J. Plant Production, Mansoura Univ., Vol. 5 (5): 821-836, 2014

INCREASING FODDER BEET PRODUCTIVITY BY INTERCROPPING WITH SOME FIELD CROPS

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ABSTRACT

A two-year study was carried out at Sids Agricultural Experiments and Research Station, A.R.C., Beni - Sweif Governorate, Egypt during 2009/2010 and 2010/2011 winter seasons to investigate the possibility of increasing fodder beet productivity and net return per unit area by intercropping fodder beet with some field crops for encouraging Egyptian farmers to grow fodder beet in their fields. Fodder beet plants were grown in one row on all ridges (60 cm width) with intercropping barley, wheat or faba bean plants on the other side of the first and third ridges. Also, fodder beet plants were grown in both side of beds (120 cm width) with intercropping barley, wheat or faba bean plants in the middle of second and forth beds in addition to sole plantings of all the tested field crops. A split plot design in randomized complete block design in four replications was used. The results can be summarized as follows:

Intercropping barley, wheat and faba bean with fodder beet led to decrease in yields of all tested field crops in comparison with sole plantings of these crops. As a result of intercropping, root yield of fodder beet was decreased by 18.44, 17.10 and 17.78% in the 1st and 2nd seasons and the combined analysis, respectively, as compared with sole fodder beet. Growing fodder beet on ridges (60 cm width) under intercropping and sole cultures had higher values of all the studied traits of fodder beet than those gown on beds (120 cm width) , whereas, yields of barley, wheat and faba bean were not affected. The interaction between cropping systems and ridge width was not significantly affect all the studied traits of all the tested crops.

For competitive relationships, intercropping fodder beet with barley, wheat and faba bean increased land equivalent ratio (LER) as compared to sole fodder beet. LER ranged from 1.05 to 1.22 with an average of 1.11. All values of relative crowding coefficient (K) exceeded 1.00. K of barley, wheat or faba bean was higher than those of fodder beet. With respect to dominance analysis, barley, wheat or faba bean plants are dominant components and fodder beet plants are dominated components.

Intercropping fodder beet with barley, wheat and faba bean increased total and net returns by about 8.98 and 11.02 per cent, respectively, as compared with sole fodder beet. Net return of intercropping fodder beet with barley, wheat and faba bean was 8903, 9015 and 14075 L.E. per faddan as compared with sole fodder beet (9605 L.E.). Growing fodder beet with faba bean plants on ridges (60 cm width) gave the highest financial return as compared with sole fodder beet. This study concluded that growing fodder beet plants in one row on all ridges (60 cm width) with intercropping faba bean plants on the other side of the first and third ridges gave high yield of fodder beet.

Keywords: Intercropping; Fodder beet; Barley; Wheat; Faba bean; Competitive relationships; Financial return.

INTRODUCTION

Egyptian forage crops production is very important for successful animal production which is severely limited by marked seasonal feed deficits.

These crops mainly fresh berseem during winter and as hay during summer represents about 60% of available local feed. Summer forage crops such as Darawa, millet, sorghum, cowpea, Sudan grass, and corn silage represent about 5% of the available local feed. Alfalfa which provides feed all the year around represents about 5% of the available local feed (El-Nahrawy, 2011).

Accordingly, there is a shortage in green forage supply during the summer season. Fodder beet (*Beta vulgaris* L.) is cultivated as an annual winter crop. It is one of the promising forage crops which is recommended as a good source for energy for dairy cows (Gaivoronskii, 1981).It offers a higher yield potential than any other "arable" fodder crop. The above and below growth parts (leaves and roots) are used to feed the animals but, the main fodder is tuberous roots (Ibrahim, 2005).The roots have an excellent feed quality and they are very palatable to ruminant stock. The leaf can be utilized if required to boost the total fodder output even further (Turk, 2010). Consequently, its cultivation may help in overcoming the problem of animal feeding in summer season; but the cultivated area is very limited and expects to be devoted to the cultivation of strategic food crops such as wheat (*Triticum aestivum* L.) and faba bean (*Vicia faba* L.) during winter season.

Also, cultivated barley (*Hordeum vulgare* L.) ranks fourth among the cereals in worldwide production. It is commonly used for animal feed and malting production (Finocchiaro *et al*., 2008). It is mostly grown by resource-poor farmers in marginal environments, receiving modest or no inputs in Egypt. Moreover, Al-Karaki and Al-Hashimi (2012) mentioned that barley is the most commonly grown forage, because it usually gives the best yield of nutrients. They recorded the highest values in green fresh yields in cowpea followed by barley, alfalfa, sorghum, and wheat, respectively. However, the differences between the crops barley, cowpea, and alfalfa in green fresh fodder yields were not significant.

In view of the previous, it was necessary to find a modern agricultural technical practice in Egypt for the cultivation of this forage crop in the Nile Valley areas. Egyptian efforts are being focused on measures that lead to a significant increase in crop production per unit area. The successful implementation of two agricultural strategies in the 1980s and the 1990s had a positive economic impact at both macro and sector levels. Several different cropping patterns are followed in the Nile Valley and Delta areas, depending on the soil type and crops. Farmers are very responsive to technology transfer, extension activities and price incentives. Intercropping is recommended to increase total agriculture products in Egypt (Metwally, 1999). But fodder beet yield was reduced by intercropping (Abdel-Gwad *et al*., 2008). However, intercropping can be used as a tool to improve competitive ability of a canopy with good suppressive characteristics (Rezvani *et al*., 2011).

The objective of this study to investigate the possibility of increasing fodder beet productivity and net return per unit area by intercropping with wheat, faba bean or barley for encouraging Egyptian farmers to grow fodder beet.

MATERIALS AND METHODS

Two experiments were carried out at Sids Agricultural Experiments and Research Station, A.R.C., Beni - Sweif Governorate (Lat. 29° 12' N, Long. 31° 01' E, 32 m a.s.l.), Egypt during 2009/2010 and 2010/2011 winter seasons to investigate the possibility of increasing fodder beet productivity and net return per unit area by intercropping with some field crops for encouraging Egyptian farmers to grow fodder beet. Fodder beet variety 'Voroshenger' and three different field crops (barley variety 'Giza 29', wheat variety 'Beni – Sweif 1'and faba bean variety 'Misr 1') were used. Fig. 1 shows the treatments which were the combinations among cropping systems and ridge width as follows:

1. Planting fodder beet on one side of the ridges (60 cm width) and planting one barley row on the other side of the fodder beet on the first and third ridge (100% fodder beet : 25% barley).
2. Planting fodder beet on one side of the ridges (60 cm width) and planting one wheat row on the other side of the fodder beet on the first and third ridge (100% fodder beet : 25% wheat)
3. Planting fodder beet on one side of the ridges (60 cm width) and planting one faba bean row on the other side of the fodder beet first and third ridge (100% fodder beet: 25% faba bean)
4. Planting fodder beet on both sides of the beds (120 cm width) and planting one barley row on middle of all fodder beet beds (100% fodder beet : 25% barley).
5. Planting fodder beet on both sides of the beds (120 cm width) and planting one wheat row on middle of all fodder beet beds (100% fodder beet : 25% wheat)
6. Planting fodder beet on both side of the beds (120 cm width) and planting one faba bean row on middle of all fodder beet beds (100% fodder beet: 25% faba bean)
7. Sole fodder beet: Planting fodder beet on one side of the ridges (60 cm width)
8. Sole barley: Planting two barley rows on both sides of the ridges (60 cm width)
9. Sole wheat: Planting two wheat rows on both sides of the ridges (60 cm width)
10. Sole faba bean: Planting two faba bean rows on both sides of the ridges (60 cm width)

Varieties of fodder beet, barley, wheat and faba bean kindly provided by Forage, Barley, Wheat and Food Legumes Res. Dept., Field Crops Res. Inst., ARC, respectively. The preceding summer crop was maize in both seasons. Normal cultural practices for growing all crops were used as recommended in the area. Fodder beet solid and in all intercropped crops was sown at the same date on 29 and 20th October at 2009/2010 and 2010/2011 seasons, respectively.

Fodder beet plants were thinned to one plant/hill at 20 cm between hills under intercropping and sole cultures. Barley and wheat grains were drilled in one row in intercropping cultures and in two rows in sole cultures.

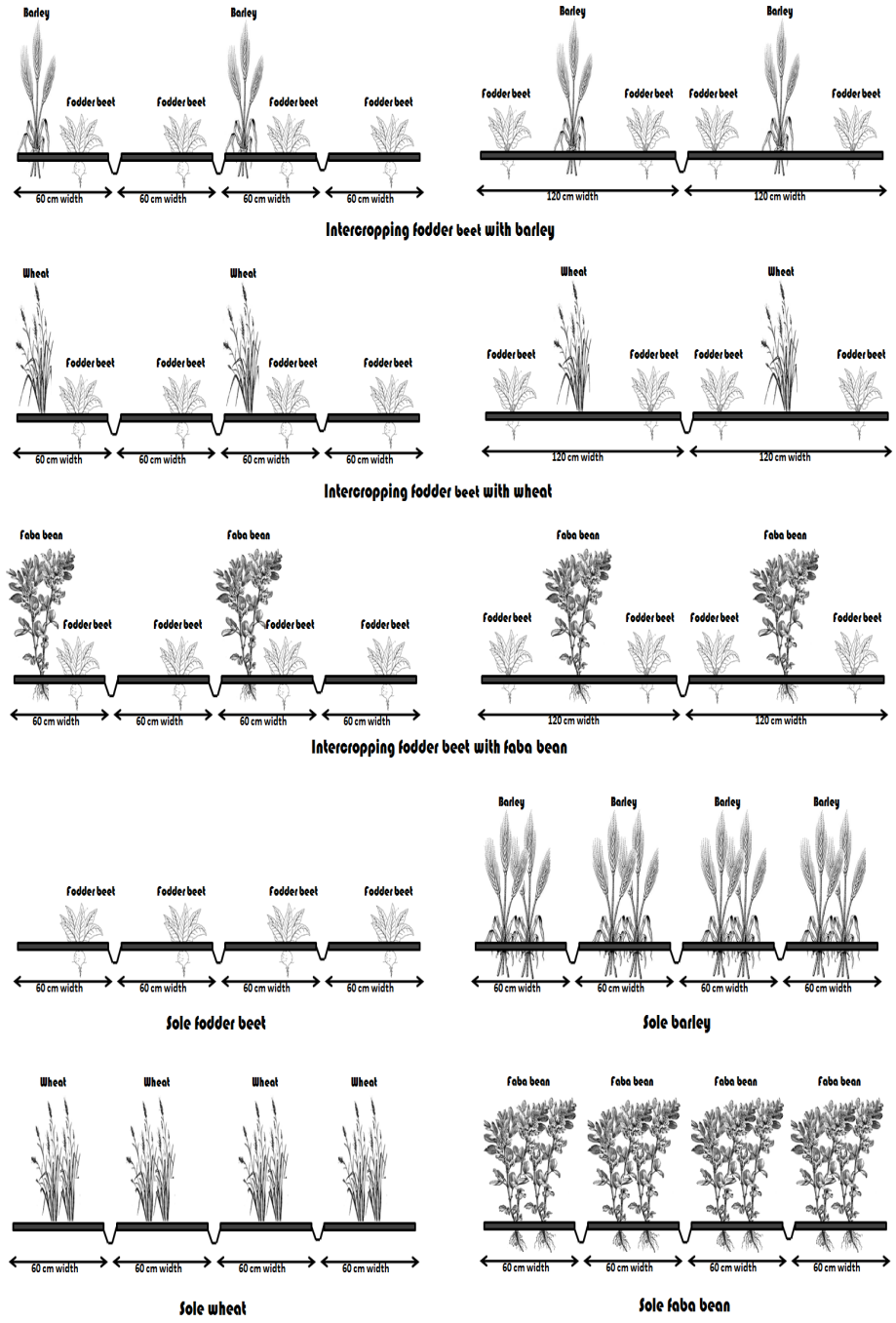

Fig.1: Intercropping barley, wheat and faba bean with fodder beet and sole cultures

Faba bean plants were thinned to two plants/hill at 25 cm between hills. Recommended solid cultures of all the tested crops were used to estimate the competitive relationships. A split plot design in randomized complete block design in four replications was used. Cropping systems (intercropping and sole) were randomly assigned to the main plots, ridge width was allocated in sub plots. The area of sub-plot was 14.4 m^2, it consisted of 8 ridges, and each ridge was 3.0 m in length and 0.6 m in width.

Yield and its attributes

At harvest, root length, diameter (cm) and root weight/plant were measured on ten guarded plants from each plot, whereas, root yields (ton/faddan) were recorded on the basis of experimental plot area by harvesting all fodder beet plants of each plot. Grain yields of barley and wheat (ardab/faddan), as well as, seed yield of faba bean (ton/faddan) were recorded on the basis of experimental plot area

Competitive relationships

Land equivalent ratio (LER)

LER defined as the ratio of area needed under sole cropping to one of intercropping at the same management level to produce an equivalent yield **(Mead and Willey, 1980)**. It is calculated as follows:

$LER = (Y_{ab} / Y_{aa}) + (Y_{ba} / Y_{bb})$

Where Y_{aa} = Pure stand yield of crop a (fodder beet)

Y_{bb} = Pure stand yield of crop b (barley, wheat or faba bean)

Y_{ab} = Intercrop yield of crop a (fodder beet)

Y_{ba} = Intercrop yield of crop b (barley, wheat or faba bean)

Relative crowding coefficient (RCC)

Relative crowding coefficient estimates the relative dominance of one species over the other in the intercropping system (Banik*et al*., 2006).It is calculated as follows: $RCC = K_a \times K_b$

$K_a = Y_{ab} \times Z_{ba} / [(Y_{aa} - Y_{ab}) \times Z_{ab}]$

$K_b = Y_{ba} \times Z_{ab} / [(Y_{bb} - Y_{ba}) \times Z_{ba}]$

Where Y_{aa} = Pure stand yield of crop a (fodder beet)

Y_{bb} = Pure stand yield of crop b (barley, wheat or faba bean)

Y_{ab} = Intercrop yield of crop a (fodder beet)

Y_{ba} = Intercrop yield of crop b (barley, wheat or faba bean)

Z_{ab} = The respective proportion of crop a in the intercropping system (fodder beet)

Z_{ba} = The respective proportion of crop b in the intercropping system (barley, wheat or faba bean)

Aggressivity (Agg)

Aggressivity represents a simple measure of how much the relative yield increase in one crop is greater than the otherin an intercropping system (Ghosh *et al*., 2006).

$A_{ab} = [Y_{ab} / (Y_{aa} \times Z_{ab})] - [Y_{ba} / (Y_{bb} \times Z_{ba})]$

$A_{ba} = [Y_{ba} / (Y_{bb} \times Z_{ba})] - [Y_{ab} / (Y_{aa} \times Z_{ab})]$

Where Y_{aa} = Pure stand yield of crop a (fodder beet)

Y_{bb} = Pure stand yield of crop b (barely, wheat or faba bean)

Y_{ab} = Intercrop yield of crop a (fodder beet)
Y_{ba} = Intercrop yield of crop b (barley, wheat or faba bean)
Z_{ab} = The respective proportion of crop a in the intercropping system (fodder beet)
Z_{ba} = The respective proportion of crop b in the intercropping system (barley, wheat or faba bean)

Farmer's benefit

It was calculated by determining the total costs and net return of intercropping culture as compared to recommended sole planting of fodder beet according to Metwally *et al.* (2009).

1. Total return of intercropping cultures = Price of fodder beet yield + price of barley, wheat or faba bean yield (L.E.)

To calculate the total return, the average of barley, wheat and faba bean prices presented by Agricultural Statistics (2013) was used, while the average of fodder beet yield price presented by market price in 2011 season.

2. Net return/fad = Total return – (fixed cost of fodder beet + variable costs of barley, wheat and faba bean according to intercropping pattern).

Statistical Manipulation

Analysis of variance of the obtained results of each season was performed. The homogeneity test was conducted of error mean squares and accordingly, the combined analysis of the two experimental seasons was carried out. The measured variables were analyzed by ANOVA using MSTATC statistical package (Freed, 1991). Mean comparisons were done using least significant differences (LSD) method at 5 % level of probability to compare differences between the means (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield and its attributes

Cropping systems

Intercropping fodder beet with barley, wheat or faba bean significantly affected root length and diameter, root weight/plant and root yield/fad in the two growing seasons and the combined analysis (Table 1). Intercropping barley, wheat or faba bean with fodder beet decreased root length and diameter, root weight/plant and root yield/fad in comparison with sole fodder beet. As a result of intercropping, root weight/plant and root yield/fad were decreased by 11.97 and 18.44% in the 1st season, 8.95 and 17.10% in the 2nd season, 10.86 and 17.78% in the combined analysis, respectively, as compared with sole fodder beet.

These data reveal that intercropping wheat or barley with fodder beet had a significant negative impact *($P \leq 0.05$)* on fodder beet plants as compared with those obtained by intercropping with faba bean. Obviously, intercropping legumes with fodder beet had lower adverse effects on yield of intercropped fodder beet than cereal crops under intercropping conditions. Legumes are plants that bear their seeds in pods. They differ markedly from grasses, cereals and other non-legume crops. Legumes in close association with nitrophilous crops have increased crop production (Waghmare and Singh, 1984). Because of their ability to biological nitrogen fixation, legumes

are largely involved in nitrogen facilitation and nitrogen dynamic in the plant community and in agrosystems (Hauggaard-Nielsen and Jensen, 2005 and Fustec *et al*., 2010). These results are in accordance with those obtained by Abdel-Gwad *et al.* (2008) they showed that root yield of fodder beet were reduced significantly by intercropping with wheat as compared with sole fodder beet.

Also, intercropping barley, wheat or faba bean with fodder beet significantly affected grain yields of barley and wheat as well as seed yield of faba bean (Table 1). Intercropping barley with fodder beet decreased grain yield/fad by 70.40% in the 1st season, 71.13% in the 2nd season and 70.81% in the combined analysis. Also, intercropping wheat with fodder beet decreased grain yield/fad by 69.56% in the 1st season, 70.12% in the 2nd season and 69.86% in the combined analysis. Moreover, intercropping faba bean with fodder beet decreased seed yield/fad by 67.89% in the 1st season, 68.59% in the 2nd season and 68.33% in the combined analysis.

It is clear that decreasing plant population density of barley, wheat and faba bean to 25% of sole plantings of these crops decreased *(P ≤ 0.05)* grain and seed yields per unit area for these crops. The reduction in grain yield of wheat per fad was quite expected as a result of decreasing stand of intercropped wheat as reported by Abdel-Gwad *et al*. (2008). Similar results were obtained by Abou-Elela and Gadallah (2012) they indicated that seed yield of faba bean per faddan was reduced significantly by intercropping with fodder beet as compared with sole faba bean.

Ridge width

All the studied traits of fodder beet were significantly affected by ridge width, except root length and diameter in the 1st season only, while, yields of barley, wheat and faba bean were not affected in both seasons (Table 1). Growing fodder beet on ridges (60 cm width) under intercropping and sole cultures had higher values of all the studied traits of fodder beet than those grown on beds (120 cm width), relatively. Growing fodder beet on ridges increased fodder beet weight/plant and fodder beet yield/fad by 0.75 and 1.16% in the 1st season, 0.78 and 1.26% in the 2nd season and 0.76 and 1.21% in the combined analysis, respectively, in comparison with that gown on beds under intercropping and sole cultures.

Obviously, decreasing ridge width from 120 to 60 cm slightly increased *(P ≤ 0.05)* fodder beet productivity per unit area. These results may be due to competition for basic resources between fodder beet and barley, wheat or faba bean was not pronounced between both patterns.

Interaction between cropping systems and ridge width

With respect to response of cropping systems to ridge width, all the studied traits of all the tested crops were not affected (Table1). These data show that each of these two factors act independently on all the studied traits of all the tested crops meaning that cropping systems responded similarly *(P > 0.05)* to ridge width. These results are in harmony with those obtained by Mack (1979) who compared 6, 12, 18, and 24-inch rows combined with three seeding rates of table beet. There was no interaction of row spacing and within-row seeding rate on yields.

1

Competitive relationships

Land Equivalent Ratio (LER)

Relative yields of fodder beet and barley, wheat or faba bean were affected significantly by the cropping systems in the two growing seasons and the combined analysis (Table 2). Intercropping fodder beet with faba bean had higher values of relative yields of fodder beet and intercrops as compared with intercropping fodder beet with barley or wheat. These data may be due to faba bean plants (as legume crop) have ability to biological nitrogen fixation, legumes are largely involved in nitrogen facilitation and nitrogen dynamic in the plant community and in agrosystems. Relative yield of fodder beet was significantly affected by ridge width, whereas, relative yield of intercrops was not affected in the two growing seasons and the combined analysis (Table 2). Growing fodder beet in ridges (60 cm width) had higher relative yield of fodder beet than growing fodder beet in beds (120 cm width) under both intercropping and sole. Relative yields of fodder beet and barley,wheat or faba bean were significantly affected by the interaction between cropping systems and ridge width in the two growing seasons and the combined analysis except relative yield of fodder beet in the 1st season only (Table 2).Intercropping fodder beet with faba bean on ridges (60 cm width) had higher values of relative yields of both crops,whereas, intercropping fodder beet with wheat had the lowest relative yield of both crops.

The values of land equivalent ratio (LER) were estimated by using data of recommended sole cultures of all crops. LER was affected significantly by the cropping systems in the two growing seasons and the combined analysis (Table 2). In general, intercropping fodder beet with barley, wheat and faba bean increased LER as compared to sole fodder beet (Table 2). It ranged from 1.05 (by intercropping fodder beet with wheat on beds, 120 cm width) to 1.22 (by intercropping fodder beet with faba bean on ridges, 60 cm width) with an average of 1.11. The advantage of the highest LER by intercropping fodder beet with faba bean over the others could be due to faba bean plants (as legume crop) have ability to biological nitrogen fixation, legumes are largely involved in nitrogen facilitation and nitrogen dynamic in the plant community and in agrosystems. It is clear that plant population density of fodder beet and barley, wheat or faba bean played a major role in increasing productivity per unit area under intercropping culture where it reached 100 and 25% of sole plantings, respectively. Similar results were obtained by Abdel-Gwad *et al.* (2008) they found that Intercropping fodder beet with wheat increased land equivalent ratio in the average of both seasons by 1.21, 1.07,1.15 and 1.22, when adding 70, 90, 110 and 130 kg N fertilizer/fad respectively. Also, Abou-Elela and Gadallah (2012) reported that LER was higher by intercropping faba bean with fodder beet than those of sole plantings.

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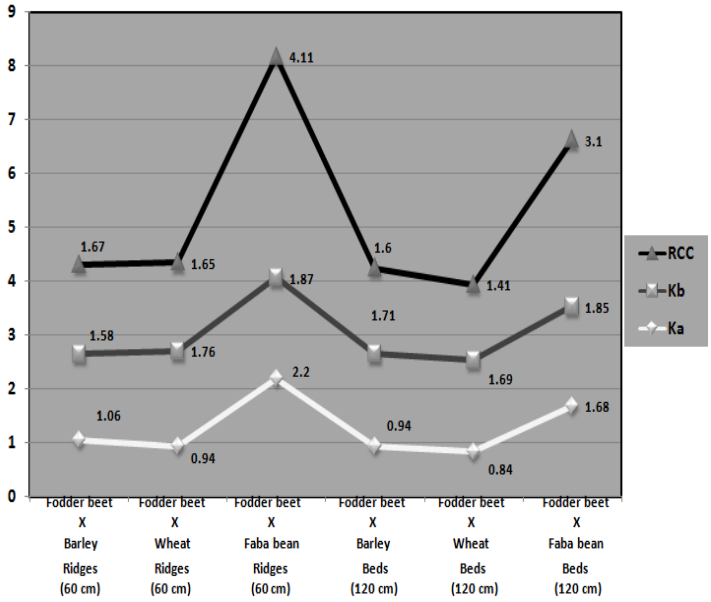

Fig. 2. Relative crowding coefficient (RCC) as affected by the intercropping system, ridge

With respect to ridge width, LER was significantly affected by ridge width in the two growing seasons and the combined analysis (Table 2). Growing fodder beet on ridges (60 cm width) gave the highest LER than those grown on beds (120 cm width) under both intercropping and sole cultures.

LER was significantly affected by the interaction between cropping systems and ridge width in the two growing seasons and the combined analysis (Table 2). Intercropping fodder beet with faba bean on ridges (60 cm width) gave the highest LER in the two growing seasons and the combined analysis, whereas, the lowest LER was obtained by growing fodder beet with wheat in the two growing seasons and the combined analysis.

Relative crowding coefficient (RCC)

The relative dominance of one species over the other in this intercropping study was estimated by the use of relative crowding coefficient (RCC). When the value of relative crowding coefficient (Rcc) is greater than 1.00, there is intercrop advantage; when RCC is equal to 1.00, there is no yield advantage; when RCC is lesser than 1.00, there is a disadvantage. Table 3 and Fig. 2 shows that all values of the total relative crowding coefficient (RCC) were exceeded 1.00. Relative crowding coefficient of barley, wheat or faba bean was higher than those of fodder beet. The lowest RCC was obtained from intercropping fodder beet with wheat on beds (120 cm width), whereas, intercropping fodder beet with faba bean on ridges (60 cm width) gave the highest RCC in the combined data across 2009/2010 and 2010/2011 seasons.

Aggressivity (Agg)

Aggressivity determines the difference in competitive ability of the component crops in intercropping association. The positive sign indicates the dominant component and the negative sign indicates the dominated component. Higher numerical values of aggressiveness denote greater difference in competitive ability, as well as, bigger difference between actual and expected yield in both crops. The results indicate that the value of aggressivity of barley, wheat and faba bean was positive for all treatments, whereas, the values of aggressivity was negative for all intercropped fodder beet in the combined data across 2009/2010 and 2010/2011 seasons (Table 3 and Fig. 3). These data show that barley, wheat or faba bean are dominant component and fodder beet plants are dominated component.

In general, the highest negative values were obtained by growing fodder beet with barley or wheat plants, whereas, intercropping fodder beet with faba bean had the lowest negative values. These results clear that intercropping fodder beet with barley or wheat is more aggressive than intercropping fodder beet with faba bean.

Economic evaluation

Intercropping fodder beet with barley, wheat and faba bean increased total and net returns by about 8.98 and 11.02 per cent, respectively, as compared with sole fodder beet (Table 4). Net return of intercropping fodder beet with barley, wheat and faba bean was 8903, 9015 and 14075L.E. per faddan as compared with sole fodder beet (9605 L.E.). Intercropping fodder beet with faba bean in ridges (60 cm width) gave the highest financial value when using high population densities of both crops which reached 100 and 25% of sole fodder beet and faba bean, respectively. The study indicated that intercropping fodder beet with faba bean is more profitable to farmers than sole fodder beet by using suitable intercropping pattern. These results are in harmony with those obtained by Abdel-Gwad *et al.* (2008) they reported that the highest return between growing fodder beet as sole crop and its growing with wheat was collected when adding 130 kg N/fad (2718.80 L.E.).

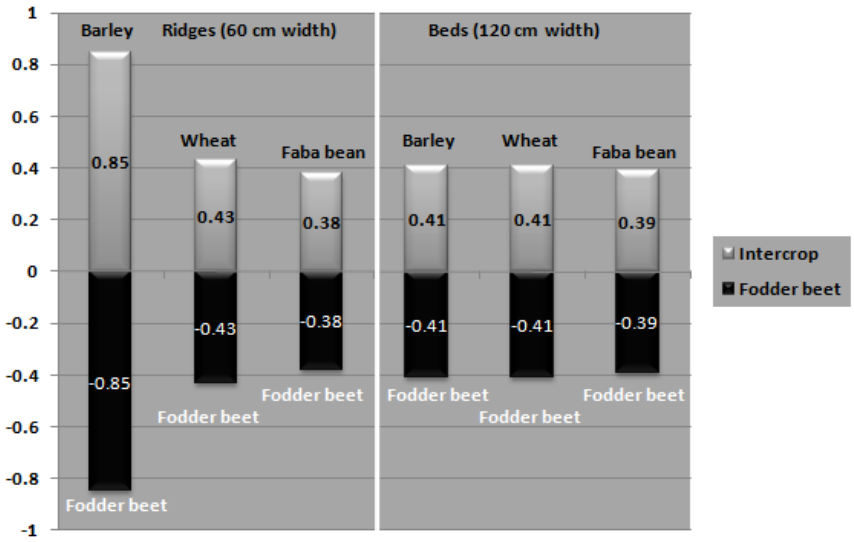

Fig. 3. Aggressivity as affected by the intercropping system, ridge width and their width and their interaction (combined data across 2009/2010 and 2010/2011 seasons) interaction (combined data across 2009/2010 and 2010/2011 seasons)

CONCLUSION

It could be concluded that although intercropping pattern resulted in adverse effects on intercropped fodder beet yield and its attributes, however, Egyptian farmers could achieve an increase in their income by about 50% as compared to sole fodder beet when growing fodder beet with faba bean on ridges (60 cm width).This paper emphasizes there is a critical need for several scientific studies including morphological and physiological characteristics to increase the productivity of intercropped fodder beet with minimizing the adverse effects of shading intercropped barley, wheat or faba bean crops which reflected positively on the financial return of fodder beet's farmer.

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زيادة إنتاجية بنجر العلف بالتحميل مع بعض المحاصيل الحقلية

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تم تنفيذ دراسة لمدة سنتين بمحطة البحوث والتجارب – مركز البحوث الزراعية بسدس بمحافظة بنى سويف – مصر خلال موسمى ٢٠١٠/٢٠٠٩ و ٢٠١١/٢٠١٠م لدراسة إمكانية زيادة إنتاجية بنجر العلف وصافى الربح لوحدة المساحة وذلك بالتحميل مع بعض المحاصيل الحقلية لتشجيع المزارعين المصريين على زراعة بنجر العلف فى حقولهم.

تمت زراعة نباتات بنجر العلف فى سطر واحد على جميع الخطوط (٦٠ سم) وزراعة نباتات الشعير والقمح والفول البلدى على الريشة الأخرى من الخط الأول والثالث وترك الخط الذى يليه بدون تحميل وهكذا. كذلك تمت زراعة نباتات بنجر العلف على مصاطب (١٢٠ سم) على الريشتين وزراعة نباتات الشعير والقمح والفول البلدى في منتصف المصطبه الثانية وترك المصطبة التى تليها بدون تحميل وهكذا إلى جانب الزراعة المنفردة لجميع المحاصيل الحقلية تحت الدراسة. تم إستخدام تصميم القطع المنشقة مرة واحدة فى أربعة مكررات ، **ويمكن تلخيص أهم النتائج فيما يلى:**

- أدى تحميل الشعير والقمح والفول البلدى إلى نقص المحصول لجميع المحاصيل الحقلية تحت الدراسة حيث إنخفض محصول الجذور لبنجر العلف بمقدار ١٨,٤٤ و١٧,١٠ و١٧,٧٨ % فى الموسم الأول والثانى والتحليل التجميعى (على الترتيب) بالمقارنة بالزراعة المنفردة لبنجر العلف. أعطى عرض الخط (٦٠ سم) أعلا القيم نسبيا لجميع صفات بنجر العلف بالمقارنة بزراعته على مصاطب (١٢٠سم) وذلك عند الزراعة المحملة أو المنفردة لبنجر العلف ، بينما لم يؤثر عرض الخط على محصول الشعير والقمح والفول البلدى المحمل مع بنجر العلف.
- لم يؤثر التفاعل بين نظم الزراعة وعرض الخط على جميع صفات المحاصيل الحقلية تحت الدراسة.
- بالنسبة للعلاقات التنافسية ، أدى تحميل الشعير والقمح والفول البلدى مع بنجر العلف إلى زيادة المكافىء الأرضى للإستغلال بالمقارنة بالزراعة المنفردة لبنجر العلف والذى تراوح من ١,٠٥ إلى ١,٢٢ بمتوسط ١,١١. كما أوضحت النتائج أن جميع قيم معامل الحشد النسبى أعلى من الواحد الصحيح حيث كان معامل الحشد النسبى للشعير والقمح والفول البلدى أعلى من معامل الحشد النسبى لبنجر العلف. وبالنظر إلى تحليل السيادة ، فأشارت النتائج إلى أن محاصيل الشعير والقمح والفول البلدى كانت سائدة بينما كان بنجر العلف هو المحصول المسود.
- أوضحت النتائج أن تحميل بنجر العلف مع الشعير والقمح والفول البلدى أدى إلى زيادة العائد الكلى وصافى الربح بنسبة ٨,٩٥ و ١١,٠٢ % (على الترتيب) بالمقارنة بالزراعة المنفردة لبنجر العلف. كما بلغ صافى الربح بتحميل بنجر العلف مع الشعير والقمح والفول البلدى ٨٩٠٣ و ٩٠١٥ و ١٤٠٧٥ جنيها (على الترتيب) مقارنة بالزراعة المنفردة لبنجر العلف (٩٦٠٥ جنيها). وقد أعطى تحميل بنجر العلف مع الفول البلدى على خطوط ٦٠ سم أعلى صافى ربح بالمقارنة بالزراعة المنفردة لبنجر العلف.
- وتوصى الدراسة لزيادة العائد من محصول العلف لبنجر العلف يتم ذلك بزراعة بنجر العلف سطر واحد على جميع الخطوط (٦٠ سم) وزراعة نباتات الفول البلدى على الريشة الأخرى من الخط الأول والثالث وترك الخط الذى يليه بدون تحميل وهكذا للحصول على أعلى عائد تحت ظروف الدراسة.

Table 1: Effect of cropping systems, ridge width and their interactions on fodder beet yield and its attributes, as well as, yields of barley, wheat and faba bean during two seasons and the combined analysis.

Characters / Treatments	Root length (cm)			Root diameter (cm)			Root weight/plant (kg)			Root yield of fodder beet (ton/faddan)			Grain yield of barley (ardab/faddan)			Grain yield of wheat (ardab/faddan)			seed yield of faba bean (ton/faddan)		
	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean
First season 2009/2010																					
Fodder beet + barley	27.75	26.00	**26.87**	13.25	12.75	**13.00**	1.25	1.22	**1.23**	38.41	37.28	**37.84**	4.85	5.03	**4.94**	--	--	--	--	--	--
Fodder beet + wheat	26.25	25.75	**26.00**	12.00	11.25	**11.62**	1.23	1.20	**1.21**	37.08	36.21	**36.64**	--	--	--	5.86	5.61	**5.73**	--	--	--
Fodder beet + faba bean	29.00	28.00	**28.50**	14.50	14.00	**14.25**	1.34	1.32	**1.33**	42.07	41.05	**41.56**	--	--	--	--	--	--	1.28	1.35	**1.31**
Average of intercropping	**27.66**	**26.58**	**27.12**	**13.25**	**12.66**	**12.95**	**1.27**	**1.24**	**1.25**	**39.18**	**38.18**	**38.68**	**4.85**	**5.03**	**4.94**	**5.86**	**5.61**	**5.73**	**1.28**	**1.35**	**1.31**
Sole planting	31.00	31.00	**31.00**	16.00	16.00	**16.00**	1.42	1.42	**1.42**	47.43	47.43	**47.43**	16.69	16.69	**16.69**	18.83	18.83	**18.83**	4.08	4.08	**4.08**
Average of ridge width	**29.33**	**28.79**	**29.06**	**14.62**	**14.33**	**14.47**	**1.34**	**1.33**	**1.33**	**43.30**	**42.80**	**43.05**	**10.77**	**10.86**	**10.81**	**12.34**	**12.22**	**12.28**	**2.68**	**2.71**	**2.69**
LSD at 0.05 Intercropping		**1.93**			**3.13**			**0.03**			**2.17**			**3.26**			**3.16**			**0.35**	
LSD at 0.05 Ridge width		**NS**			**NS**			**0.01**			**0.58**			**NS**			**NS**			**NS**	
LSD at 0.05 Interaction		**NS**			**NS**			**NS**			**NS**			**NS**			**NS**			**NS**	
Second season 2010/2011																					
Fodder beet + barley	26.25	25.50	**25.87**	13.40	12.60	**13.00**	1.21	1.19	**1.20**	38.25	37.50	**37.87**	4.60	4.96	**4.78**	--	--	--	--	--	--
Fodder beet + wheat	25.75	24.25	**25.00**	12.47	11.77	**12.12**	1.20	1.18	**1.19**	37.75	36.75	**37.25**	--	--	--	5.63	5.53	**5.58**	--	--	--
Fodder beet + faba bean	29.50	28.75	**29.12**	14.55	13.35	**13.95**	1.29	1.27	**1.28**	42.85	41.32	**42.08**	--	--	--	--	--	--	1.41	1.32	**1.36**
Average of intercropping	**27.16**	**26.16**	**26.66**	**13.47**	**12.57**	**13.02**	**1.23**	**1.21**	**1.22**	**39.61**	**38.52**	**39.06**	4.60	4.96	**4.78**	**5.63**	**5.53**	**5.58**	**1.41**	**1.32**	**1.36**
Sole planting	30.90	30.90	**30.90**	15.50	15.50	**15.50**	1.34	1.34	**1.34**	47.12	47.12	**47.12**	16.56	16.56	**16.56**	18.68	18.68	**18.68**	4.33	4.33	**4.33**
Average of ridge width	**29.03**	**28.53**	**28.78**	**14.48**	**14.03**	**14.25**	**1.28**	**1.27**	**1.27**	**43.36**	**42.82**	**43.09**	**10.58**	**10.76**	**10.67**	**12.15**	**12.10**	**12.12**	**2.87**	**2.82**	**2.84**
LSD at 0.05 Intercropping		**2.60**			**1.75**			**0.01**			**1.53**			**1.66**			**0.69**			**0.65**	
LSD at 0.05 Ridge width		**0.59**			**0.58**			**0.01**			**0.49**			**NS**			**NS**			**NS**	
LSD at 0.05 Interaction		**NS**			**NS**			**NS**			**NS**			**NS**			**NS**			**NS**	
Combined analysis																					
Fodder beet + barley	27.00	25.75	**26.37**	13.32	12.67	**12.99**	1.23	1.20	**1.21**	38.32	37.39	**37.85**	4.72	4.99	**4.85**	--	--	--	--	--	--
Fodder beet + wheat	26.00	25.00	**25.50**	12.23	11.51	**11.87**	1.21	1.19	**1.20**	37.41	36.48	**36.94**	--	--	--	5.74	5.57	**5.65**	--	--	--
Fodder beet + faba bean	29.25	28.37	**28.81**	14.52	13.67	**14.09**	1.31	1.29	**1.30**	42.46	41.18	**41.82**	--	--	--	--	--	--	1.34	1.33	**1.33**
Average of intercropping	**27.41**	**26.37**	**26.89**	**13.35**	**12.61**	**12.98**	**1.25**	**1.22**	**1.23**	**39.39**	**38.35**	**38.87**	4.72	4.99	**4.85**	**5.74**	**5.57**	**5.65**	**1.34**	**1.33**	**1.33**
Sole planting	30.95	30.95	**30.95**	15.75	15.75	**15.75**	1.38	1.38	**1.38**	47.28	47.28	**47.28**	16.62	16.62	**16.62**	18.75	18.75	**18.75**	4.20	4.20	**4.20**
Average of ridge width	**29.18**	**28.66**	**28.92**	**14.55**	**14.18**	**14.36**	**1.31**	**1.30**	**1.30**	**43.33**	**42.81**	**43.07**	**10.67**	**10.80**	**10.73**	**12.24**	**12.16**	**12.20**	**2.77**	**2.76**	**2.76**
LSD at 0.05 Intercropping		**1.80**			**1.66**			**0.02**			**1.43**			**1.58**			**1.42**			**0.42**	
LSD at 0.05 Ridge width		**0.50**			**0.37**			**0.008**			**0.41**			**NS**			**NS**			**NS**	
LSD at 0.05 Interaction		**NS**			**NS**			**NS**			**NS**			**NS**			**NS**			**NS**	

Table 2: Relative yields and land equivalent ratio as affected by cropping systems, ridge width and their interactions during the two seasons and the combined analysis.

Characters / Treatments	Relative yield						LER		
	$L_{Fodder\ beet}$			$L_{intercrop}$					
	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean
First season 2009/2010									
Fodder beet + barley	0.80	0.78	0.79	0.29	0.30	0.29	1.09	1.08	1.08
Fodder beet + wheat	0.78	0.76	0.77	0.31	0.29	0.30	1.09	1.05	1.07
Fodder beet + faba bean	0.88	0.86	0.87	0.31	0.33	0.32	1.19	1.19	1.19
Average of intercropping	0.82	0.80	0.81	0.30	0.30	0.30	1.12	1.10	1.11
Sole planting	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LSD at 0.05 Intercropping		0.008			0.01			0.007	
LSD at 0.05 Ridge width		0.008			NS			0.004	
LSD at 0.05 Interaction		NS			0.01			0.01	
Second season 2010/2011									
Fodder beet + barley	0.81	0.79	0.80	0.27	0.29	0.28	1.08	1.08	1.08
Fodder beet + wheat	0.80	0.76	0.78	0.30	0.29	0.29	1.10	1.05	1.07
Fodder beet + faba bean	0.90	0.87	0.88	0.32	0.30	0.31	1.22	1.17	1.19
Average of intercropping	0.82	0.80	0.81	0.29	0.29	0.29	1.13	1.10	1.11
Sole planting	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LSD at 0.05 Intercropping		0.01			0.01			0.006	
LSD at 0.05 Ridge width		0.006			NS			0.003	
LSD at 0.05 Interaction		0.01			0.01			0.008	
Combined analysis									
Fodder beet + barley	0.80	0.78	0.79	0.28	0.29	0.28	1.08	1.08	1.08
Fodder beet + wheat	0.79	0.76	0.77	0.30	0.29	0.29	1.09	1.05	1.07
Fodder beet + faba bean	0.89	0.86	0.87	0.31	0.31	0.31	1.20	1.18	1.19
Average of intercropping	0.82	0.80	0.81	0.29	0.29	0.29	1.12	1.10	1.11
Sole planting	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LSD at 0.05 Intercropping		0.007			0.003			0.006	
LSD at 0.05 Ridge width		0.004			NS			0.003	
LSD at 0.05 Interaction		0.01			0.005			0.008	

Table 3: Relative crowding coefficient (K) and Aggressivity (Agg) as affected by cropping systems, ridge width and their interactions, combined analysis.

Characters / Treatments	RCC									Aggressivity			
	Ka			Kb			K			Agg+		Agg-	
	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	60 cm	120 cm
Fodder beet + barley	1.06	0.94	1.00	1.58	1.71	1.64	1.67	1.60	1.63	0.85	0.41	-0.85	-0.41
Fodder beet + wheat	0.94	0.84	0.89	1.76	1.69	1.72	1.65	1.41	1.53	0.43	0.41	-0.43	-0.41
Fodder beet + faba bean	2.20	1.68	1.94	1.87	1.85	1.86	4.11	3.10	3.60	0.38	0.39	-0.38	-0.39

Table 4: Financial return as affected by cropping systems, ridge width and their interactions (combined data across 2009/2010 and 2010/2011 seasons)

Characters / Treatments	Financial return											
	Fodder beet			Intercrops			Total			Net		
	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean	60 cm	120 cm	Mean
Fodder beet + barley	13412	13086	13249	1434	1516	1475	14846	14602	14724	9025	8781	8903
Fodder beet + wheat	13093	12768	12930	2020	1960	1990	15113	14728	14920	9208	8823	9015
Fodder beet + faba bean	14861	14413	14637	5324	5284	5304	20185	19697	19941	14319	13831	14075
Average of intercropping	13788	13422	13605	2926	2920	2923	16714	16342	16528	10850	10478	10664
Sole planting of fodder beet	15165	15165	15165	--	--	--	15165	15165	15165	9605	9605	9605

Prices of main products are that of 2011:
350 L.E./ton of fodder beet
304 L.E./ardab of barley
352 L.E./ardab of wheat
596 L.E./ardab of faba bean
Intercropping fodder beet with faba bean increased variable costs of intercropping culture 4470 L.E. over those of sole fodder beet.