INFLUENCE OF INTERCROPPING ONION WITH FABA BEAN ON FABA BEAN PRODUCTIVITY AND ITS QUALITY UNDER DIFFERENT RIDGE WIDTHS

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ABSTRACT

The study was carried out during the two successive seasons of 2013/14 and 2014/15 at the farm of Sers El-Lyan Agricultural Research Station, Agricultural Research Center, El – Menofiya Governorate, Egypt to study the influence of different ridge widths and patterns of intercropping onion with faba bean on faba bean productivity and its quality. The treatments between three ridge widths (60, 90 and 120 cm) and ten cropping systems (100% faba bean + 27% onion, 100% faba bean + 33% onion, 100% faba bean + 41% onion, 100% faba bean + 55% onion, sole faba bean 'recommended', sole faba bean 'I', sole faba bean 'II', sole onion 'recommended', sole onion 'I' and sole onion 'II') were studied. The experimental layout was conducted in split plot design with three replications by allocating the ridge widths in the main-plots and cropping systems in the sub-plots. Sub-plot area consisted of (12 ridges-60 cm width or 8 ridges-90 cm width and 6 ridges-120 cm apart) and 3 meters long. The results showed that' faba bean at ridges 90 cm had the highest values of number of seeds per pod and plant and pods weights, seed yield per plant , 100 – seed weight and harvest index. Meanwhile' the widest ridge width produced the highest seed and straw yields per fad and seed phosphate content compared to the other ridge widths. Sole faba bean had the highest numbers of branches per plant and pods per plant, number of seeds per pod, plant total weight, pods weight per plant, seed yield per plant, 100 – seed weight, seed yield per fad, protein yield per fad, harvest index and seed phosphate content compared to those of intercropping patterns. Intercropping pattern of 100% faba bean + 27% onion produced the highest numbers of branches and pods per plant, number of seeds per pod, pods weight per plant, seed yield per plant, 100 – seed weight, seed yield per fad and protein yield per fad compared to those of the other intercropping patterns. The interaction between ridge widths and cropping systems was significant for most traits. Intercropping pattern of 100% faba bean + 55% onion of ridge width 120 cm achieved high seed P content and seed yield per fad.

Keywords: *Ridge width, intercropping, faba bean, onion, quality.*

الملخص :

اجريت هذه الدراسة بمحطة البحوث والتجارب الزراعية – محطة البحوث الزراعية بسرس الليان بمحافظة المنوفية – مصر خلال موسمى الزراعة الشتوية ٢٠١٣/٢٠١٤م و ٢٠١٤/٢٠١٥م لدراسة تأثير تحميل البصل مع الفول البلدى على إنتاجية وجودة بذور الفول البلدى تحت مستويات مختلفة من عرض الخط .

وقد كانت العوامل المدروسة هى عرض الخطوط (٦٠ سم, ٩٠ سم ، ١٢٠ سم) ونظم التحميل (١٠٠% فول +٢٧ %بصل) و(١٠٠% فول +٣٣ %بصل) و(١٠٠% فول +٤١ %بصل) و(١٠٠% فول +٥٥ %بصل) بالاضافة الى الزراعة النقية لكل من الفول والبصل على الخطوط (٦٠ سم, ٩٠ سم ، ١٢٠ سم) وقد استخدمت القطع النقية للمحصولين على خط عرضه٦٠ سم لحساب العلاقات التنافسية. نفذت التجربة فى ثلاث مكررات فى تصميم القطع المنشقة حيث استخدم عرض الخطوط فى القطع الرئيسية ونظم التحميل فى القطع الشقية .اثرت الاختلافات فى عرض الخطوط معنويا على كل من ارتفاع نبات الفول ،عدد البذور للقرن،وزن النبات الكلى ،وزن القرون للنبات ،وزن البذور للنبات،وزن ١٠٠ بذرة ،محصول البذور للفدان ودليل الحصاد فى حين لم يتاثر عدد الفروع للنبات،عدد القرون للنبات ومحصول البروتين للفدان بالاختلافات فى عرض الخطوط . وقد اعطت الخطوط عرض ٩٠ سم اعلى القيم فى كل من عدد البذور

للنبات ،وزن القرون للنبات ، محصـول البذور للنبات،وزن ١٠٠ بذره ودليل الحصـاد ,كما اعطت خطوط ١٢٠ سـم اعلى محصـــول قش وبذور للفدان . تشـير النتائج ان نظم التحميل المختلفه قد اثرت معنويا على كل من ارتفاع نبات الفول ،عدد الفروع ،عدد القرون للنبات ،عدد البذور للقرن ،الوزن الكلى للنبات ،وزن القرون للنبات ،محصـــول البذور للنبات ،وزن ١٠٠بذرة ومحصـولى البذور و البروتين للفدان،ووزن القش للفدان ودليل الحصـاد فى موسـمى الدراسـه . اعطت الزراعة النقية اكبر عدد للفروع للنبات ،عدد القرون للنبات ،عدد البذور للقرن ،وزن النبات الكلى ،وزن القرون للنبات ،وزن البذور للنبات ،وزن ١٠٠ بذره ومحصول البذور للفدان، محصول البروتين للفدان ودليل الحصاد فى كلا الموسمين بالمقارنه بنظم التحميل الاخرى .فى حين اعطت الزراعه النقيه اقل محصـول قش للفدان فى كلا الموسـمين مقارنة بنظم التحميل الاخرى .أدى تحميل البصـل على الفول البلدى في نظام(١٠٠% فول +٢٧% بصـل) إلى الحصـول على أعلى عدد فروع للنبات ، عدد قرون للنبات، عدد البذور للقرن، وزن القرون للنبات،وزن البذور للنبات،وزن١٠٠ بذرة،محصـــول البذور للفدان ومحصـــول البروتين للفـدان مقـارنـة بباقي نظم التحميـل.على العكس من ذلـك فقـد أدى تطبيق نظـام التحميل(١٠٠%فول+٥٥%بصـل) إلى الحصـول على أقل القيم فى كل من عدد البذور للقرن، وزن القرون للنبات ، وزن البذور للنبات، وزن ١٠٠بذرة،محصـــول البذور للفدان وكذا محصـــول البروتين للفدان فى الفول البلدى (الموسـم الاول مقارنة بباقى نظم التحميل). سجل التفاعل بين عرض الخطوط ونظم التحميل تأثيرا معنويا على كل من ارتفاع النبات ،عدد الفروع،عدد القرون،عدد البذور للقرن،وزن القرون للنبات،وزن البذور للنبات،وزن١٠٠بذرة ومحصـــول كل من البذور والبروتين والقش للفدان فى موســمى الزراعـة.أدى إختلاف عرض الخطوط إلى تـأثيرات معنويـة على كل من محتوى الفوسـفور فى الموسـم الأول في حين لم تتأثر نسـبة الفوسـفور فى الموسـم الثانى وكذا نسـبة البروتين فى كلا الموسـمين وأعطت الخطوط ١٢٠سم أعلى محتوى للفوسفور .أثرت نظم النحميل معنويا على محتوى كلا من البروتين والفوسفور فى الموسم الثانى فقط وأعطت الزراعة النقية أعلى محتوى للفوسفور.فى حين تفوق نظام التحميل (١٠٠%فول+٥٥%بصل) فى الحصـــول على أعلى محتوى للبروتين ونظام التحميل (١٠٠%فول+٣٣%بصـــل) فى الحصـــول على اعلى محتوى للفوســـفور مقارنة بباقى نظم التحميل.أظهر التفاعل بين عرض الخطوط ونظم التحميل تأثيرا معنويا على كل من محتوى الفوسفور ومحصول البروتين فى كلا الموسمين .ولم تسجل النتائج اتجاها واضحا فى هذا التأثير على نسبة الفوسفور فى حين تم الحصـــول على اعلى محصـــول للبروتين تحت نظام التحميل (١٠٠%فول+٥٥%بصـــل) على خطوط ٩٠ سـم مقارنة بباقى نظم التحميل.

INTERODUCTION

Faba bean (*Vicia faba* L.) is a legume crop grown primarily for its edible seeds (beans). Unfortunately, production of faba bean is still limited and falls to face the increasing local consumption of the crop. However, farmers suffer from high costs of production and consequently the reduction in the net income per unit area. This is due to the strong competition between faba bean and other strategic winter season crops such as wheat and clover on the limited arable land in Nile valley and Delta. In response to rising input costs and narrowing profit margins, scientific efforts are continually looking for ways to increase land use efficiency in Egypt. The cropping system adopted by the farmer in these soils must be physically viable, sustainable, less exhaustive acceptable to farming community and most important thing is that it should be economical. Moreover, mixing species in cropping systems may lead to a range of benefits that are expressed on various space and time scales, from a short-term increase in crop yield and quality, to longer-term agro-ecosystem sustainability, up to societal and ecological benefits **(Malezieux *et al*., 2009)**.

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. Accordingly, it is important to address our efforts to this fundamental issue by intercropping. Intercropping is the growing two or more crop species simultaneously in the same field area and has been widely practiced worldwide **(Francis, 1986)**. It provides an important pathway to fix atmospheric N_2, lower the risk of crop failure or disease and increase land use efficiency **(Trenbath, 1993 and Morris and Garrity, 1993**). Also, it is recommended to increase total agriculture products in Egypt **(Metwally, 1999)**.

On the other hand, onion (*Allium cepa* L.) is produced for home consumption and as income sources for many small scale farmers and commercial growers in Egypt. Onions could be consumed fresh as in green salad or in many other forms (as bulbs for cooking and pickling consumption) and use in food processing. However, more information is needed for determining the optimal spatial arrangement of intercropping onion with faba bean through the manipulation of both hill distance and ridge width; it is a general principle that if appropriate number of plants is not used in the unit of land in fact the available potential has not been used optimally. Thereby, yield of faba bean can be governed by plant density and distribution of these plants per unit area with regard to onion cultivar and its plant density as the competition for environmental resources between the two field crops must be less than exists within the same species **(Vandermeer, 1989)**. Yield per unit area declines since yield per plant tends to decrease with further increase in the plant density' because of competition for growth factors between adjacent plants **(Silvertooth, 2001)**. It is known that' faba bean production is affected by different factors such as genotypes, plant distribution and plant density **(Khalil *et al*., 2010 and Abd El-Rahman, 2014)**.

Hence, plant density is an important factor for the production of onion **(Mlik, 1994)**. In this concern, **Pakyurek *et al.* (1994)** and **Rizk (1997)** showed that' the highest planting density produced a noticeably higher yield of good quality bulbs than the lower sowing rate. Also, **Dawar *et al*. (2007)** revealed that' maximum yield bulbs (7072 kg ha^{-1}) was produced at density of 80 plants/ $4m^2$'while minimum yield of bulbs (5133 kg ha^{-1}) was recorded at planting density of 40 plants/ $4m^2$. Thus, the main target of this study is to identify the influence of different ridge widths and patterns of intercropping onion with faba bean on faba bean productivity and its quality.

MATERIALS AND METHODS

The present investigation was carried out during the two successive seasons of 2013/14 and 2014/15 at the farm of Sers El-Lyan Agricultural Research Station, Agricultural Research Center, El – Menofiya Governorate, Egypt. The aim of the present investigation was to study the influence of different ridge widths and patterns of intercropping onion with faba bean on faba bean productivity and its quality. The treatments were the combinations between ridge widths and cropping systems as follows:

1. Growing two sides of ridge with faba bean plants (2 plants/hill spaced at 25 cm apart) on a ridge of 60 cm width. This pattern was expressed as sole faba bean (recommended).
2. Growing three rows of onion transplants spaced at 10 cm apart in the upper of ridge of 60 cm width. This pattern was expressed as sole onion (recommended).
3. Growing two sides of ridge with faba bean plants (2 plants/hill spaced at 25 cm apart) on a ridge of 60 cm width, besides growing one row of onion transplants spaced at 12 cm apart on the middle of the ridge. This pattern was expressed as 100% faba bean + 27% onion.
4. Growing two sides of ridge with faba bean plants (2 plants/hill spaced at 25 cm apart) on a ridge of 60 cm width, besides growing one row of onion transplants spaced at 10 cm apart on the middle of the ridge. This pattern was expressed as 100% faba bean + 33% onion.
5. Growing two sides of ridge with faba bean plants (2 plants/hill spaced at 25 cm apart) on a ridge of 60 cm width, besides growing one row of onion transplants spaced at 8 cm apart on the middle of the ridge. This pattern was expressed as 100% faba bean + 41% onion.
6. Growing two sides of ridge with faba bean plants (2 plants/hill spaced at 25 cm apart) on a ridge of 60 cm width, besides growing one row of onion transplants spaced at 6 cm apart on the middle of the ridge. This pattern was expressed as 100% faba bean + 55% onion.
7. Growing three rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 90 cm width. This pattern was expressed as sole faba bean (I).
8. Growing four rows of onion plants on one ridge transplants spaced at 9 cm apart in ridge of 90 cm width. This pattern was expressed as sole onion (I).
9. Growing three rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 90 cm width, besides growing one row of onion transplants spaced at 8 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 27% onion.

10. Growing three rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 90 cm width, besides growing one row of onion transplants spaced at 6.6 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 33% onion.
11. Growing three rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 90 cm width, besides growing two rows of onion transplants spaced at 10.6 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 41% onion.
12. Growing three rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 90 cm width, besides growing two rows of onion transplants spaced at 8 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 55% onion.
13. Growing four rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 120 cm width. This pattern was expressed as sole faba bean (II).
14. Growing six rows of onion transplants spaced at 10 cm apart on ridge of 120 cm width. This pattern was expressed as sole onion (II).
15. Growing four rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 120 cm width, besides growing two rows of onion transplants spaced at 12 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 27% onion.
16. Growing four rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 120 cm width, besides growing two rows of onion transplants spaced at 10 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 33% onion.
17. Growing four rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 120 cm width, besides growing two rows of onion transplants spaced at 8 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 41% onion.
18. Growing four rows of faba bean plants on one ridge (2 plants/hill spaced at 25 cm apart) on a ridge of 120 cm width, besides growing two rows of onion transplants spaced at 6 cm apart in the same ridge. This pattern was expressed as 100% faba bean + 55% onion.

Recommended cultural practices for growing faba bean and onion crops were used. The experimental soil texture was clay. Onion seedlings were sown on November 5th and 7th in 2013 and 2014 seasons, respectively, while, faba bean seeds were sown three weeks later. Onion seedlings (var. Giza 20) kindly provided by Onion Research Department, and faba bean seeds (var. Giza 843) kindly provided by Food Legumes Research Department, Field Crops Research Institute, ARC.

The experimental layout was conducted in split plot design with three replications by allocating the ridge widths in the main- plots and cropping systems in the sub-plots. Sub-plot area consisted of (12 ridges-60 cm width or 8 ridges-90 cm width and 6 ridges-120 cm apart) and 3 meters long.

The studied traits: At harvest, ten plants were taken randomly from each sub-plot to estimate the following traits:

1. Plant height (cm).
2. Number of branches / plant.
3. Number of pods / plant.
4. Number of seeds / plant.
5. Seed yield / plant (g).
6. 100 – seed weight (g).
7. Seed yield(ardab) / fad: it was recorded on the basis of experimental sub plot and expressed as ardab per fad.
8. Straw yield / plant (g).
9. Straw yield(ton) / fad: it was recorded on the basis of experimental sub plot and expressed as ton per fad.
10. Harvest index (%) according to **Clipson *et al*. (1994)** where

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

11. Protein yield (kg/fad) = Seed protein content (%) x Seed yield (kg/fad)
12. Bulbs yield(ton) / fad: it was recorded on the basis of experimental sub- plot and expressed as ton per fad.

a. QUALITY OF FABA BEAN SEEDS:

1- **PROTEIN PERCENTAGE** :

The total N of faba bean seeds was determined using Microkjeldahl apparatus according to **A.O.A.C. (2000)**. Crude protein content was calculated by multiplying total N by 6.25 for faba bean **(Sadasivam and Manickam, 1997)**.

2- **PHOSPHATE PERCENTAGE** :

Phosphate percentage in seed was determined asreportedby **Jachson (1958).**

These analyses were done by the Regional Center for Food & Feed, Agricultural Research Center, Giza, Egypt.

STATISTICAL ANALYSIS:

The data were subjected to proper statistical analysis of variance. The treatments means were compared by using the least significant differences (L.S.D.) test at 5% and 1% levels of probability, F test was also followed to differentiate among means of studied characters as recommended by **Snedecor and Cochran (1973)** and by SAS 2006 Statistical analysis program, SAS User´s Guide: Statistics. SAS Institute Inc Editor, cary, NC.

RESULTS AND DISCUSSION

A. YIELD AND ITS ATTRIBUTES

1. EFFECT OF RIDGE WIDTHS

Data in Table (1) showed that' ridge widths had significant effects on plant height, number of seeds per pod, plant total weight, pods weight per plant, seed yield per plant, 100 – seed weight, seed yield per fad, straw yields per plant and per fad and harvest index, meanwhile numbers of branches and pods per plant and protein yield per fad were not significantly affected. These results indicated that' the ridge width of 90 cm had the highest values of number of seeds per pod, seed yield per plant , 100 – seed weight and harvest index, in both seasons and plant height and plant and pods weights in the 2nd season without significant difference than the widest ridge of 120 cm. for no.of seeds/pod, plant height in both seasons, seed yield/plant, 100-seed weight and seed yield (ardab)/fad in the 2nd season. Meanwhile' the widest ridge of 120 cm produced the highest seed and straw yields per fad compared to the other ridge widths (Table 1).

The increase in number of seeds per pod, pods weight per plant, seed yield per plant and 100 – seed weight at ridge width of 90 cm could be due to that the three rows of faba bean grown at 90 cm ridge width decreased intra-specific competition between plants of faba bean for basic growth resources as compared with the others. Accordingly, three rows of faba bean on ridge led to environmental balance between above and under – ground conditions for faba bean growth through enhancing the efficiency of photosynthetic process of the plant and consequently more dry matter accumulation in different parts of the plant organs. These results

indicated that' change ridge width played a major role in distribution of faba bean plants per unit area and thereby yield attributes of the plant during the early growth and development of faba bean. These results are in similar trends to those obtained by **Ageeb (1983), Saleh (1985) and El-Douby *et al*. (2000)**.

The significantly maximum seed yield per fad (11.32 ardab in 1st season and 10.35 ardab in 2nd season) and straw yield per fad (3.80 ton 1st season and 3.78 ton in 2nd season) were obtained at 120 cm ridge width. These results could be attributed to that the widest ridge width had the highest number of plants per unit area' which reflected positively on final yield per unit area and harvest index. Similar trend of results were observed by **Loss *et al.* (1998)** who demonstrated that' increases in plant numbers at higher densities more than compensated for a lower seed weight per plant, effectively producing higher yields per hectare.

2. Effect of cropping systems

Data in Table (1) showed that' cropping systems had significant effects on plant height, numbers of branches and pods per plant, number of seeds per pod, plant total weight, pods weight per plant, seed yield per plant, 100 – seed weight, seed and protein yields per fad, straw yields per plant and per fad and harvest index in both seasons, except straw yield per plant in the second season wher the values did n't reach to the level of significant. The results showed that' sole faba bean had the highest numbers of branches per plant pods per plant, seeds per pod, plant total weight , pods weight per plant, seed yield per plant, 100 – seed weight, seed yield per fad, protein yield per fad and harvest index in both seasons compared to those of intercropping patterns. However, the sole faba bean treatment had no significant difference than 100% faba bean + 27% onion cropping system for no.of branches/plant,no.of seeds/pod and protein yield/fad.

Sole culture of faba bean could be decreased intra–specific competition between plants of the same species for basic growth resources, especially solar radiation which increased numbers of branches and pods per plant and resulted in a positive effect on 100 – seed weight and harvest index compared to those by intercropping patterns. Conversely, sole faba bean produced the lowest straw yield per plant (47.33 g in 1st season) and straw yield per fad (2.71 ton in 1st season and 3.33 ton in 2nd season) compared to those of intercropping patterns. Accordingly, it is expected that growth resources such as water and nutrients were more completely absorbed by sole faba bean and converted to crop biomass during the early growth and development stages of faba bean plants compared to those of intercropping patterns.

With respect to intercropping patterns, the results in Table (1) revealed that' intercropping pattern of 100% faba bean + 27% onion came in the first rank, where it produced the highest numbers of branches per plant and pods per plant, number of seeds per pod, pods weight per plant, seed yield per plant, 100 – seed weight, seed yield per fad and protein yield per fad in both seasons, compared to those of the other intercropping patterns. Conversely, intercropping pattern of 100% faba bean + 55% onion produced the lowest number of seeds per pod, pods weight per plant, seed yield per plant, 100 – seed weight, seed yield per fad and protein yield per fad in both seasons, compared to those of the other intercropping patterns.On the other hand, the same intercropping patterns gave the highest values of straw yield per plant and per faddan in both seasons.

These results could be due to that intercropping pattern of 100% faba bean + 27% onion furnished better environmental resources for faba bean plants to grow well during the early growth and development stages compared to the others. In other words, the lowest plant density of onion could be decreased inter – specific competition between plants of the intercrops for basic growth resources' which reflected positively on the economic yield of intercropped faba bean.

Table (1): Effect of ridge width, cropping systems and their interaction on faba bean yield and its attributes during 2013/14 and 2014/15 seasons.

Traits / Treatments		plant height (cm)		Number of Branches/plant		Pods/plant		Seeds/pod	
		2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Ridge widths									
60 cm		100.80	110.93	2.96	3.50	15.95	14.27	2.83	2.63
90 cm		104.40	119.07	2.80	3.57	15.48	13.39	2.98	2.80
120 cm		109.07	116.80	2.83	3.47	15.68	13.86	2.93	2.77
F - test		*	*	**N.S.**	**N.S.**	**N.S.**	**N.S.**	*	*
L.S.D	**0.05**	**3.82**	**5.10**	---	---	---	---	**0.07**	**0.11**
	0.01	---	---	---	---	---	---	---	---
Cropping systems									
Sole faba bean		103.78	113.89	3.10	3.63	16.91	14.76	3.50	3.24
100% faba bean + 27% onion		103.56	116.11	2.95	3.59	15.94	14.40	3.26	3.05
100% faba bean + 33% onion		106.67	118.33	2.80	3.38	15.66	13.89	2.84	2.71
100% faba bean + 41% onion		106.67	119.00	2.81	3.51	14.90	13.25	2.59	2.43
100% faba bean + 55% onion		103.11	110.67	2.65	3.43	15.09	12.89	2.36	2.22
F - test		*	*	*	*	*	*	*	*
L.S.D	**0.05**	**2.30**	**3.50**	**0.30**	**0.20**	**0.71**	**0.47**	**0.34**	**0.32**
	0.01	---	---	---	---	---	---	---	---
Interactions									
60 cm x sole faba bean (Recommended)		100.00	109.33	3.17	3.77	16.73	15.30	3.47	3.13
60 cm x (100% faba bean + 27% onion)		96.67	102.67	3.37	3.83	15.90	15.00	3.20	2.87
60 cm x (100% faba bean + 33% onion)		98.33	108.00	2.67	3.53	16.77	14.63	2.77	2.57
60 cm x (100% faba bean + 41% onion)		107.33	120.00	2.83	3.13	14.90	13.40	2.43	2.37
60 cm x (100% faba bean + 55% onion)		101.67	114.67	2.77	3.23	15.43	13.00	2.30	2.20
90 cm x sole faba bean (I)		105.33	115.67	3.13	3.87	16.33	14.33	3.57	3.40
90 cm x (100% faba bean + 27% onion)		103.67	119.00	2.97	3.43	16.00	13.90	3.30	3.13
90 cm x (100% faba bean + 33% onion)		103.00	125.33	2.67	3.50	15.73	13.17	2.93	2.80
90 cm x (100% faba bean + 41% onion)		101.67	116.67	2.67	3.87	14.67	12.87	2.73	2.57
90 cm x (100% faba bean + 55% onion)		108.33	118.67	2.57	3.17	14.67	12.70	2.37	2.10
120 cm x sole faba bean (II)		104.00	107.00	3.00	3.27	17.67	14.67	3.47	3.20

120 cm x (100% faba bean + 27% onion)		111.00	120.00	2.53	3.53	15.93	14.30	3.30	3.17
120 cm x (100% faba bean + 33% onion)		109.33	115.00	3.07	3.13	14.50	13.87	2.83	2.77
120 cm x (100% faba bean + 41% onion)		111.00	118.33	2.93	3.53	15.13	13.50	2.63	2.37
120 cm x (100% faba bean + 55% onion)		110.00	123.67	2.63	3.90	15.17	12.97	2.43	2.37
F - test		*	*	*	*	*	*	*	*
L.S.D	**0.05**	**5.01**	**10.41**	**0.42**	**0.32**	**0.24**	**2.12**	**0.81**	**0.61**
	0.01	---	---	---	---	---	---	---	---

Table (1): Continued.

Traits / **Treatments**		**Total weight of plant (g)**		**Pods weight/plant (g)**		**Seed yield/plant(g)**		**100-seed weight (g)**		**Seed yield (ardab/fad)**	
		2013/14	**2014/15**	**2013/14**	**2014/15**	**2013/14**	**2014/15**	**2013/14**	**2014/15**	**2013/14**	**2014/15**
Ridge widths											
60 cm		94.47	93.73	43.18	36.75	29.40	25.07	70.54	67.70	10.85	10.01
90 cm		85.63	95.33	42.79	39.18	29.52	27.87	76.56	69.37	10.38	10.15
120 cm		94.27	85.47	39.28	36.14	26.61	27.09	69.53	68.46	11.32	10.35
F - test		*	*	*	*	*	*	*	*	*	*
L.S.D	**0.05**	**2.90**	**5.68**	**2.27**	**2.16**	**1.90**	**1.77**	**2.14**	**0.97**	**0.84**	**0.21**
	0.01	---	---	---	---	---	---	---	---	---	---
Cropping systems											
Sole faba bean		103.40	100.60	46.25	46.76	32.23	33.00	76.01	72.94	11.59	11.27
100% faba bean + 27% onion		83.20	85.70	43.68	36.18	29.79	26.00	73.49	67.66	10.99	10.49
100% faba bean + 33% onion		86.56	92.33	40.96	34.92	26.63	25.46	71.21	67.56	10.86	9.91
100% faba bean + 41% onion		94.17	90.89	40.03	35.16	27.54	25.25	70.68	67.51	10.60	9.48
100% faba bean + 55% onion		89.89	88.11	37.83	33.77	26.36	23.26	69.67	66.89	10.20	9.72
F - test		**	**	**	**	**	**	**	**	**	**
L.S.D	**0.05**	---	---	---	---	---	---	---	---	---	---
	0.01	**12.63**	**8.32**	**2.94**	**2.28**	**2.14**	**1.38**	**2.22**	**2.14**	**0.84**	**0.59**
Interactions											
60 cm x sole faba bean (Recommended)		99.33	96.67	49.17	46.50	32.00	34.33	74.00	74.83	11.83	11.00
60 cm x (100% faba bean + 27% onion)		93.67	91.00	45.50	34.67	29.33	22.00	71.40	66.00	11.07	10.82
60 cm x (100% faba bean + 33% onion)		89.33	92.67	43.17	33.25	28.67	23.33	66.30	66.33	10.73	9.63
60 cm x (100% faba bean + 41% onion)		91.00	94.33	41.08	34.83	28.00	23.00	71.37	66.33	10.47	9.15

60 cm x (100% faba bean + 55% onion)		99.00	94.00	37.00	34.50	29.00	22.67	69.63	65.00	10.17	9.45
90 cm x sole faba bean (I)		98.33	99.33	45.92	45.58	32.00	32.67	80.33	70.00	11.23	11.23
90 cm x (100% faba bean + 27% onion)		76.00	95.00	41.80	38.58	29.05	27.00	78.47	68.67	10.20	10.08
90 cm x (100% faba bean + 33% onion)		84.00	97.33	43.53	38.00	29.70	27.00	77.00	67.67	10.57	9.61
90 cm x (100% faba bean + 41% onion)		88.17	93.33	41.78	37.83	29.20	27.33	74.00	70.87	10.34	10.08
90 cm x (100% faba bean + 55% onion)		81.67	91.67	40.92	35.92	27.67	25.33	73.00	69.67	9.53	9.77
120 cm x sole faba bean (II)		112.67	105.67	43.67	48.18	32.69	32.00	73.70	74.00	11.70	11.57
120 cm x (100% faba bean + 27% onion)		80.00	71.00	43.75	35.29	31.00	29.00	70.60	68.30	11.70	10.57
120 cm x (100% faba bean + 33% onion)		86.33	87.00	36.20	33.50	21.53	26.05	70.33	68.67	11.30	10.48
120 cm x (100% faba bean + 41% onion)		103.33	85.00	37.23	32.81	25.41	25.42	66.67	65.33	11.00	9.20
120 cm x (100% faba bean + 55% onion)		89.00	78.67	35.57	30.89	22.41	22.97	66.37	66.00	10.90	9.93
F - test		**N.S.**	*	*	**	**	**	**	**	*	*
L.S.D	**0.05**	**---**	**18.41**	**6.51**	**---**	**---**	**---**	**---**	**---**	**1.15**	**1.32**
	0.01	**---**	**---**	**---**	**6.82**	**6.42**	**4.16**	**6.63**	**3.41**	**---**	**---**

Table (1): Continued.

Treatments \ **Traits**		**Protein yield (kg/fad)**		**Straw yield /plant (g)**		**Straw yield (ton/fad)**		**Harvest index (%)**		**Bulbs yield of oni (ton/fad)**	
		2013/14	**2014/15**	**2013/14**	**2014/15**	**2013/14**	**2014/15**	**2013/14**	**2014/15**	**2013/14**	**2014/1**
Ridge widths											
60 cm		405.90	379.36	55.13	67.53	3.15	4.18	33	25	4.92	4.46
90 cm		393.29	373.87	48.06	57.77	2.62	3.42	36	30	5.20	4.61
120 cm		412.48	381.98	57.60	66.87	3.80	3.78	30	28	5.82	4.87
F - test		**N.S.**	**N.S.**	*	*	*	*	*	*	**	*
L.S.D	**0.05**	**---**	**---**	**1.33**	**5.38**	**0.32**	**0.43**	**1.20**	**1.00**	**---**	**0.32**
	0.01	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**0.61**	**---**
Cropping systems											
Sole faba bean		454.74	421.09	47.33	62.99	2.71	3.33	39	33	12.03	10.40
100% faba bean + 27% onion		403.73	393.27	53.22	59.67	2.88	3.73	33	29	2.78	2.31
100% faba bean + 33% onion		390.29	347.99	50.44	66.87	3.19	4.03	33	26	3.39	2.70
100% faba bean + 41% onion		390.36	354.14	53.21	66.30	3.18	3.86	32	26	3.67	3.45
100% faba bean + 55% onion		380.33	375.53	63.78	64.45	3.55	4.10	29	26	4.68	4.37
F - test		*	*	*	**N.S.**	*	*	*	*	**	**

L.S.D	**0.05**	**61.90**	**55.40**	**6.83**	**---**	**0.30**	**0.52**	**3.50**	**2.80**	**---**	**---**
	0.01	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**0.56**	**0.68**
Interactions											
60 cm x sole faba bean (Recommended)		447.17	381.15	57.33	56.67	3.35	2.81	34	36	12.15	10.20
60 cm x (100% faba bean + 27% onion)		466.60	421.98	54.00	69.00	2.93	5.26	36	23	2.54	2.28
60 cm x (100% faba bean + 33% onion)		402.37	351.01	53.33	69.33	3.09	4.44	34	24	3.20	2.62
60 cm x (100% faba bean + 41% onion)		353.36	391.16	50.33	71.33	2.92	4.40	34	23	3.16	3.42
60 cm x (100% faba bean + 55% onion)		360.01	351.54	60.67	71.33	3.48	4.61	30	23	3.53	3.80
90 cm x sole faba bean (I)		480.08	384.06	41.67	68.64	2.27	3.85	42	30	11.47	10.16
90 cm x (100% faba bean + 27% onion)		342.72	391.60	45.00	42.00	2.40	2.37	38	38	2.8	2.26
90 cm x (100% faba bean + 33% onion)		358.32	332.98	47.33	60.95	2.61	3.80	37	27	3.16	2.34
90 cm x (100% faba bean + 41% onion)		372.24	338.68	48.97	61.58	2.69	3.45	36	30	3.68	3.68
90 cm x (100% faba bean + 55% onion)		413.12	422.06	57.33	55.70	3.12	3.73	31	28	4.47	4.59
120 cm x sole faba bean (II)		436.99	498.08	43.00	63.67	2.52	3.39	41	33	12.47	10.83
120 cm x (100% faba bean + 27% onion)		401.89	366.25	60.67	68.00	4.57	3.94	27	28	3.02	2.38
120 cm x (100% faba bean + 33% onion)		410.19	359.98	50.67	70.33	4.12	3.88	29	28	3.80	3.14
120 cm x (100% faba bean + 41% onion)		445.50	332.58	60.33	66.00	4.05	3.77	28	26	4.17	3.26
120 cm x (100% faba bean + 55% onion)		367.87	353.01	73.33	66.33	4.07	3.96	28	27	5.65	4.73
F - test		*	*	**N.S.**	*	*	*	**N.S.**	*	*	*
L.S.D	**0.05**	**102.0**	**96.06**	**---**	**18.96**	**1.10**	**1.40**	**---**	**5.20**	**1.23**	**1.10**
	0.01	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**	**---**

These results are in similar trends to those obtained by **El Kalla *et al*. (1999)**, **El-Mallah (2001)**, **Abou-Keriasha *et al*. (2013)** and **Abdullah and Fouad (2016)**.

3. EFFECT OF THE INTERACTION BETWEEN RIDGE WIDTHS AND CROPPING SYSTEMS

Data in Table (1) showed that' the interaction between ridge widths and cropping systems had significant effects on plant height, numbers of branches and pods per plant, number of seeds per pod, pods weight per plant, seed yield per plant, 100 – seed weight, seed and protein yields per fad and straw yield per fad in both seasons, as well as, total weight of the plant, straw yield per plant and harvest index in the second season only. The data showed that' each of these two factors act dependently for plant height, numbers of branches and pods per plant, number of seeds per pod, plant total weight, pods weight per plant, seed yield per plant, 100 – seed weight, seed and protein yields per fad, straw yields per plant and per fad and harvest index, where there is no obvious trend for these traits with respect to the interaction between ridge width and cropping system. Moreover, each of these two factors act independently for total weight of the plant, straw yield per plant and harvest index in the first season.

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B. FABA BEAN SEED QUALITY

1. EFFECT OF RIDGE WIDTHS

Data in Table (2) showed that' ridge widths had significant effects on seed phosphate content in 1st season only, meanwhile seed protein content in both season and seed phosphate content in 2nd season were not significantly affected. The results showed that' faba bean on ridges of 120 cm had the highest seed phosphate content, meanwhile ridge width of 60 cm produced the lowest one, (Table 2).

Table (2): Effect of ridge width, cropping systems and their interaction on quality of faba bean seeds during 2013/14 and 2014/15 seasons.

Treatments \ Traits		Protein (%)		Phosphate (%)	
		2013/14	2014/15	2013/14	2014/15
Ridge widths					
60 cm		24.88	25.34	0.29	0.44
90 cm		25.28	24.60	0.40	0.44
120 cm		24.30	24.50	0.46	0.45
F - test		**N.S.**	**N.S.**	*****	**N.S.**
L.S.D	**0.05**	**---**	**---**	**0.11**	**---**
	0.01	**---**	**---**	**---**	**---**
Intercropping patterns					
Sole faba bean		26.20	24.87	0.36	0.44
100% faba bean + 27% onion		24.47	25.00	0.31	0.34
100% faba bean + 33% onion		23.93	23.43	0.39	0.43

100% faba bean + 41% onion		24.50	25.00	0.33	0.42
100% faba bean + 55% onion		25.00	25.77	0.32	0.40
F - test		**N.S.**	*	**N.S.**	*
L.S.D	**0.05**	**---**	**0.16**	**---**	**0.08**
	0.01	**---**	**---**	**---**	**---**
Interactions					
60 cm x sole faba bean (Recommended)		25.2	23.1	0.30	0.56
60 cm x (100% faba bean + 27% onion)		28.1	26.0	0.29	0.39
60 cm x (100% faba bean + 33% onion)		25.0	24.3	0.25	0.40
60 cm x (100% faba bean + 41% onion)		22.5	28.5	0.34	0.40
60 cm x (100% faba bean + 55% onion)		23.6	24.8	0.27	0.46
90 cm x sole faba bean (I)		28.5	22.8	0.41	0.50
90 cm x (100% faba bean + 27% onion)		22.4	25.9	0.36	0.38
90 cm x (100% faba bean + 33% onion)		22.6	23.1	0.55	0.40
90 cm x (100% faba bean + 41% onion)		24.0	22.4	0.29	0.45
90 cm x (100% faba bean + 55% onion)		28.9	28.8	0.40	0.48
120 cm x sole faba bean (II)		24.9	28.7	0.36	0.27
120 cm x (100% faba bean + 27% onion)		22.9	23.1	0.29	0.25
120 cm x (100% faba bean + 33% onion)		24.2	22.9	0.36	0.49
120 cm x (100% faba bean + 41% onion)		27.0	24.1	0.36	0.41
120 cm x (100% faba bean + 55% onion)		22.5	23.7	0.29	0.25
F - test		*	*	*	*
L.S.D	**0.05**	**4.1**	**3.1**	**0.27**	**0.11**
	0.01	**---**	**---**	**---**	**---**

2. EFFECT OF CROPPING SYSTEMS

Data in Table (2) showed that' cropping systems had significant effects on seed protein and phosphate contents in the second season, meanwhile seed protein and phosphate contents in the first season were not significantly affected. In general, the results showed that' sole faba bean had the highest seed phosphate content, meanwhile intercropping pattern 100% faba bean + 55% onion had the highest seed protein content compared to the other intercropping patterns.

3. EFFECT OF THE INTERACTION BETWEEN RIDGE WIDTHS AND CROPPING SYSTEMS

Data listed in Table (2) showed that' the interaction between ridge widths and cropping systems had significant effects on seed protein and phosphate contents in both seasons. The results showed that' there was not clear behavior for seed phosphate content among the treatments but the highest values of seed protein content (28. 9 in 1st season and 28.8 in 2nd season) was obtained by intercropping pattern of 100% faba bean + 55% onion of ridge width 90 cm.

Obviously, doubling ridge width from 60 to 120 integrated with the highest plant density of onion to increase inter or intra – specific competition between plants of the two species or plants

of the same species, respectively, for basic growth resources which reflected negatively on the economic yield of both species under intercropping conditions. These data revealed that' there was effect of ridge widths x intercropping patterns on quality of faba bean seeds.

CONCLUSION

Our results revealed that growing four rows of faba bean plants (2 plants/hill spaced at 25 cm apart) on a ridge of 120 cm width, besides growing two rows of onion transplants spaced at 6 cm apart in both sides of the same ridge could be recommended. This treatment achieved high seed yield with good quality.

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