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EFFECT OF SOWING DATES AND PLANT DENSITY OF LUPINE INTERCROPPED WITH SUGAR BEET ON THE PRODUCTIVITY AND ECONOMIC RETURN

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ABSTRACT: A field experiment was carried out in Sers El- Layan Research, Station at Menoufia Governorate, Egypt during 2020/2021 and 2021/2022 seasons to study the effect of three sowing dates and plant density of lupine intercropped with sugar beet on productivity of sugar beet and lupine. The experiment consisted of three sowing dates of lupine (D1: at the same time with sugar beet, D2 and D3: 21 and 42 days after sowing sugar beet, respectively) and three lupine plant densities 12.5, 25 and 37.5% of its pure stand, respectively + 100% sugar beet. A split-plot design with three replicates was used. The results obtained showed that all studied characters of sugar beet recorded their highest values when lupine intercropped with sugar beet at D3 in both seasons. On the other hand, lupine characters gave the highest values at D2 in both seasons. Treatment of (100% sugar beet +12.5% lupine) gave the highest values for sugar beet characters under study, except TSS% and sucrose% in both seasons. Lupine characters behaved the same trend of sugar beet characters in both seasons, except lupine seed yield was showed with P3 (100% sugar beet +37.5% lupine) in both seasons. Sugar beet yield and chemical characters as well as lupine seed yield were significantly affected by the interaction in both seasons. Treatment of D2×P3 recorded the highest values for LEC increased by 39and 37% in the first and second seasons, respectively. Increases in economic return were 14870 and 18598 LE. compared with sugar beet alone in the first and second seasons, respectively. It can be concluded that, under Menoufia Government conditions, the maximum land equivalent ratio and economic return were achieved by intercropping of 100% sugar beet + 37.5% lupine after 21 days of planting sugar beet.

Key words: Land equivalent ratio, Land equivalent coefficient, Relative crowding coefficient, Aggressivity, economic return

INTRODUCTION

As a source of sugar, sugar beet root is a significant crop in Egypt and around the world. Increasing agricultural intensity is thought to be a key strategy for addressing or lowering the significant discrepancy between sugar beet root output and consumption of some strategic crops, such as faba bean, lupine, etc. Therefore, fundamental agricultural methods including fertilization, intercropping patterns, and sowing dates are thought to be necessary to increase land usage and farmer income overall. Be seem, wheat, etc. by Four weeks after sugar beet was planted, Farrag (1990) and Abou- Elela, A.M. (2012)., reported that intercropping faba beans with sugar beet did not significantly alter sugar beet output, but the combined income from both crops increased. According to Hussein *et al.* (2002) and Hassan and sanaa (2007), an early sowing date significantly enhanced the faba bean's vegetative growth and output. The timing of sowing had a substantial impact on all aspects of sunflower vegetative growth, including its constituent bold. Kaleem *et al.*, (2010). Abou–Elela (2012) examined the impact of planting wheat on dates that coincided with sugar beet planting, i.e., 21, and 42 days after sugar beet planting. After 42 days of seeding sugar beet, all investigated sugar beet characters that were strongly impacted by planting wheat attained the greatest values of sugar beet characters. Compared to seeding wheat with sugar beet root at the same time and after 21 days, respectively, the increase in root yield/fed by wheat sown after 42 days was 7.29 and 3.41% in the first season

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and 12.26 and 5.56% in the season respectively. The findings showed that purity% was not significant, but TSS% and sucrose% in sugar beet root had the greatest values when cropping wheat 42 days after sugar beet root was sown in the two seasons. Mohamed (2014) studied the effect of intercropping faba bean plant densities and sugar beet 100% at three planting dates and three planting distributions. Under the 1 October sowing date, 100% sugar beet and 12.5% faba bean density produced the maximum yield of faba beans. The highest Land Equivalent Ratio (LER) values were observed when a sowing date of October 15th was used, with 100% sugar beet and 12.5% faba bean density. The earlier planting date was shown to give better seed yields than later planting Ahmed *et al.*, (2015). Yield and its components of sugar beet significantly affected by sowing date of faba bean Hassan (2007). Abou-Elela (2012) and Badr (2017) intercropped wheat with sugar beet. Enan *et al.* (2013) discovered that the sunflower seed output and fad were highly impacted by the sowing date of the sunflower intercropping with cane. The production and characteristics of sugar beet cultivars, as well as the percentage of sucrose, were found to differ significantly. when intercropped with fata beau the production and qualities of sugar beet were greatly enhanced by intercropping faba bean at low plant density. By reducing the density of faba bean plants, yield attributes rose dramatically. EL Mehy *et al.*, (2020). Khamis and El-Mehy (2021) investigated the effects on yield and yield components of sunflower and sugar beet as affected by of three sunflower sowing dates and three intercropping systems (25%, 33.3%, and 50% of sunflower plant density + 100% sugar beet). The findings demonstrated that the intercropping systems of sunflower and the date seeding had a substantial impact on sugar beet characters. The intercropping system greatly improved sugar beet root characteristics. Considerable variations were seen in the characteristics of sunflowers analyzed in relation to the intercropping systems. El- Borai and Radi (1993) reported that decreasing faba bean ratio from 100 % to 50 % or 33.3 % when intercropped to sugar beet lowered LER, however sugar quality as reflected in sucrose, TSS and purity percentages were not changed. Amer *et al.* (1997) reported that intercropping sugar beet with faba bean did not significantly influence sucrose, TSS and purity percentages, but drastically lowered root and sugar yields. The number of branches, pods, and seeds per plant, as well as the faba bean seed production, all showed notable increases; nevertheless, the solid faba bean seed yield outperformed the intercrop. Hussein and El-Deeb (1999) discovered that growing faba beans alongside sugar beet at a density of 4 plants/m2 enhanced profitability by 12.5% compared to growing solid sugar beet. Abd El-All (2002) discovered that intercropping 16 faba bean plants m^2 with sugar beet produced the highest levels of LER; while, intercropping 5 faba bean plants / m^2 produced the maximum yield of sugar beet.) compared to sugar beet solo planting. On the other hand, intercropping faba bean with a rather high planting density hat is, 33% significantly decreased sugar beet root output by 15%. Farghaly *et al.*, (2003). Also, they reported that when faba beans were interplanted at a 33% planting density, the percentages of total soluble solids (TSS) and sugar decreased and the percentage of purity increased. Saleh (2003) examined the impact of onion intercropping systems on sugar beet root yield and yield components. The results showed that intercropping onion with sugar beet, as opposed to sugar beet pure stand in the two seasons, significantly reduced yield, yield components, and chemical characteristics of sugar beet. However, when onions were interplanted with sugar beet root, TSS%, sucrose%, and purity% increased. Throughout the two seasons, TSS% exhibited the opposite tendency. El-Shaikh and Bekheet (2004) stated that faba bean and sugar beet intercropping patterns produced land equivalent ratio (LER) values larger than one. The highest sugar beet yield was obtained using an intercropping pattern consisting of 100% sugar beet plus 12.5% faba bean, whereas the highest LER and net revenue were reported by using 100% sugar beet plus 33% faba bean. Mohammed *et al.* (2005). Ibrahim and El. Abbas (2010) examined three plant densities: 25%, 75%, and 100% sugar beetroot root plus lupine. While the yield and fad of lupine under three rows system climbed by 4.5 and 6.8% in comparison to one and two rows system, the yield and fad of sugar beetroot root under one row system expanded by 8.6 and 15.5%, respectively, in contrast to two and three rows. Mohammed and Abd El Zaher (2013) and Sheha *et al.* (2017) revealed that the components of sugar beet root yield and fad rose with decreasing sunflower plant density, while the components of sugar beet seed yield and fad increased with increasing sunflower plant density with sugar beet. In Sers EL-layan district, Menoufia Governorate, the aim of this study is to ascertain the optimal land utilisation and economic return for farmers through intercropping lupine with sugar beetroot patterns.

MATERIALS AND METHODS

A field experiment was carried out in Sers El-Layan Research Station, Menoufia Governorate, Egypt during, 2020/2021 and 2021/2022 seasons. The experiment consisted of three sowing dates of lupine [D1: at the same time with sugar beet, D2 and D3: 21 and 42 days after sowing sugar beet, respectively] and three lupine plant densities by planting [P1: one plant /hill, P2: two plants/hill and P3: three plants/hill at 20 cm apart to give 12.5, 25 and 37.5% of its pure stand, respectively + 100% sugar beet. Beside of pure stands of sugar beet and lupine as recommended. The trial was laid out in a Randomized Complete Block Design (RCBD) using a split-plot comprising Nine treatments arrangement with three replicates. The three sowing dates of lupine occupied the main plots and the three plant densities of lupine were arranged in sub-plots. The sub-plot area was 21 m^2, included 5 beds, 3.5 m long and 1.2 m width for each one. Sugar beet was planted at 20 cm apart between hills and leaving one plant/hill at the two sides of sugar beet beds (1.2 m wide) in intercropping; and one side of the ridge (60 cm wide) in pure stand to give 35000 plants/fed either intercropping or pure stand. Lupine was planted at 20 cm a part between hills and leaving two plants/hill at the two sides of the ridge (60 cm width) to give 140000 plants /fed in pure stand. The soil samples throughout soil preparation were randomly taken from (0 - 30 cm) from the soil surface, particle size distribution and chemical analyses were conceded by the method described by Page *et al.* (1982), and its results are exposed in Table (1).

Table (1). Some physical and chemical properties of the experimental soil in 2020/2021 and 2021/2022 seasons.

Properties		2020/2021 seasons	2021/2022 seasons
A: Particle size distribution			
Coarse sand%		1.27	1.59
Fine sand %		27.12	32.12
Silt%		30.90	27.89
Clay%		40.71	38.40
Texture		clay loam	clay loam
B: Chemical analysis			
PH		7.80	7.48
EC (dSm^2)		1.92	1.57
Available (mg/kg)	N	40.02	41.00
	P	21.09	23.00
	K	348.05	347.90
Soluble cations (mgq/L)	Ca^{++}	1.81	1.71
	Mg^{++}	1.32	1.32
	Na^{+}	3.25	3.25
	K^{+}	5.49	5.42
Soluble anions(mgq/L)	Co_3^{--}	0.00	0.00
	Hco_3^{-}	3.02	3.20
	CL^{-}	4.91	4.80
	So_4^{--}	3.94	3.70

Corn was the previous summer harvest in both years. At the time of seed bed preparation, a basic dose of P and K was evenly dispersed, equivalent to 31 kg P_2O_5 as a super phosphate fertilizer (15.5% P_2O_5) and 24 kg K_2O as potassium sulphate (48% K_2O) fertilizer. During the first and second irrigations of sugar beetroot, 80 kg N/fed of ammonium nitrate (33.5%) was applied as nitrogen fertiliser at two equal dosages to both solo and intercropping cultures. In the first and second seasons. Agricultural operations for the two crops were carried out according to the technical recommendations for each crop, respectively, sugar beetroot (Beta vulgaris L.) C.V. The sugar beet variety Hossam seeds were planted on 27 October and 25 October. In both seasons, lupine (Lupinus tervais.) C.V. Giza 1 was planted at the sugar beet sowing date, after 21 days (at first irrigation) and 42 days (at second irrigation) in both seasons.

Data recorded

1- Sugar beet, ten guarded plants were randomly taken at harvest from the central ridges of each sub-plot to estimate: top Length (cm), root length (cm), root diameter (cm) and top root fresh weight/plant (g). Top and root yields were determined on the whole plot basis then it was transferred to ton/fad.

Juice quality characteristics

Samples of fresh root were taken from each sub plot to determine:

A. Total soluble solids (%) (TSS%) measured by refract meter according to A.O.A.C. (1990).

B. Sucrose percentage was determined according to method described by Le-Docte (1927).

C. Juice purity percentage was calculated according to the method describing by Carruthers and Oldfield (1961).

$$\text{Purity (\%)} = \frac{Sucrose}{TSS} \times 100$$

D. Sugar yield (ton/fad.) = root yield (ton/fad) x (sugar %)

2- Lupine, ten lupine guarded plants were randomly taken at harvest from each sub-plot to estimate: plant height (cm), no. of branches/ plant, no. of pods/plant, no. of seeds/plant, wt. of pods /plant, wt. of seeds/plant and 100 - seed wt. Lupine plants were harvested and threshed from each sub-plots and converted to estimate the seed yield/fed (ard).

Competitive relationships and yield advantages

A- Land equivalent ratio (LER) was described by Willey (1979) and determined according to the following formula:

LER = (Yab/Yaa) + (Yba/Ybb)

Where: Yaa and Ybb were pure stand of crop a (sugar beet) and b (lupine), respectively. Yab is mixture yield of crop a and Yba is mixture yield of crop b.

B- Land equivalent coefficient (LEC)

A measure of interaction concerned with the strength of relationship was calculated thus, LEC=La x Lb. Where, La= partial LER of main crop (a) and Lb = partial LER of intercrop Aditiloye *et al.*, (1983), for a two- crop mixture the minimum expected productivity coefficient (PC) is 25% that is a yield advantage is obtained if LEC exceeds 0.25.

C- Relative crowding coefficient (RCC)

This was proposed according to De-wit (1960**).** It assumes that mixture treatment forms a placement series. Each series has its own coefficient (K) which gives a measure to indicate that series has produced more, less or equal yield to that expected. Relative crowding coefficient (RCC) was determined according to the following formula: for species in mixture with species

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

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

Where: Zab is sown proportion of species a (in a mixture with b) and Zba is sown proportion of species b (in a mixture with a). If a species has a coefficient less than, equal to, or greater than one, means it has produced less yield, the same yield, or more yield than the “expected”, respectively. The component crop with the higher coefficient is the dominant one. to determine if there is a yield advantage of mixing, the product of the coefficient is formed by multiplying K = Ka x Kb Where: Ka for sugar beet, Kb for lupin and K for the two crops were calculated as follows:

If K > 1, there is yield advantage, If K< 1 there a yield disadvantage.

D - Aggressivity (Ag)

This parameter was proposed by Mc-Gilichrist (1965). It gives a simple measure of how much the relative yield increase in species (a) is greater than that of species (b). Aggressivity "A" is determined according to the following formula

For crop (a),

$$Aab = \frac{Yab}{Yaa \times Zab} - \frac{Yba}{Ybb \times Zba}$$

• and for the crop (b),

$$Aba = \frac{Yba}{Ybb \times Zba} - \frac{Yab}{Yaa \times Zab}$$

Where:

Zab= Sown proportion of species a (in a mixture with b)

Zba = Sown proportion of species b (in a mixture with a).

An aggressivity value of zero indicates that the component species are equally competitive. For any other situation, both species will have the same numerical value but the sign of the dominant species will be positive and the dominated negative. The greater the numerical value the bigger the difference in competitive abilities and the bigger the difference between actual and "expected" yield

Economic evaluation

1- Total return = price of sugar beet yield + price of lupine (LE).
2- Net return/ fed (from intercropping treatments) = Total return - (fixed costs of sugar beet + variable costs of both crops according to intercropping treatments).

Gross profit from each treatment was calculate to Egyptian pounds (LE) using the average market price of two seasons the local prices were 625,759 and 2250 LE of one ton of sugar beet and one ardab of lupine seeds, respectively.

Statistical Analysis

The obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split-plot design as published by Gomez and Gomez (1984) using the "MSTAT-C" software package. In addition, treatment means were compared using the least significant difference (L.S.D.) method at a 5 % probability level, as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSIONS

I- Sugar beet

1-Effect of lupine sowing date:

a- yield and yield components:

Data in Table (2), showed that lupine sowing dates in both seasons had a substantial impact on sugar beet growth, yield, and yield component characteristics. Data in Table (2) showed that postponing lupine sowing dates from 0 to 21 up to 42 days from sugar beet sowing date in both seasons boosted sugar beet growth characters, i.e. top length and root length. This is the outcome of the lupine and sugar beetroot plants competing with one another for light. In thiscoucer Abou-Elela, (2012) obtained comparable outcomes. Data showed that postponing the lupine sowing dates from simultaneously to 21 to 42 days after the sugar beet sowing date increased the yield components characteristics of the plant, such as root diameter, top and root weights, and top and root yields/fed. The sugar beetroot yield and yield components exhibited a contrary tendency to the growth features. The results clearly showed that the maximum yield values and yield components of sugar beet were obtained from lupine sown 42 days after sugar beet, whereas the lowest yield values were obtained from sugar beet sowed 21 days later. Delaying the lupine sowing dates leads to less inter-competition between sugar beetroot and lupine plants for light, water, and nutrients. The top yields in the first and second seasons are 11.86, 12.51, and 12.71 tons/fed, respectively, when the lupine sowing date is postponed from concurrent to 21 to 42 days after sugar beetroot. Additionally, the first season's root yield/fed was 25.50, 26.91, and 27.33 tones, and the second season's root yield/fed was 25.27, 26.49 and 27.57 tones. Comparable outcomes were noted by Mohammed (2014), Mehy *et al.* (2020) and Khamis and El-Mehy (2021).

b- Chemical characters and sugar yield/fed.

Data in Table (2) showed that lupine sowing dates in both seasons had a substantial impact on the chemical characteristics of sugar beetroot, such as total soluble percentage, sucrose percentage, and purity percentage. According to the data, D3 had the highest TSS%, sucrose%, and purity% values, followed by D1, and D2 had the lowest values throughout the first few seasons. In the both season, D1 and D2 had the lowest values for sucrose and TSS% and D3 had the highest values. In terms of purity%, the data showed that in the first season, D3 recorded the greatest values, followed by D2, D1, and D2, whereas in the second season, DI recorded the lowest values and D2 the highest. In the first season, sugar yield/fed had the highest value, followed by D3 and D2, which had the lowest values. Information provided by Ibrahim and El. Abbas (2010) Bold Sheha *et al.*, (2017) indicated that chemical characters of sugar beet were significantly affected by sowing dates of intercropped crop.

2- Effect of lupine plant density

a- Yield and yield components characters:

The data in Table (3) showed that in both seasons, the various plant densities of lupine had a substantial impact on sugar beet growth, yield, and yield components. By raising the lupine plant density from 12.5 to 25 up to 37.5% of its pure plant density in both seasons, the top length of sugar beetroot was greatly increased. The primary cause of the market's increase in top length when sugar beetroot was interplanted at a high density of lupine plants is the substantial increase in interspecific competition for light between sugar beetroot and lupine plants. Comparable outcomes were attained by Mohammed (2014).

Table (2). Effect of sowing date, plant density of lupine on sugar beet characters in 2020/2021 and 2021/2022 seasons.

Characters / Treatments	Top length plant^{-1}	Root Length (cm)	Root Diameter (cm)	Top weight plant^{-1}	Root weight plant (g)	Top yield/ fed (t)	Root yield/ Fed (t)	TSS%	Sucrose %	Purity %	Sugar yield/fed (t)
2020/2021											
D_1	56.00	24.92	12.78	391.23	806.67	11.86	25.50	17.00	14.19	83.47	3.62
D_2	56.98	25.55	13.02	397.05	818.67	12.51	26.91	17.80	15.24	85.62	4.10
D_3	57.44	26.15	13.68	406.86	838.89	12.71	27.33	17.94	16.40	91.42	4.18
LSD at 5 %	0.50	0.85	0.36	5.26	10.85	0.15	0.33	0. 71	0.04	1.27	0.18
Solid	58.00	26.35	13.70	658.00	843.00	19.43	28.43	18.20	16.20	89.00	4.61
2021/2022											
D1	57.13	26.51	12.04	430.0	886.67	11.75	25.27	17.62	14.52	82.41	3.67
D2	57.59	27.28	12.84	435.6	898.11	12.32	26.49	17.68	15.63	88.40	4.14
D3	59.22	27.58	13.66	442.7	912.78	12.82	27.57	17.83	15.84	88.84	4.37
LSD at 5 %	0.58	0.36	0.22	3.78	7.79	0.09	0.20	NS	0.72	2.77	0.26
Solid	60.70	27.60	13.70	861.30	917.00	23.10	28.68	18.40	16.00	86.96	4.59

D1: lupine sowing at the same time with sugar beet.

D2: lupine Sowing 21 days after sowing sugar beet.

D3: lupine Sowing 42 days after sowing sugar beet.

Table (3). Effect of plant density of lupine on sugar beet characters in 2020/2021 and 2021/2022 seasons.

Characters / Treatments	Top length (cm)[1]	Root length (cm)	Root diameter (cm)	Top weight $plant^{-1}$	Root weight plant (g)	Top yield/ fed (t)	Root yield/ fed (t)	TSS%	Sucrose %	Purity %	Sugar yield/fed
2020/2021											
P_1	58.29	26.07	13.64	402.28	829.44	12.68	27.26	17.57	15.64	89.02	4.26
P_2	56.73	25.64	13.16	400.13	825.00	12.46	26.80	17.52	15.49	88.41	4.15
P_3	55.40	24.92	12.68	392.74	809.78	11.94	25.67	16.55	13.99	84.53	3.59
LSD at 5%	0.61	0.44	0.16	4.08	8.41	0.09	0.19	0.32	0.03	5.15	0.10
Solid	58.00	26.35	13.70	658.00	843.00	19.43	28.43	18.20	16.20	89.00	4.61
2021/2022											
P_1	58.56	28.19	13.38	444.0	915.56	12.83	27.58	18.00	15.82	87.88	4.36
P_2	57.97	26.92	12.90	435.6	898.11	12.27	26.38	17.67	15.45	87.44	4.08
P_3	57.42	26.26	12.27	428.7	883.89	11.80	25.37	17.46	14.72	84.31	3.73
LSD at 5 %	0.54	0.82	0.23	7.05	14.54	0.04	0.08	0.44	0.67	3.30	0.11
Solid	60.70	27.60	13.70	861.30	917.00	23.10	28.68	18.40	16.00	87.00	4.59

P1: lupine plant density =12.5% of its pure stand.

P2: lupine plant density =25% of its pure stand.

P3: lupine plant density =37.5% of its pure stand.

Results provided in Table (3) indicated that when sugar beet were intercropped with 12.5% plant density of lupine alone sugar beet offered the maximum value followed by sugar beet with 25.0% and simultaneously the lowest value was due to 37.5% lupine plant density. For root length, root diameter, and top and root weight in the first and second seasons, this was absolutely correct. This decline in sugar beetroot yield component characteristics amply demonstrates the intense competition brought about by lupine plants, which shade the crop and increase plant density to 37.5%. It also highlights the interdependent relationship between the two crops for water and nutrients. Comparable outcomes were attained by Ibrahim and El. Abbas (2010). The data demonstrated that, in both seasons, the yield components of top yield/fed and root yield/fed followed the same trend, as indicated in Table (3). The increase in yields of sugar beetroot because of its superiority in yield component characteristics. In the first season, the loss in sugar beet root yield/fed due to the use of lupine plant density 12.5 to 25.0 to 37.5% was 1.17, 1.63, and 2.76 tons/fed, respectively in the first season compared with sugar beet alone, and 1.1, 2.29, and 3.31 tons/fed in the second season. Comparable outcomes were attained by Ibrahim and El. Abbas (2010) and Mohammed (2014).

(b): Chemical characters and sugar yield /fed

Data presented in Table (3) showed that total soluble solids (TSS%), sucrose % and purity % were significantly affected by lupine plant density in both seasons. Data indicated that intercropping 25% lupine with sugar beet achieved the highest values for these traits followed by 12.5%. lupine and the lowest values was obtained with 37.5 lupine in the first season. sugar yield/fed = root yield/fed × sucrose% sugar yield/fed was related to root yield /fed in both seasons. So,100% sugar beet + 12.5%. lupine of its pure stand gave the highest value for sugar yield/fed followed by 100% sugar beet + 25.0% lupine and the lowest value was obtained by 100% sugar beet + 37.5% in both seasons. Similar results were agreeing with Farghaly *et al.* (2003).

3- Interaction effects

Data presented in Table (4) revealed that most sugar beet characters were significantly affected by the interaction between sowing date and plant density of lupine in both seasons, except top length and root diameter in the second season only. sugar beet characters *i.e.,* root diameter, root diameter, top weight, root weight, top yield and root yield in both seasons and top length and TSS% in one season Also, data revealed that D3 × P2 recorded the highest values for sucrose%, purity% and sugar yield /fed in one season out of two. On the other hand, D1 × P3 recorded the lowest values for root length, root diameter, top weight/plant root weight/plant, top yield/fed, root yield/ fed and sugar yield /fed in both seasons and sucrose % and purity % in one season. So, must be delay lupine planting to D3 and apply 12.5% of lupine plant density to obtain the best of sugar beet yield per unit area with lupine. Similar results were obtained by El- Borai and Radi (1993), Amer *et al.* (1997), Saleh (2003) and Mohammed (2014).

Table (4). Effect of the interaction between sowing date and plant density of lupine on some sugar beet characters in 2020/2021 and 2021/2022 seasons.

Treatments \ Characters		Top length (cm)	Root length (cm)	Root diameter (cm)	Top weight plant^{-1}	Root weight/ plant(g)	Top yield / fed (t)	Root yield/ fed (t)	TSS%	Sucrose %	Purity%	Sugar yield/ fed
2020/2021												
D1	P_1	57.67	25.19	13.20	396.10	816.67	12.04	25.90	16.02	14.30	89.26	3.70
	P_2	55.33	24.99	12.80	394.50	813.33	11.98	25.75	16.93	15.36	90.73	3.96
	P_3	55.00	24.59	12.33	383.20	790.00	11.56	24.85	15.34	12.90	84.09	3.21
D2	P_1	58.53	26.53	13.57	399.3	823.33	12.91	27.75	17.86	15.00	83.99	4.16
	P_2	57.53	25.31	13.17	400.94	826.67	12.67	27.24	17.63	14.60	82.81	3.98
	P_3	54.87	24.80	12.33	390.91	806.00	11.96	26.72	17.28	14.00	81.02	3.74
D3	P_1	58.67	26.48	14.17	411.44	848.33	13.08	28.13	18.84	17.62	93.52	4.96
	P_2	57.33	26.61	13.50	405.0	835.00	12.74	27.40	17.96	16.52	91.98	4.53
	P_3	56.33	25.36	13.37	404.2	833.33	12.30	26.45	17.02	15.06	88.48	3.98
LSD at 5 %		1.06	NS	0.27	NS	NS	0.15	0.33	0.55	0.06	2.82	0.052
Solid		58.00	26.35	13.70	658.00	843.00	19.43	28.43	18.20	16.20	89.00	4.61
2021/2022												
D1	P_1	57.70	27.27	12.47	442.97	913.33	12.25	26.33	18.03	14.82	82.20	3.90
	P_2	57.27	26.47	12.10	428.42	883.33	11.73	25.23	17.51	14.20	81.10	3.58
	P_3	56.43	25.80	11.57	418.72	863.33	11.27	24.23	17.31	14.01	80.94	3.39
D2	P_1	57.63	28.50	13.37	441.35	910.00	12.97	27.89	18.92	16.82	88.90	4.69
	P_2	57.63	27.00	13.00	433.75	894.33	12.31	26.47	17.61	15.81	89.78	4.18
	P_3	57.50	26.33	12.17	431.65	890.00	11.69	26.13	16.49	14.27	86.54	3.73
D3	P_1	60.33	28.80	14.30	447.81	923.33	13.26	28.52	17.05	15.82	92.79	4.51
	P_2	59.00	27.30	13.60	444.58	916.67	12.76	27.45	17.88	16.34	91.39	4.49
	P_3	58.33	26.63	13.07	435.69	898.33	12.44	26.75	18.57	15.36	82.71	4.11
LSD at 5 %		NS	NS	NS	NS	NS	0.07	0.14	0.76	1.17	5.71	0.18
Solid		60.70	27.60	13.70	861.30	917.00	23.10	28.68	18.40	16.00	87.00	4.59

D1: Sowing lupine and sugar beet simultaneously.
D2: lupine Sowing 21 days after sugar beet (at first irrigation).
D3: lupine Sowing 42 days after sugar beet (at second irrigation).
P1: lupine plant density =12.5% of its pure stand.
P2: lupine plant density =25% of its pure stand.
P3: lupine plant density =37.5% of its pure stand.

II-Lupine crop

1. Effect of lupine sowing date

Data in Table (5) indicated that all tested characters of lupine were significantly influenced by lupine sowing date in both seasons. Data revealed that the second date (D2) gave the highest values in all traits, followed by the first date (D1), and the lowest results were for the third date (D3). This was completely true for plant height, number of branches/ plant, no of pods/plant, no. of seeds/plant, weights of pods and seeds/plant, 100-seed wt. and seed yield/fed in both seasons. These results may be due to the similarity of the second date (D2) for planting lupine with the optimum sowing date for lupine crop compared with other sowing dates under this district condition.

2. Effect of lupine plant density

The Data in Table (6) showed that, in both seasons, lupine plant densities had a significant impact on every attribute of the examined lupine. The findings in Table (6) demonstrated that in both seasons, increasing the density of lupine plants with sugar beet from 12.5 to 25.0 to 37.5% of their pure stand resulted in a decrease in lupine plant height. The observed outcome could potentially be attributed to both intraspecific and interspecific competition for light between lupine and sugar beet plants. Comparable outcomes were attained by Mohammed (2014).

Results indicated that (100% sugar beet + 12.5% lupine) intercropping pattern recorded the highest value followed by (25.0 %+ 100%) and the lowest value was showed with (100% + 37.5%) in both seasons. All of the lupine yield components number of branches per plant, number of pods and pods per plant, number of seeds per plant, weight of pods and seeds per plant, and 100-seed weight are entirely correct. These findings could be the consequence of increasing intraspecific rivalry amongst lupine plants in addition to interspecific conflict between lupine plants and sugar beetroot for light, water, and nutrients, which could result in a rise in lupine plant densities from 12.5 to 25.0 up to 37.5%. These outcomes lined up with as indicated in Table (6), increasing lupine plant densities in both seasons resulted in a considerable increase in seed yield/fed of lupine. In both seasons, the trend of plant height was consistent with the seed yield/fed. The treatment that produced the highest lupine intercropped yield was 100% sugar beet + 37.5% lupine in both seasons. In the first and second seasons, respectively, the seed yield was only 38.62 % and 40% of the pure stand yield, while 100% + 25.0% produced 30.34 % and 29.93 % of the seed yield, and 100% + 12.5% produced the lowest seed yield, 16.55 % and 17.32% of the pure stand yield. Results reported by Mohammed *et al.* (2005), Ibrahim and El. Abbas (2010), Mohammed and Abd El Zaher (2013) and Sheha *et al.*, (2017) are consistent with these results.

Table (5). Effect of sowing date and plant density of lupine on lupine characters in 2020/2021 and 2021/2022 seasons.

Characters / Treatments	Plant height (cm)	Number of branches/ plant	Number of pods/ plant	Number of seeds/ plant	Weight of pods/ plant	Weight of seeds/ plant	Weight of 100 seed	Seed yield (ard./fed)
2020/2021								
D_1	157.00	3.81	28.10	95.30	48.45	37.27	37.67	2.41
D_2	159.00	4.22	29.10	111.30	57.79	46.23	39.89	2.65
D_3	97.33	2.22	21.20	65.60	38.88	27.84	28.78	1.14
LSD at 5 %	0.87	0.03	1.31	11.61	6.93	5.50	0.69	0.04
Solid	158.00	4.00	34.00	115.00	57.00	46.00	39.00	7.25
2021/2022								
D_1	159.00	4.01	29.84	97.51	51.25	36.95	37.83	2.64
D_2	161.00	4.42	31.70	112.03	60.79	45.11	40.03	2.91
D_3	101.33	2.62	22.54	66.22	39.95	28.68	30.67	1.30
LSD at 5 %	0.87	0.03	1.10	7.52	6.93	3.37	0.68	0.04
Solid	160.00	4.30	35.80	125.00	70.00	55.00	41.00	7.85

D1: Sowing lupine and sugar beet simultaneously

D2: lupine sowing 21 days after sugar beet (at first irrigation).

D3: lupine sowing 42 days after sugar beet (at second irrigation).

Table (6). Effect of plant density of lupine on lupine characters in 2020/2021and 2021/2022 seasons.

Characters / Treatments	Plant height (cm)	Number of branches/ plant	Number of pods/ plant	Number of seeds/ plant	Weight of pods/plant	Weight of seeds/ plant	Weight of 100 seed	Seed yield (ard./fed)
2020/2021								
P_1	140.22	3.53	28.80	102.10	58.05	44.85	36.66	1.20
P_2	139.11	3.43	26.50	95.70	49.93	38.55	35.56	2.20
P_3	134.00	3.29	23.10	74.40	37.14	27.95	34.11	2.80
LSD at 5 %	1.16	0.08	0.48	10.03	5.08	3.93	0.66	0.05
Solid	158.50	4.00	34.00	115.00	57.00	46.00	39.00	7.25
2021/2022								
P_1	142.89	3.80	30.39	99.17	61.78	42.68	37.65	1.36
P_2	141.78	3.70	28.37	98.82	51.67	39.27	36.15	2.35
P_3	136.67	3.56	25.33	77.78	38.54	28.78	34.73	3.14
LSD at 5 %	1.16	0.08	0.66	4.51	5.08	3.65	1.01	0.08
Solid	160	4.30	35.80	125.00	70.00	55.55	41.00	7.85

P1: Lupine plant density =12.5% of its pure stand.
P2: lupine plant density =25% of its pure stand.
P3: lupine plant density =37.5% of its pure stand.

3-Interaction effects

Data presented in Table (7) indicated that no. of pods/ plant, weight of pods / plant weight of seeds / plant and seed yield / fed of lupine crop were significantly affected by the interaction between two factors under study in both seasons and no. of seeds / plant in one season. On the other hand, plant height, no of branches / plant and 100-seed weight were not significantly affected in both seasons. Data revealed that D2 × P1 recorded the highest values for all characters of lupine except, seed yield / fed which showed with D2XP3 in both seasons. On the other hand, D3× P3 recorded the lowest values of lupine characters in both seasons. So, lupine planting after 21 days from sugar beet sowing date October 27th and 25th in the first and second seasons, respectively was coincided with the optimum sowing late of lupine (November 17th and 15th in the first and second season, respectively and 37.5%. lupine plant density with sugar beet to obtain the best seed yield/fed. Similar results were showed with Ibrahim and El. Abbas (2010).

III- Competitive relationships and yield advantages of intercropping:

1- Land equivalent Ratio (LER):

Table (8) Results in showed that intercropping lupine and sugar beet increased land consumption in all systems in both seasons when both species were planted in combination with lupine plant density and its sowing dates with sugar beet. The first season saw increases in land utilization of 1.09 to 1.39%, while the second season saw increases in land usage of 1.11 to1. 37%. When lupine plants were planted at the second planting date (D2 × P3) in both seasons, the treatment that produced the maximum value for land usage was 37.5% of the plant density; in the first season, this was 39%, and in the second, 37%. Conversely, the lowest land productivity value was associated with a 12.5% lupine plant density and occurred concurrently with sugar beet production in both seasons (LER; first season values were 1.09 and second season values were 1.11%, respectively). Comparable outcomes were attained by Abd El-All (2002), El-Shaikh and Bekheet (2004) and Mohammed *et al.* (2005).

2- Land equivalent coefficient (LEC)

Data in Table (8) revealed that yield advantages which increased than 25% were achieved with Four treatments only in both seasons. The treatments, which achieved yield advantages were DI × P2, D1 × P3, D2 × P2 and D2 × P3. Similar results were obtained with those obtained by Abd El-All (2002) and El-Shaikh and Bekheet (2004).

3- Aggressivity (Ag)

Table (8) results indicated that whereas sugar beet root was the dominating crop in two and three treatments during the first and second seasons, respectively, lupine crop was the main component crop in six treatments during the first season and seven treatments during the second season.

Table (7). Effect of the interaction between sowing date and plant density of lupine on some lupine characters in 2020/2021 and 2021/2022 seasons.

Treatments \ Characters		Plant height (cm)	Number of branches/ plant	Number of pods/ plant	Number of seeds/ plant	Weight of pods/ plant	Weight of seeds/ plant	Weight of 100 seed	Seed yield (ard./fed)
2020/2021									
D_1	P_1	159.67	3.93	31.00	104.40	58.33	44.87	39.33	1.33
	P_2	158.33	3.83	28.30	103.40	50.15	38.58	37.33	2.45
	P_3	153.00	3.67	25.00	78.10	36.86	28.36	36.33	3.44
D_2	P_1	161.67	4.33	32.30	123.80	70.24	56.19	41.00	1.38
	P_2	160.33	4.23	29.00	117.70	58.83	47.07	40.00	3.02
	P_3	155.00	4.10	26.00	92.50	44.30	35.43	38.67	3.55
D_3	P_1	99.33	2.33	23.20	78.00	45.57	33.48	29.67	0.87
	P_2	98.67	2.23	22.20	65.90	40.81	30.01	29.33	1.13
	P_3	94.00	2.10	18.30	52.80	30.27	20.05	27.33	1.42
LSD at 5 %		NS	NS	0.830	NS	NS	NS	NS	0.08
Solid		158.50	4.00	34.00	115.00	57.00	46.00	39.00	7.25
2021/2022									
D_1	P_1	161.67	4.13	32.70	104.37	61.13	42.10	39.01	1.50
	P_2	160.33	4.03	30.03	105.10	52.95	39.48	37.84	2.58
	P_3	155.00	3.87	26.80	83.07	39.66	29.26	36.64	3.83
D_2	P_1	163.67	4.53	34.30	121.15	73.24	50.96	41.27	1.55
	P_2	162.33	4.43	31.90	121.48	61.83	47.83	40.27	3.29
	P_3	157.00	4.30	28.90	93.46	47.30	36.53	38.57	3.90
D_3	P_1	103.33	2.73	24.17	71.98	50.97	34.98	32.67	1.03
	P_2	102.67	2.63	23.17	69.87	40.21	30.51	30.33	1.19
	P_3	98.00	2.50	20.30	56.80	28.67	20.55	29.00	1.68
LSD at 5 %		NS	NS	NS	NS	NS	NS	NS	0.13
Solid		160.00	4.30	35.80	125.00	70.00	55.00	41.00	7.85

D1: sowing lupine and sugar beet simultaneously
D2: lupine sowing 21 days after sugar beet (at first irrigation).
D3: lupine sowing 42 days after sugar beet (at second irrigation).
P1: lupine plant density =12.5% of its pure stand.
P2: lupine plant density =25% of its pure stand.
P3: lupine plant density =37.5% of its pure stand.

Table (8). Competitive relationships and yield advantages as effected by sowing date and lupine plant density in 2020/2022 and 2021/2022 seasons

Characters / Treatments		Land equivalent Ratio (LER)			Land equivalent coefficient (LEC)	Relative Crowding Coefficient (RCC)			Aggressivity (Ag)	
		sugar beet (Lm)	lupine (Ls)	LER= Lm+Ls	LEC=Lm xLs	Km	Ks	K=Km xKs	A ugar beet	A lupine
2020 /2021										
D1	P_1	0.91	0.18	1.09	0.17	1.28	1.80	2.31	-0.63	+0.63
	P_2	0.91	0.34	1.24	0.31	2.40	2.04	4.90	-0.56	+0.56
	P_3	0.87	0.47	1.35	0.42	2.61	2.41	6.28	-0.54	+0.54
D2	P_1	0.98	0.19	1.17	0.19	5.12	1.88	9.64	-0.62	+0.62
	P_2	0.96	0.42	1.38	0.40	5.74	2.86	16.42	-0.89	+0.89
	P_3	0.90	0.49	1.39	0.44	3.56	2.56	9.11	-0.55	+0.55
D3	P_1	0.99	0.12	1.11	0.12	11.84	1.09	12.96	+0.03	-0.03
	P_2	0.96	0.16	1.12	0.15	6.65	0.74	4.91	+0.43	-0.43
	P_3	0.93	0.20	1.13	0.18	5.02	0.65	3.25	+0.56	-0.56
2021/2022										
D1	P_1	0.92	0.19	1.11	0.18	1.40	1.89	2.64	-0.69	+0.69
	P_2	0.88	0.33	1.21	0.29	1.83	1.96	3.58	-0.54	+0.54
	P_3	0.84	0.49	1.33	0.41	2.05	2.54	5.20	-0.63	+0.63
D2	P_1	0.97	0.20	1.17	0.19	4.39	1.97	8.63	-0.68	+0.68
	P_2	0.92	0.42	1.34	0.39	3.00	2.88	8.64	-0.94	+0.94
	P_3	0.88	0.50	1.37	0.44	2.66	2.63	6.99	-0.61	+0.61
D3	P_1	0.99	0.13	1.13	0.13	21.80	1.21	26.27	-0.06	+0.06
	P_2	0.96	0.15	1.11	0.15	5.58	0.71	3.99	+0.44	-0.44
	P_3	0.93	0.21	1.15	0.20	5.20	0.72	3.76	+0.50	-0.50

D1: sowing lupine and sugar beet simultaneously
D2: lupine sowing 21 days after sugar beet (at first irrigation
D3: lupine sowing 42 days after sugar beet (at second irrigation).
P1: lupine plant density =12.5% of its pure stand.
P2: lupine plant density =25% of its pure stand.
P3: lupine plant density =37.5% of its pure stand.

4- Relative Crowding coefficient (RCC)

Results in Table (8) indicated that all treatments under study were achieved yield advantages in both seasons. The treatments of D2 × P2 and D3 × P1 achieved the highest values of yield advantages in the first and second seasons, respectively and; R CC: were 16.42 and 26.27 in the first and second seasons, respectively. The lowest values of RCC were 2.31 and 2.64 in the first and second seasons, respectively which recorded by the treatment of D1 × P1 in both seasons.

5- Net return

Data presented in Table (9) indicated that net return was increased in all treatments compared sugar beet alone in both seasons. Data illustrated that sugar beet economic return was more contributed compared with lupine in all treatments in both seasons. This may be due to sugar beet plant density (100%) whereas, lupine plant densities were ranged between 12.5 and 37.5% of its pure stand. Also data revealed that D2 × P3 recorded the highest values (14870 and 18598 LE) compared with sugar beet alone (9166 and 13016 LE) in the first and second seasons respectively. The increase of net return was (5704 and 5582 LE) for D2 × P3 treatment compared with sugar beet net return in the first and second seasons, respectively.

Table (9). Effect of sowing date and lupine plant density Land equivalent Ratio (LER) and economic return of sugar beet and lupine association in 2020/2021 and 2021 /2022seasons.

Characters / Treatments		Economic return/fad (L.E)									
		2020/2021					2021/2022				
		Sugar beet income	Lupine income	Total income (L.E)	Total cost (L.E)	Net return (L.E)	Sugar beet income	Lupine income	Total income (L.E)	Total cost (L.E)	Net return (L.E)
D1	P1	16188	2993	19180	9006	10174	19984	3375	23359	9170	14189
	P2	16094	5513	21606	9412	12194	19150	5805	24955	9590	15365
	P3	15531	7740	23271	9818	13453	18391	8618	27008	10010	16998
D2	P1	17344	3105	20449	9006	11443	21169	3488	24656	9170	15486
	P2	17025	6795	23820	9412	14408	20091	7403	27493	9590	17903
	P3	16700	7988	24688	9818	14870	19833	8775	28608	10010	18598
D3	P1	17581	1958	19539	9006	10533	21647	2318	23964	9170	14794
	P2	17125	2543	19668	9412	10256	20835	2678	23512	9590	13922
	P3	16531	3195	19726	9818	9908	20303	3780	24083	10010	14073
Solid sugar beet		17769	0.00	17769	8603	9166	21768	0.00	21768	8752	13016
Solid lupine		0.00	16313	16313	3250	13063	0.00	17663	17663	3360	14303

D1: sowing lupine and sugar beet simultaneously

D2: lupine sowing 21 days after sugar beet (at first irrigation).

D3: lupine sowing 42 days after sugar beet (at second irrigation).

P1: lupine plant density =12.5% of its pure stand.

P2: lupine plant density =25% of its pure stand.

P3: lupine plant density =37.5% of its pure stand.

Conclusion

It can be concluded that, under Menoufia Government conditions, the maximum land equivalent ratio and economic return were achieved by intercropping of 100% sugar beet + 37.5% lupine after 21 days of planting sugar beet.

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تأثير مواعيد الزراعة والكثافة النباتية للترمس المحمل مع بنجر السكر على الانتاجية والعائد الاقتصادي

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الملخص العربي

أقيمت تجربة حقلية بمحطة بحوث سرس الليان بمحافظة المنوفية وذلك خلال موسمي ٢٠٢٠ /٢٠٢١و٢٠٢١/٢٠٢٢ لدراسة تأثير ثلاث مواعيد زراعية للترمس (الزراعة مع بنجر السكرD1 ، بعد ٢١ يوم D2 وبعد ٤٢ يوم D3 من زراعة بنجر السكر على الترتيب) وثلاث كثافات نباتية للترمس (١٢.٥% P1، ٢٥% P2، ٣٧.٥% P3 من الزراعة المنفردة للترمس) على انتاجية كلا من بنجر السكر والترمس المحملين معا وكان التصميم المستخدم تصميم القطع المنشقة مرة واحدة في ثلاث مكررات، حيث وضعت مواعيد زراعة الترمس الثلاثة فى القطع الرئيسية وتم وضع الثلاثة كثافات النباتية للترمس في القطع المنشقة.

وكانت أهم النتائج المتحصل عليها كالآتي: -

١- سجلت اعلي لصفات بنجر السكر عند تحميل الترمس مع بنجر السكر بعد ٤٢ يوم (D3)، وعلى الجانب الآخر أعطت كل صفات الترمس أعلى القيم مع (D2) خلال موسمي الزراعة.

٢ - ادي تحميل ١٢.٥% من الكثافة النباتية للترمس مع ١٠٠% بنجر السكر (P1) علي الحصول علي أعلى القيم لكل صفات بنجر السكر عدا صفتي النسبة المئوية لكل من المواد الصلبة الكلية وللسكروز خلال موسمي الزراعة، وكذا صفات الترمس عدا صفة محصول البذور/الفدان والتي سجلت أعلى القيم مع (P3) خلال موسمي الزراعة.

٣- تأثير محصولى بنجر السكر والترمس وكذا الصفات الكيميائية لبنجر السكر تأثرت معنويا بالتفاعل بين D x P في كلا الموسمين. سجلت المعاملة D2 x P3 أعلى القيم لكلا من LER بنسبة ٣٩ و٣٧ % في الموسم الاول والثاني على التوالي. بينما زاد العائد الاقتصادي بمقدار ١٤٨٧٠ ، ١٨٥٩٨ جنيه مقارنة بمحصول بنجر السكر المنفرد خلال الموسم الأول والثاني على التوالي.

الاستنتاج: للحصول على أفضل معامل لاستغلال الأرض وعائد اقتصادي للمزارع يوصي بتحميل الترمس بنسبة ٣٧.٥% من الكثافة المنفردة للترمس مع ١٠٠% لبنجر السكر بعد ٢١ يوم من زراعة بنجر السكر وذلك تحت الظروف البيئية لمنطقة سرس الليان – محافظة المنوفية