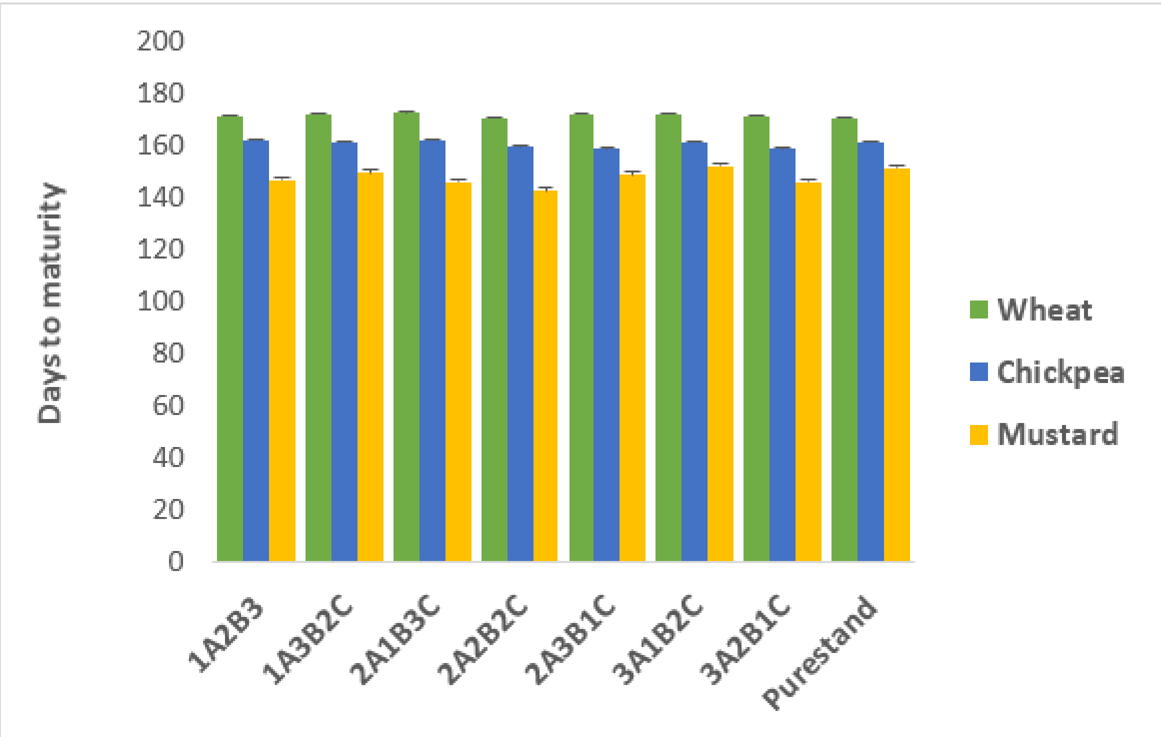

Figure 6: Effect of intercropped species on number of days to maturity.

3.7. Grain Yield (g). m^{-2}

Grain yield displayed in figure (7) shows a wide variation, the highest mean values was (182.0 g. m^{-2}) in the mix consortia 1:2:3, whereas the lowest were at (78.2 g. m^{-2}) in the pure stands of wheat plants. The highest chickpea were (82.4 g. m^{-2}) when intercropped with wheat and mustard at 2:2:2 ratio, but the lowest value was (54.6 g. m^{-2}) in the 3:1:2 row consortia. Wild mustard at pure stand recorded (54.9 g. m^{-2}) which was the highest mean value, while 3:1:2 row consortium recorded lowest value (28.9 g. m^{-2}). There has been a decline in grain yield due to the physiological and morphological characteristics of wheat and weeds that have led to a similar convergence towards the use of natural resources towards final photosynthesis (Sinha *et al*., 2009).

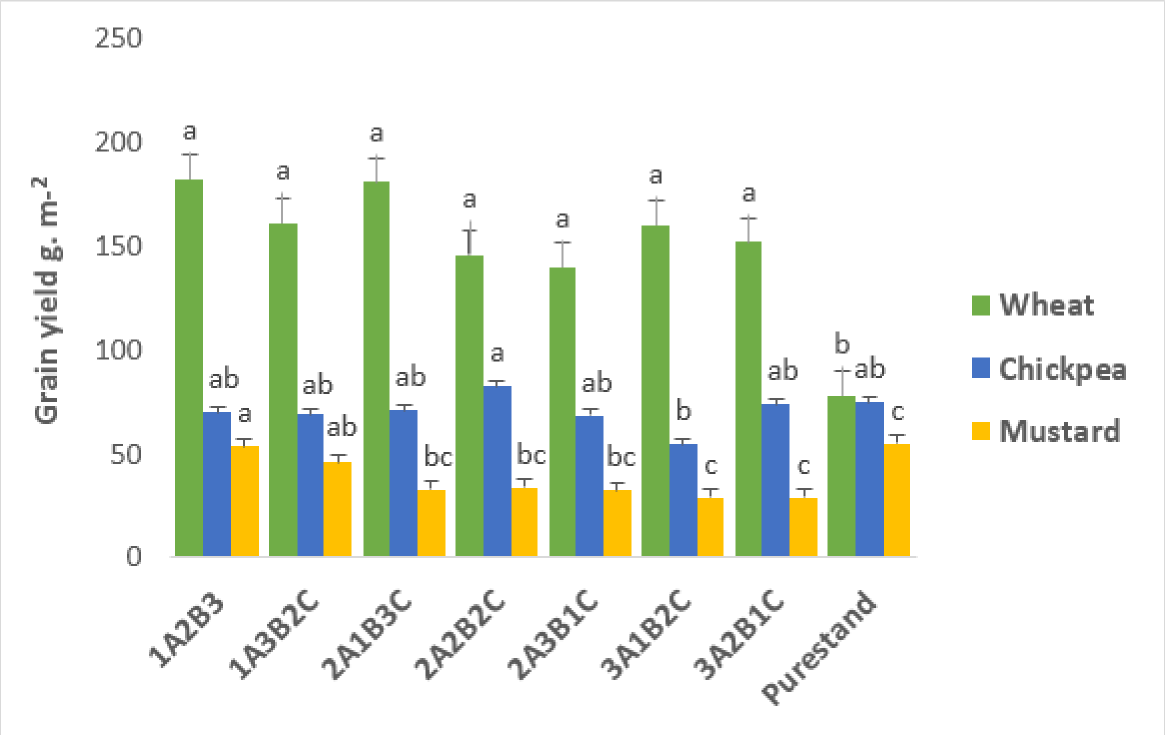

Figure 7: Effect of intercropped species on grain yield (g). m^{-2}.

3.8. Straw Yield (g). m^{-2}

Figure (8) revealed that straw yield recorded highest significant mean value of wheat in the mix stand 1:2:3 was (752.5 g. m^{-2}), whereas the lowest value was (385.7 g. m^{-2}) in the pure stand. Wild mustard cultivated produced higher straw yield (211.9 g. m^{-2}) in the pure stand over all mix-consortia. However chickpea plants showed non-significant effected on mean straw yield over all studied treatments. Hossain *et al.* (2010), suggested that straw yield decreases with increased competition for weeds, because the plant cannot take more light for photosynthesis and tillage production, while disagree results were noted by (Marof, 2008).

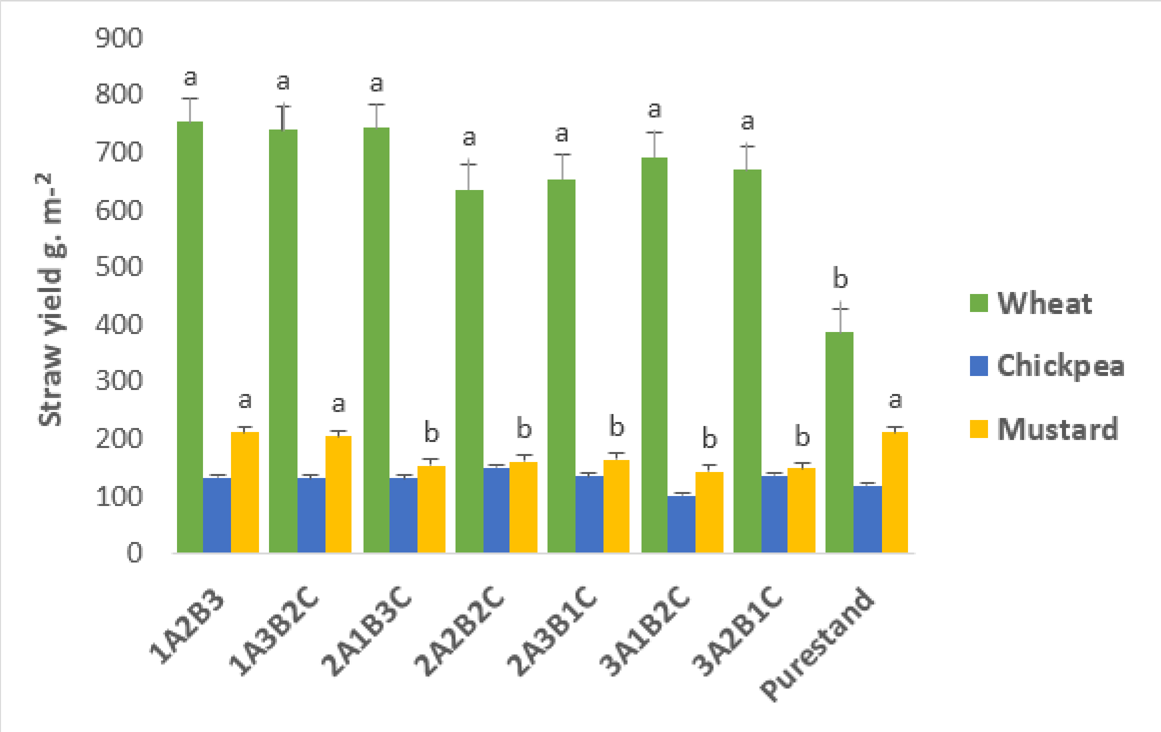

Figure 8: Effect of intercropped species on straw yield (g). m^{-2}.

3.9. Biological Yield (g). m^{-2}

Biological yield is correlated with plant height and number of tillers. The data presented in figure (9) shows that chickpea and wild mustard possessed the highest mean value (233.1 and 266.7 g. m^{-2}) in 2:2:2 mix and pure stand respectively. In addition 3:1:2 row mix-consortia recorded the lowest value which was (155.5 and 171.8 g. m^{-2}) respectively. Additionally wheat plant didn't possess any significant differences over all mix and pure stands in this trait.

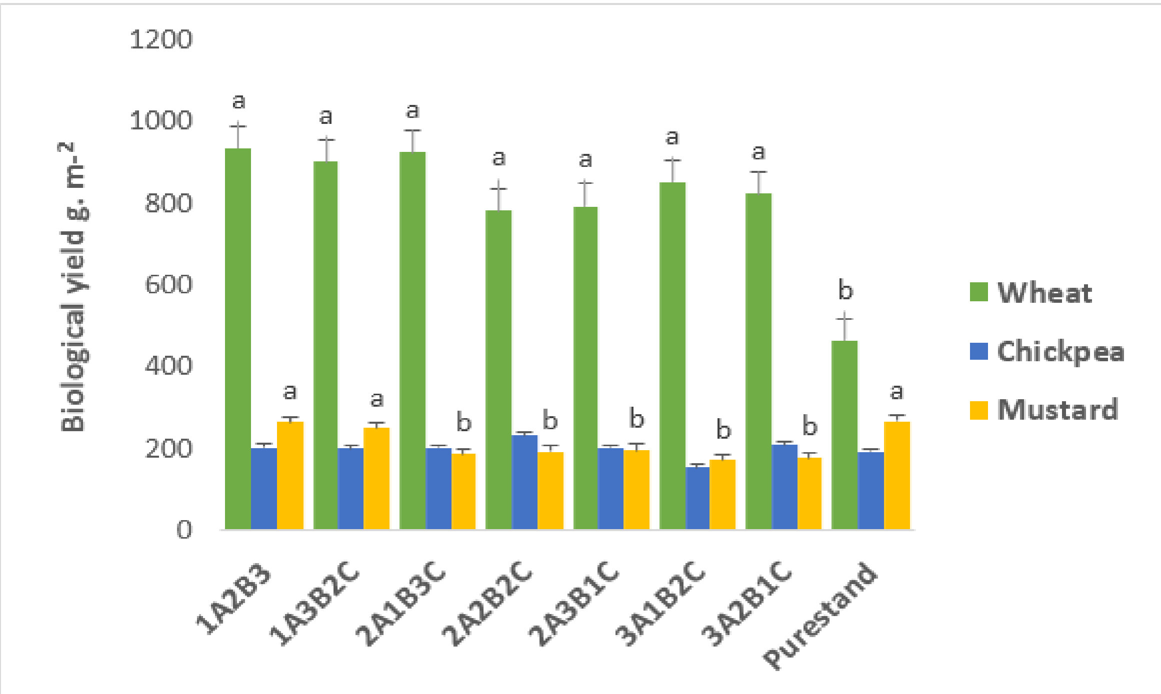

Figure 9: Effect of intercropped species on biological yield (g). m^{-2}.

3.10. Harvest Index

The results of harvest index displayed in figure (10) the higher mean value of cultivated chickpea was (0.38) in pure-stand, whereas the lowest was recorded at 2:3:1 which was (0.33). The maximum was for mustard provided (0.20) in mix consortia 1:2:3 and pure stand respectively. However, wheat plant showed no significant differences among all studied treatments.

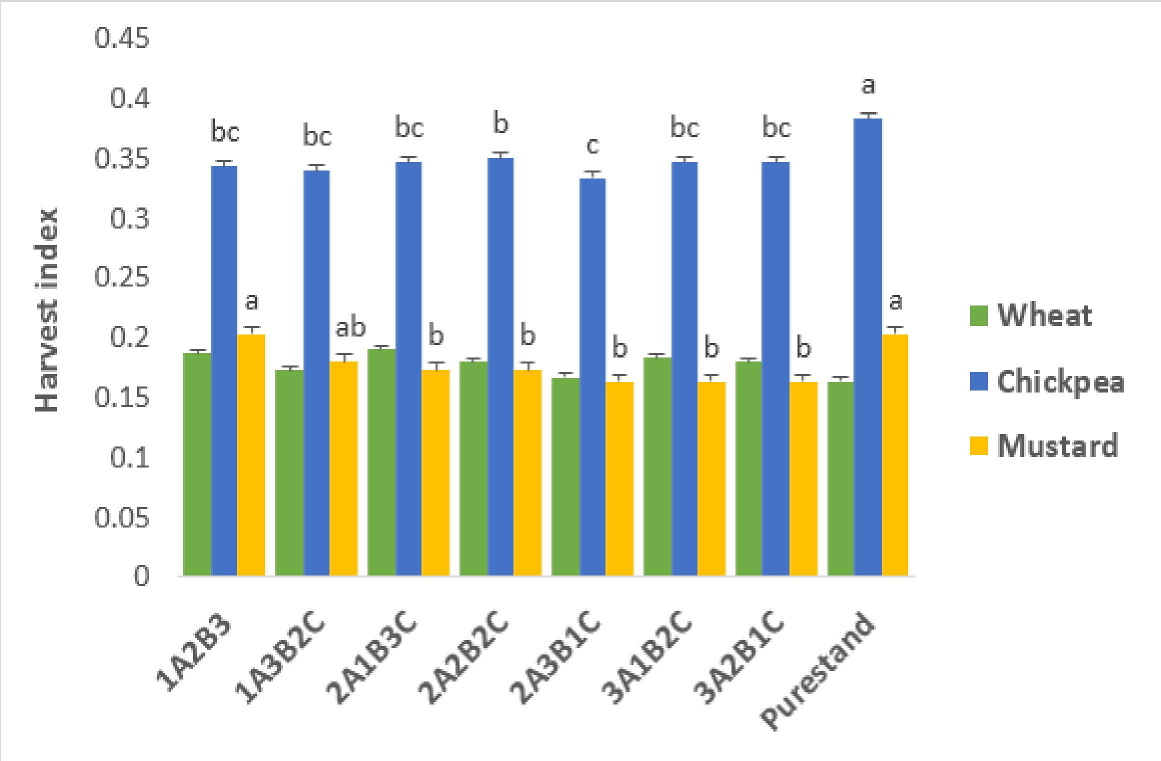

Figure 10: Effect of intercropped species on harvest index.

3.11. Relative Yield and Relative Yield Total

The data presented in figure (11) turns out that partial relative yield of chickpea and mustard plant scored highest significant mean value 1.102 in mix consortium 2:2:2 and 0.979 in 1:2:3 mix consortia over pure stands, while wheat plant didn't scored any significant effects. Total relative yield scored higher mean value 1.414 in mix consortia 1:2:3 and lower mean value 1.098 in 2:3:1 mix consortium.

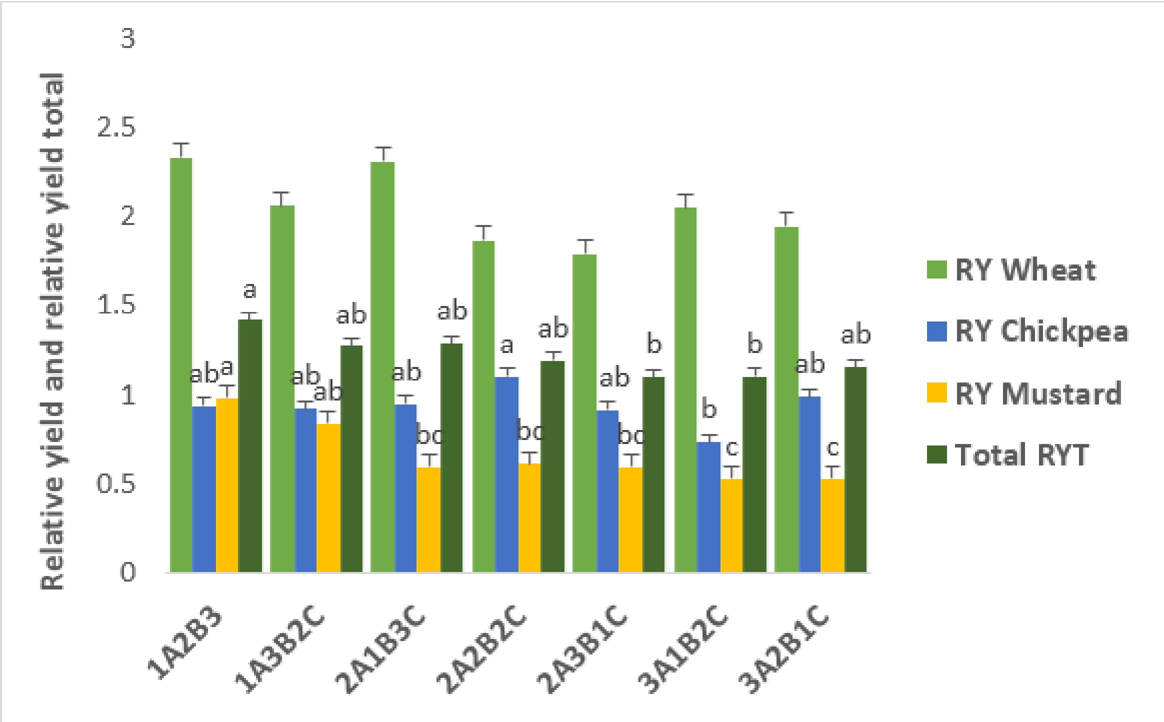

Figure 11: Effect of intercropped species on relative yield and relative yield total.

Table (2): The analysis of variance (ANOVA) for the effect of intercropped species on growth, yield and yield components.

Crop	Source DF / Parameters	Sum of Squares	df	Mean Square	F	Sig.
Wheat	Days to flowering	14	7	2	0.857	0.559
	Plant height (cm)	394.8	7	56.4	3.091	0.029
	N. of tiller. plant^{-1}	9.052	7	1.293	3.119	0.028
	Spike length (cm)	5.166	7	0.738	1.665	0.188
	Grain number. spike^{-1}	260	7	37.143	2.19	0.092
	Days to maturity	10.5	7	1.5	0.643	0.715
	Grain yield g. m^{-2}	22390.3	7	3198.61	2.314	0.078
	Straw yield g. m^{-2}	295105	7	42157.8	5.454	0.002
	Biological yield g. m^{-2}	476683	7	68097.6	4.544	0.006
	Harvest index	0.002	7	0	0.581	0.762
Chickpea	Days to flowering	54.5	7	7.786	1.797	0.157
	Plant height (cm)	287.265	7	41.038	1.992	0.12
	N. of branch. plant^{-1}	11.958	7	1.708	1.864	0.143
	Pod length (cm)	0.516	7	0.074	1.351	0.291
	Grain number. pod^{-1}	283.958	7	40.565	1.732	0.172
	Days to maturity	43.833	7	6.262	0.737	0.645
	Grain yield g. m^{-2}	1290.05	7	184.293	1.007	0.462
	Straw yield g. m^{-2}	4445.96	7	635.137	0.971	0.484

	Biological yield g. m^{-2}	9765.76	7	1395.11	0.917	0.519
	Harvest index	0.005	7	0.001	13.321	0
Wild Mustard	Days to flowering	79.167	7	11.31	1.299	0.312
	Plant height (cm)	952.213	7	136.03	4.448	0.006
	N. of branch. $plant^{-1}$	33.292	7	4.756	5.188	0.003
	Silique length (cm)	0.576	7	0.082	1.317	0.304
	Grain number. $silique^{-1}$	26.625	7	3.804	1.049	0.437
	Days to maturity	202	7	28.857	0.63	0.725
	Grain yield g. m^{-2}	2492.85	7	356.121	5.316	0.003
	Straw yield g. m^{-2}	18298	7	2614	5.313	0.003
	Biological yield g. m^{-2}	34028.4	7	4861.19	5.665	0.002
	Harvest index	0.006	7	0.001	2.904	0.037

Significant occurs when $P \leq 0.05$

4. CONCLUSIONS

Intercropping could reduce the yield of mustard to about 30% compared to the yield in its sole cropping. Wheat and chickpea did not show any reciprocal significant harm effects on each other.

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