RESULTS AND DISCUSSION

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Studied parameters were estimated for each of the grown fodder components of the proposed agroforestry plantations. It should be pointed out that results and discussion will handle the effect of each of the applied factors on the studied parameter averaged over the other factors.

Homogenity test proved the validity of the combined analysis. Accordingly, results and discussion will be focused on the combined analysis and will be referred to the individual seasons wherever necessary.

Results and discussion will be presented according to following topics in chronological order:

1. Production and morphological characteristics.

<u>Prennial fodder shrubs</u>:

1.1. *Acacia saligna*.

1.1.1. Fresh and dry fodder yield.

1.1.2. Height of shrubs.

1.1.3. Number of branches.

1.1.4. Stem diameter.

1.1.5. Crown volume.

1.2. *Medicago arborea*:

The inter planted fodder shrubs at various population densities per unit area of land.

1.2.1. Fresh and dry fodder yield.

1.2.2. Height of shrubs.

1.2.3. Number of branches.

1.2.4. Crown volume.

1.3. The interplanted herbaceous fodder crops (barley and vicia).

1.3.1. Fresh and dry fodder yield.

1.3.2. Height of plants.

1.3.3. Number of barley tillers and vicia branches/squar meter.

2. Chemical constituents of the fodder components of the grown, agroforestory plantations (on dry matter basis).

2.1. Phosphorus content (P).

2.2. Carbohydrate content (NFE).

2.3. Crude protein content (CP).

2.4. Crude fiber content (CF).

2.5. Ether extract (EE).

3. Nutritive potentialities.

3.1. Total freh and dry fodder production per unit area of land for the grown plantations.

3.2. Total digestible nutrient (TDN) for each fodder component of the grown plantations.

3.3. Average of the total digestible nutrient for all of the components of the whole grown agroforestry plantation systems.

1. Production and morphological characteristics:

The behaviour of each component of the grown agroforetery plantation will be discussed as follows:

1.1. *Acacia saligna*:

1.1.1. Fresh and dry fodder yield:

Fresh and dry fodder yields of acacia were significantly affected by the applied population denities of the interplanted *Medicago arborea* (*M. arborea*) shrubs as shown in Tables (3 and 4).

From the combined analysis, it was clear that fresh and dry fodder yields of acacia were simultaneously decreased as the interplanted population densities of *M. arborea* shrubs increased.

Productivity of acacia was 215.0, 199.0, 165.0 and 154.0 kg/feddan of fresh fodder yield (Table 3) and 71.0, 67.0, 57.0 and 55.0 kg/feddan of dry yield (Table 4) at the respective population densities of interplanted 100, 200, 300 and 400 *M. arborea* shrubs per feddan.

Such reducion in fresh fodder yield of acacia was significant with a differences of 23 and 28% when comparing

Table (3) : Fresh fodder yield of acacia (Kg/fed.) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A +300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	134	158	146	155	202	179	128	115	122	116	119	118	133	149	141
With	177	357	267	184	222	203	192	153	173	154	153	154	177	221	199
Mean	156	258	207	170	212	191	160	134	148	135	136	136	155	185	170
L.S.D. at 5% for :	Density (D) = 19 D x F = 21			Species (S) = NS D x S x F = 29			Fertilizer (F) = 10								
	2nd season :														
Without	128	216	172	133	183	158	161	150	156	143	140	142	141	172	157
With	134	410	272	153	350	252	242	175	209	219	187	203	187	281	234
Mean	131	313	222	143	267	205	202	163	183	181	164	173	164	227	196
L.S.D. at 5% for :	D = NS D x S = 52			S = 26 S x F = 16			F = 11 D x S x F = 32								
	Combined (two seasons) :														
Without	131	187	159	144	193	169	145	133	139	130	130	130	138	161	150
With	156	384	270	169	286	228	217	164	191	186	170	178	182	250	316
Mean	144	286	215	157	240	199	181	149	165	158	150	154	160	206	183
L.S.D. at 5% for :	D = 27 D x S = 47			S = 24 D x F = 28			F = 14 S x F = 20			D x S x F = 40 Years = 19					

Table (4) : Dry yield of acacia (Kg/fed.) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	44	41	43	54	47	51	44	47	46	44	39	42	47	44	46
With	55	85	70	63	52	58	62	54	58	63	53	58	61	61	61
Mean	50	63	57	59	50	55	53	51	52	54	46	50	54	53	54
L.S.D. at 5% for :	Density (D) = NS			Species (S) = NS			Fertilizer (F) = 6.0								
2nd season :															
Without	46	66	56	64	72	68	48	56	52	46	51	49	51	61	56
With	67	158	113	87	90	89	72	68	70	68	70	69	74	97	86
Mean	57	112	85	76	81	79	60	62	61	57	61	59	63	79	71
L.S.D. at 5% for :	D = NS D x S = 24.8			S = 12.4 D x F = 15.6			F = 7.8 S x F = NS			D x S x F = 22					
Combined (two seasons) :															
Without	55	54	50	59	60	60	46	52	49	45	45	45	49	53	51
With	61	122	92	75	71	73	67	61	64	65	62	64	67	79	73
Mean	54	88	71	67	66	67	57	57	57	55	54	55	58	66	62
L.S.D. at 5% for :	D = 11.1 D x S = 12.3			S = 6.2 D x F = 13			F = 9.2 Years = 7.9			D x S x F = 18.4					

between the first with the third and the fourth population densities of the interplanted *M. arborea* shrubs (Table 3) being 20 and 23% for dry fodder yield (Table 4).

Similar trend was almost obtained for each of the two growing seasons as presented in the following chart:

Population of *M. arborea* (shrubs/fed.)	Acacia fodder production					
	1st year		2nd year		Combined	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
100	207	57	222	85	215	71
200	191	55	205	79	199	67
300	148	52	183	61	165	57
400	136	50	173	59	154	55
L.S.D. at 5%	19	NS	NS	NS	27	11.1

Such decrease in fresh and dry fodder yield of acacia by intensifying the population densities of the interplanted *M. arborea* shrubs could be due to its severe competition for light, water, nutrients and the other essential requirements for growth and production.

Regarding the effect of interplanted herbaceous fodder crops in the interspaces within the grown fodder shrubs, results showed significant higher fresh and dry fodder yield production of acacia when the interplanted herbaceous crop was vicia rather than barley. Combined analysis indicated a reduction of 29% and 14% in fresh and dry yields of acacia, respectively, when the interplanted herbaceous crop was barley as compared with vicia as seen from the following chart:

Acacia production	interplanted herbaceous fodder crops		Differences
	Barley	Vicia	
Fresh yield	160	206	29%
Dry yield	58	66	14%

This result could indicate that barley was more competative than vicia for the essential environmental requirements for growth and development. Also, the unique characteristics of vicia as a leguminous herbaceous crop in respect of its symbiotic natural nitrogen fixation and its postulated nature of growth are of more advantages for the interplanting aspect as compared with the cereal crop barley, which has high nitrogen demands and has an erect nature of growth. Moreover, the superiority of acacia fodder dry yield when interplanted with vicia rather than barley proved the less competitive effect of vicia for the essential elementsfor growth as compared with barley.

Unlikely, Shekhawat *et al.* (1988) reported that acacia fresh fodder yield was not affected by the interplanted crops. Moreover, the circumstances of such trials could vary widely than what is prevaling in Matruh desert.

It is also clear from the combined analysis (Tables 3 and 4) that the applied fertilization treatment of phosphorus + sulphur (300 kg calcium superphosphate, 15.5% P_2O_5 + 500 kg mineral sulphur per feddan), significantly increased fresh and dry fodder yield of acacia.

The obtained fresh fodder yield of acacia was almost doubled by the applied fertilization treatment (316 kg/feddan) as compared with the control (150 kg/feddan).

Averaged over the applied treatments, results behaved similarly with some difference in the obtained fresh and dry yield in the first growing year compared to the second one.

It looks to be true that the applied fertilization treatment (phosphorus + sulphur) enriched the phosphorus content of the soil by the applied amount of phosphorus and increased the availability of the already unavailable phosphorus content of the soil. This is through the effect of the applied sulphur in decreasing the soil pH.

Such decrease in pH release the other micronutrients to be available to the growing plants. This effect was noticed for either fresh or dry yield of acacia shrubs. Similar results were reported by Helal *et al.* (1987).

Among the researchers whom they proved the effect and the role of phosphorus in increasing the yield potentialities of acacia were Barrow (1977); Hingston (1982); Maltby (1983); Schonau (1984) and Jasper (1989).

On the other hand, Thomas (1981) and Maasdrop (1986) did not detect the role of phosphorus in increasing the growth and yield of acacia. This could be due to the different nature of the soil in respect of its physical and chemical characteristics and/or the prevailing environmental conditions.

In general, it should be noted that the differences in the environmental seasonal variation in the two growing years of 1991/92 and 1992/93 (Table 2) was reflected on the productivity of the components of the grown fodder plantations.

Also, it should be pointed out that the reduction in fodder yield of the grown fodder shrubs was not as severe as it was with the herbaceous shrubs due to the decrease in the preciptation in the second year as compared with the first one, in addition to the slight compensation of yield reduction for the perennial shrubs by its continiual accumulated growth. This is not the case for the herbaceous annual winter crop that was severly affected by the reduction in the preciptation of the second growing season as presented in Table (2).

Fresh and dry fodder yields of acacia were higher when the interplanted herbaceous crop was vicia rather than barley. This was due to the different nature of growth of vicia as a leguminous herbaceous crop and barley as a herbaceous cereal crop as previously mentioned.

The interaction effect of the applied three factors on the obtained fresh and dry fodder yield of acacia was significant (combined over the two years). Such result indicated that the highest fresh fodder (384 kg/feddan) and dry yield (122 kg/feddan) of acacia were obtained when the intensity of the interplanted *M. arborea* was 200 shrubs/feddan and the interplanted herbaceous crop was vicia, where the whole agroforestry plantation was fertilized with the applied fertilizer formula of phosphorus + sulphur.

Such result are confounding with the obtained results for each component of the grown plantation of the proposed agroforstery system. This is because it could be missleading to investigate the individual components of the proposed plantations. This is realy true since our ultimate target is the whole production of each set up of plantations a unique agroforestry system for better use of natural resources in better fodder production per unit area of land in a sustainable and environmentally accepted desert developmnt aspect.

Also, the interactions between the components of the grown plantations could be of great synergestic effect for enhancing growth rates and creating favourable microenvironment for the benifits of the whole fodder production of better quality per unit area of land.

Further results will be presented later on the total fresh and dry fodder productions and the total digestable nutrients (T.D.N.), for the grown plantations of the proposed agroforestry systems.

In concluson, increasing the population density of the interplanted *M. arborea* caused a continuous decrease in the fresh and dry fodder yields of acacia.

Such reduction in fresh and dry yield of acacia per unit area of land could be over compensated by the added up fodder production of the other components of the proposed plantations. This could be achieved from the intensification of the proposed plantations using the atmost interplantation of herbaceous fodder crops within the interspaces of an intensive interplantation of perennial fodder shrubs properly fertilized with phosphorus + sulphur.

1.1.2. **Height of acacia shrubs:**

Results in Table (5) did not show any significant effect for intensifying the interplanted *Medicago arborea* shrubs on the height of acacia shrubs. Also, the height of acacia shrubs was not affected by the interplanted herbaceous crops whether it was vicia or barley. This result could be attributed to the very early effect of the very young interplanted *M. arborea* on such character of acacia. Meanwhile, the interplanted herbaceous crops was not high enough to compete with height of the acacia shrubs.

However, it is obviously clear that the height of acacia shrubs was significantly affceted by the applied fertilization treatment of phosphorus + sulphur (Table 5). Such increase in the height of acacia shrubs was 11, 19 and 15 cm in the first season, second season and the combined analysis, respectively, as compared with the control treatment. Similar results were obtained by Messina and Barton (1985) for phosphorus and Draze *et al.* (1993) for sulphur on their effect in increasing the height of acacia shrubs.

This obtained effect of phosphorus + sulphur application on such calcareous soil in increasing the height of acacia shrubs as a growth factor is due to the availability of the required phosphorus and the other essential micronutrients

Table (5) : Height of acacia plants (cm) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	49	50	50	52	51	52	54	54	54	50	70	60	51	56	54
With	54	62	58	65	62	64	61	68	65	60	86	73	60	70	65
Mean	52	56	54	59	57	58	58	61	60	55	78	67	56	63	60
L.S.D. at 5% for :	Density (D) = NS			Species (S) = NS			Fertilizer (F) = 2.5								
2nd season :															
Without	75	66	71	59	71	65	83	76	80	73	83	78	73	74	74
With	85	87	86	94	92	93	94	93	94	92	104	98	91	94	93
Mean	80	77	79	77	82	80	89	85	87	83	94	88	82	84	84
L.S.D. at 5% for :	D = NS D x F = 5.0			S = NS			F = 2.5								
Combined (two seasons) :															
Without	62	58	60	56	61	59	69	65	67	62	76	69	62	65	64
With	69	75	72	80	77	79	78	81	80	76	95	86	76	82	79
Mean	66	67	66	68	69	69	74	73	74	69	86	78	69	74	72
L.S.D. at 5% for :	D = NS D x F = 6.3			S = NS Years = 8.2			F = 3.2			D x S x F = 9.1					

and due to the effect of sulphur in decreasing the high pH of such calcareous soil.

In conclusion, the tallest acacia plants (95 cm) were produced when the interplanted population density of *M. arborea* was 400 shrubs/feddan interspaced with the herbaceous fodder crop vicia fertilized with the applied amount of phosphorus + sulphur. This result was true since the interaction effect of the above 3 factors on the height of acacia plants was significant (Table 5).

1.1.3. <u>Number of branches</u>:

As it is clear from Table (6), neither the intensity of the interplanted *Medicago arborea* nor the species of the interplanted herbaceous fodder crops affected the number of branches per shrub of acacia. This result is more likely reasonable since such character is not easily affected by applied factors under study especially at the very early stages of growth.

Combined analysis showed 38% increase in the number of branches/shrub of acacia as a result of the applied fertilization treatment where the number of branches/shrub was 5.5 vrs 4 for the control.

Similar results for the effect of phosphorus in increasing number of branches of acacia plants were recorded by Yadav (1980) and for sulphur in increasing the

Table (6) : Number of acacia branches as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	3	3	3	3	3	3	3	4	3.5	4	4	4	3	3.5	3
With	4	5	4.5	5	4	4.5	4	5	4.5	5	7	6	4.5	5	5
M e a n	3.5	4	4	4	3.5	4	3.5	4.5	4	4.5	5.5	5	4	4	4
L.S.D. at 5% for :	Density (D) = NS			Species (S) = NS			Fertilizer (F) = 0.9								
	2nd season :														
Without	3	5	4	4	4	4	4	6	5	4	5	4.5	4	5	4.5
With	4	6	5	6	6	6	5	8	6.5	7	8	7.5	5.5	7	6
M e a n	3.5	5.5	4.5	5	5	5	4.5	7	6	5.5	6.5	6	5	6	5.5
L.S.D. at 5% for :	D = NS			S = NS			F = 0.7								
	Combined (two seasons) :														
Without	3	4	3.5	3.5	3.5	3.5	3.5	5	4	4	4.5	4	3.5	4	4
With	4	5.5	5	5.5	5	5	4.5	6.5	5.5	6	7.5	7	5	6	5.5
M e a n	3.5	5	4	4.5	4	4	4	6	5	5	6	5.5	4	5	5
L.S.D. at 5% for :	D = NS Years = 0.7			S = 0.8			F = 0.7								

magnitudes of the same character of acacia were recorded by Draz *et al.* (1993).

In conclusion, the effect of applied phosphorus + sulphur in increasing the number of branches of acacia vegetative growth component is very well accepted because of the well known effect of phosphorus and sulphur in improving the calcareous physical and chemical soil characteristics for the sake of plant growth and development.

1.1.4. <u>Stem diameter</u>:

Stem diameter of acacia shrubs was not affected by the increase of the applied population densities of the interplanted *M. arborea* shrubs (Table 7).

Acacia stem diameter was significantly increased when the interplanted herbaceous crop was barley rather than vicia. This indicated the more competation of barley as compared with vicia for some of the essential requirements for growth. This was clear from the combined analysis and the individual growing years as well.

Also, the applied phosphorus + sulphur treatment produced significantly thicker stems (1.70 cm) of acacia plants as compared with the untreated shrubs (1.35 cm). Such results were true from the combined analysis and the individual growing years as well. Meanwhile, Mahmood *et al.*

Table (7) : Stem diameter of acacia (cm) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	1.31	1.23	**1.27**	1.04	1.37	**1.21**	1.11	1.23	**1.17**	0.81	1.12	**0.97**	1.07	1.24	**1.16**
With	1.46	1.54	**1.50**	1.34	1.53	**1.44**	1.68	1.62	**1.65**	1.20	1.46	**1.33**	1.42	1.54	**1.48**
Mean	**1.39**	**1.39**	1.39	**1.19**	**1.45**	1.33	**1.40**	**1.43**	1.41	**1.01**	**1.29**	1.15	**1.25**	**1.39**	1.32
L.S.D. at 5% for :	Density (D) = NS			Species (S) = 0.08			Fertilizer (F) = 0.12								
2nd season :															
Without	1.64	1.79	**1.72**	1.37	1.71	**1.54**	1.41	1.47	**1.44**	1.47	1.50	**1.49**	1.47	1.62	**1.55**
With	1.93	1.93	**1.93**	1.75	2.17	**1.96**	1.86	1.84	**1.85**	1.80	2.07	**1.94**	1.84	2.00	**1.92**
Mean	**1.79**	**1.86**	1.83	**1.56**	**1.94**	1.75	**1.64**	**1.66**	1.65	**1.64**	**1.79**	1.72	**1.66**	**1.81**	1.74
L.S.D. at 5% for :	D = NS			S = 0.10			F = 0.11								
Combined (two seasons) :															
Without	1.47	1.50	**1.49**	1.20	1.54	**1.37**	1.26	1.35	**1.31**	1.14	1.31	**1.23**	1.27	1.43	**1.35**
With	1.70	1.74	**1.72**	1.55	1.85	**1.70**	1.77	1.73	**1.75**	1.50	1.77	**1.64**	1.63	1.77	**1.70**
Mean	**1.59**	**1.62**	1.61	**1.38**	**1.70**	1.54	**1.52**	**1.54**	1.53	**1.32**	**1.54**	1.44	**1.45**	**1.60**	1.53
L.S.D. at 5% for :	D = NS Years = 0.25			S = 0.09			F = 0.15								

(1980) recorded similar results for phosphorus effect on the stem diameter of acacia shrubs.

No interaction effect between any the applied factors on this particular studied character was detected (Table 7).

1.1.5. Crown volume:

Data in Table (8) showed the effect of the applied factors on the crown volume of acacia shrubs.

Crown volume of acacia increased as the interplanted *M. arborea* population densities per unit area of land increased. This increase was significant when comparing between the effect of first with the third, and the fourth densities (combined analysis, Table 8). A similar trend was obtained in the two growing years with significant difference in the first one. Such result was true since the growth was somewhat slow in the first year. Whereas, in the second year the effect of population densities of the interplanted *M. arborea* started to affect the crown volume of acacia shurbs through the accumlated growth of such perennial shrubs.

Also, it should be pointed out that the increase in crown volume of acacia due to the increase in population density of the interplanted *M. arborea* was more likely due to the space competition of *M. arborea* for the essential

Table (8) : Crown volume of acacia (m^3) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	3.4	5.4	4.4	2.3	4.7	3.5	4.0	3.2	3.6	5.0	3.4	4.2	3.7	4.2	4
With	4.2	2.3	3.3	3.4	6.0	4.7	4.1	7.1	5.6	6.8	13.3	10.1	4.6	7.2	5.9
Mean	3.8	3.9	3.9	2.9	5.4	4.1	4.1	5.2	4.6	5.9	8.4	7.2	4.2	5.7	5
L.S.D. at 5% for :	Density (D) = NS			Species (S) = NS			Fertilizer (F) = 1.8								
	2nd season :														
Without	10.3	3.8	7.1	3.3	6.0	4.7	10.9	8.8	9.9	8.4	8.2	8.3	8.2	6.7	7.5
With	13.1	4.8	9	6.8	24.2	15.5	16.4	11.3	13.9	18.5	12.2	15.4	13.7	13.1	13.4
Mean	11.7	4.3	8.1	5.1	15.1	10.1	13.7	10.1	11.9	13.5	10.2	11.9	11	9.9	10.5
L.S.D. at 5% for :	D = 2.9 D x S = 2.0			S = 1.0 D x F = 1.8			F = 0.9			D x S x F = 2.6					
	Combined (two seasons) :														
Without	6.9	4.6	5.8	2.8	5.4	4.1	7.5	6	6.8	6.7	5.8	6.3	6	5.5	5.8
With	8.7	3.6	6.2	5.1	15.1	10.1	10.3	9.2	9.8	12.7	12.8	12.8	9.2	10.2	9.7
Mean	7.8	4.1	6	4	10.3	7.1	8.9	7.6	8.3	9.7	9.3	9.6	7.6	7.9	7.8
L.S.D. at 5% for :	D = 1.8 D x S = 2			S = NS S x F = 1.8			F = 1.3 Years = 2.6			D x S x F = 3.7					

growth requirements which forced the acacia shrubs to grow more vertically. This could cause the increase in its crown volume.

Results also showed that the interplanted herbaceous species did not affect the crown volume of acacia shrubs. In other words, crown volume of acacia shrubs was not affected whether the interplanted herbaceous crops was vicia or barley (averaged over the two years).

Phosphorus + sulphur application to the soil significantly increased the crown volume of acacia shrubs. Combined analysis showed a significant increase in this parameter with 67% compared to the control treatment. Crown volume of acacia was 5.9, 13.4 and 9.7 cubic meters for the fertilizer treated plots compared with 4.0, 7.5 and 5.8 cubic meter for the respective untreated plots of the respective first year, second year, and the combined analysis. The obtained increase in crown volume of acacia due to the applied fertilizer application was a result of the presence and the availability of phosphorus and the other essential micronutrients which combined with the decrease in pH value of the calcareous soil of Matruh. Similar results were obtained by Seif *et al.* (1990).

The interaction effect over the two seasons of the applied population densities of the interplanted *M. arborea* x the interplanted herbaceous crops x the applied fertilizer treatment on the crown volume of acacia was significant (Table 8).

This interaction showed that the greatest crown volume of acacia shrubs (15.1 cubic meter), was obtained at 400 shrubs/feddan of *M. arborea* interplanted with vicia rather than barley and fertilized with the applied phosphorus + sulphur treatment.

Regarding the studied morphological characteristics of acacia shrubs as affected by the applied treatments, it could be generally concluded that:

1. Increasing population densities of the interplanted *M. arborea* significantly increased number of branches and the crown volume per shrub, but significantly decreased stem diameter of the grown shrubs, whereas, the heights of shrubs differed insignificantly.

2. When the interplanted herbaceous crop was vicia as compared with barley, number of branches and stem diameter of acacia shrubs were significantly increased, whereas, height of shrubs was increased insignificantly and crown volume was significantly decreased.

3. The applied fertilization formula of phosphorus + sulphur caused significant increase in all of the studied morphological characteristics of acacia plants (height of plant, number of branches, stem diameter and crown volume).

1.1. *Medicago arborea*:

1.1.1. Fresh and dry fodder yield:

As the population densities of the interplanted *M. arborea* increased from 100 up to 400 shrubs/feddan, fresh and dry fodder yields of such shrubs were significantly increased (Tables 9 and 10). This trend was noticed from the combined analysis as well as the first and second growing seasons.

Fresh and dry fodder yield of *M. arborea* as affected by its applied population densities could be summarized in the following chart:

Population of *M. arborea* (shrubs/fed.)	*M. arborea* production					
	1st year		2nd year		Combined	
	Fresh	Dry	Fresh	Dry	Fresh	Dry
100	28.8	6.4	40.5	11.8	34.7	9.1
200	46.8	10.4	62.6	19.4	54.7	15.0
300	48.6	10.8	81.3	26.9	65.0	18.9
400	55.9	13.0	91.0	31.3	76.0	22.8
L.S.D. at 5%	5.9	2.1	15.7	4.9	7.9	3.4

Table (9) : Fresh fodder yield of Medicago arborea(kg/f) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	11.2	28.7	20	19.5	35.2	27.4	36.8	50.1	43.5	38	46.4	42.2	26.4	40.1	33.3
With	25.8	49.3	37.6	58.9	73.3	66.1	37.9	69.2	53.4	43	96.2	69.6	41.4	72.0	56.3
Mean	18.5	38.9	28.8	39.2	54.3	46.8	37.4	59.7	48.6	40.5	71.3	55.9	33.9	55.1	45
L.S.D. at 5% for :	Density (D) = 9.2 D x F = 5.4			Species (S) = 6.9 S x F = 3.8			Fertilizer (F) = 2.7			D x S x F = 7.7					
2nd season :															
Without	21.3	45.7	33.5	44.0	46.7	45.4	41.0	87	64	84	72	78	47.6	62.9	55.3
With	33.7	61.0	47.4	71.3	88.0	79.7	82.0	115	98.5	98	136	117	71.3	100	85.7
Mean	27.5	53.4	40.5	57.7	67.4	62.6	61.5	101	81.3	91	104	91	59.5	81.5	70.5
L.S.D. at 5% for :	D = 23.8			S = 15.7			F = 12.4								
Combined (two seasons) :															
Without	16.3	37.2	26.8	31.8	41	36.4	38.9	68.6	53.8	61	59.2	60.1	37.0	51.5	44.3
With	29.8	55.2	42.5	65.1	80.7	72.9	60	92.1	76.1	70.5	116.1	93.3	56.4	86	71.2
Mean	23.1	46.2	34.7	48.5	60.9	54.7	49.5	80.4	65	65.8	87.7	76.7	46.7	68.8	57.8
L.S.D. at 5% for :	D = 11.3 S x F = 11.7			S = 7.9 D x S x F = 23.3			F = 8.3 Years = 8.0								

Table (10) : Dry Yield of Medicoga arborea (kg/F) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	1.6	6.7	4.2	3.4	8.4	5.9	7.3	10.7	9	7.6	10.7	9.2	5	9.1	7.1
With	4.3	12.7	8.5	11.6	18	14.8	8.7	16.5	12.6	9.4	24.2	16.8	8.5	17.9	13.2
Mean	3.0	9.7	6.4	7.5	13.2	10.4	8	13.6	10.8	8.5	17.5	13.0	6.8	13.5	10.2
L.S.D. at 5% for :	Density (D) = 2.7 D x F = 1.4			Species (S) = 2.1 S x F = 1.0			Fertilizer (F) = 0.7			D x S x F = 2.0					
2nd season :															
Without	5.7	11.8	8.8	13.3	14.5	13.9	12	28.6	20.3	25.3	23.9	24.6	14.1	19.7	16.9
With	10	19.3	14.7	22.3	27.5	24.9	25.7	41	33.4	32	44	38	22.5	33	27.8
Mean	7.2	15.6	11.8	17.8	21	19.4	18.9	34.8	26.9	28.7	34	31.3	18.3	26.4	22.4
L.S.D. at 5% for :	D = 8.0			S = 4.9			F = 3.9								
Combined (two seasons) :															
Without	3.7	9.3	6.5	8.4	11.5	10	9.7	19.7	14.7	16.5	17.3	16.9	9.6	14.5	12
With	7.2	16	11.6	17	22.8	19.9	17.2	28.8	23	22.0	34.1	28.7	15.5	25.4	20.5
Mean	5.5	12.7	9.1	12.7	17.2	15.0	13.5	24.3	18.9	19.3	25.7	22.8	12.6	20	16.3
L.S.D. at 5% for :	D = 3.7 S x F = 3.5			S = 3.4 Years = 2.6			F = 2.5								

It should be noticed that by intensifying population densities of the interplanted *M. arborea* shrubs from 100 to 400 shrubs/feddan, the obtained fresh and dry fodder yield were doubled.

In more details, there was a significant increase in fresh fodder yield of *M. arborea* when compared between population densities of 100 and 200 shrubs/feddan. The relevant increase in fresh fodder yield was 58%, 63% and 55% from the combined analysis, first year and second year, respectively. The corresponding increase in fresh fodder yield of *M. arborea* due to the increase in population densities from 100 to 400 shrubs/feddan was 121%, 94% and 125%.

A similar trend was obtained for the dry fodder yield of the interplanted *M. arborea* shrubs. Doubling population densities of *M. arborea* from 100 to 200 shrubs/feddan caused an increase in its fodder yield by 65%, 63% and 64% as shown from the combined analysis, first year, and the second year, respectively. The relevant respective increase in dry fodder yield for the second increment of increase in *M. arborea* population densities (100 to 400 shrubs/feddan) was 151, 103 and 165%.

It should be pointed out that although the obtained dry fodder yield of the interplanted *M. arborea* shrubs was not high in the first two years of establishment, the obtained dry yield was significantly increased by increasing number of shrubs per unit area of land. This result is very well accepted since intensifying the number of shrubs per unit area of land exerted its impact on the obtained fresh and dry yield per unit area of land.

This also indicated the absence of competition between the intensive plantations of such shrubs especially at the early stages of establishment. Such effect will be under observations for further studies at later stages of accumulated growth.

Data in Tables (9 and 10) showed the effect of the interplanted herbaceous species on the fresh and dry fodder yield of *M. arborea*. Results could be summarized in the following chart:

M. arborea production in	interplanted herbaceous fodder crops			
	Barley		Vicia	
	Fresh	Dry	Fresh	Dry
	(kg/fed.)			
First year	33.9	6.8	56.1	13.5
Second year	59.5	18.3	81.5	26.4
Combined	46.7	12.6	68.8	20.0

Combined analysis showed that fresh and dry fodder yield of *M. arborea* was 46.7 and 12.6 kg/feddan, respectively when the interplanted herbaceous crop was barley. Whereas, the respective fresh and dry fodder yield was 68.8 and 20.0 kg/feddan when the interplanted herbaceous fodder crop was vicia. So, it could be concluded that there was an increase of 47% in fresh fodder yield and 59% in dry fodder yield if the interplanted herbaceous crop was vicia rather than barley. A similar trend was obtained in each of the two growing seasons.

It looks to be true that interplanting vicia, the herbaceous leguminous postulated crop with *M. arborea* created better microenvironmental and soil microfloral conditions for growth and yield of *M. arborea* shrubs as compared with barley.

The applied fertilization formula of phosphorus + sulphur caused significant increase in fresh and dry fodder yield of the interplanted *M. arborea* shrubs as compared with the control (71.2 vrs 44.3 and 20.5 vrs 12.0 kg/feddan) for the fertilized compared with the unfertilized treatment. This presented an increase of 61% and 71% in fresh and dry yield, respectively. Such results supported the concept of the applied phosphorus and sulphur in improving the physical and chemical properties of the calcareous soil of Matruh for better crop growth and production.

Along the same line, Goss and Stewart (1979) reported the beneficial effect of phosphorus on fodder yield productivity of *M. arborea*. Meanwhile, Rehm (1987) reported similar response to the application of phosphorus and sulphur.

It should be pointed out that fresh and dry fodder yield of the interplanted *M. arborea* was higher in the second year than the first year inspite of the lower preciptation in the second year than the first one. This is more likely due to the accumulated growth and development of such perennial shrubs. This was not the case for the interplanted annual (winter) herbaceous crops.

The highest population density of *M. arborea* (400 shrubs/feddan) interplanted with the herbaceous leguminous crop vicia and fertilized with phosphorus + sulphur formula produced the highest fresh fodder yield (116.1 kg/feddan) with a significant interaction effect for the above 3 factors (Table 9).

However, dry fodder yield of *M. arborea* was affected by the first order interaction (two factors) of the interplanted herbaceous crops and fertilization where the highest dry yield (25.4 kg/feddan) was obtained when the interplanted herbaceous crop was vicia and the fertilization treatment was applied with no interaction effect for the third applied factor (densities of the interplanted *M. arborea*) in such particular plantation as shown in Table (9).

In conclusion, the highest population density (400 shrubs per feddan) of *M. arborea* interplanted with the herbaceous leguminous crop vicia fertilized with phosphorus + sulphur treatment produced the highest fresh and dry fodder yield of the interplanted *M. arborea* shrubs. This could represent the best set up of the components for such particular agroforestry plantation system that fertilized properly with phosphorus + sulphur under the prevailing condition of Matrouh desert.

1.2.2. **Height of *Medicago arborea* shrubs**:

Heights of *M. arborea* shrubs were not affected by the applied different population densities of such shrubs. These results were true as shown from the combined analysis and the individual growing years as well (Table 11).

Moreover, the height of *Medicago arborea* shrubs was not affected wether the interplanted herbaceous fodder crop was barley or vicia.

It looks to be true that the competition between *M. arborea* shrubs of different population densities and/or the interplanted herbaceous fodder crop was not severe to affect the heights of *M. arborea* shrubs.

However, the heights of *M. arborea* shrubs were slightly increased as the fertilizer formula of phosphorus

Table (11) : Height of Medicago arborea shrubs (cm) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	12	10	**11**	14	12	**13**	13	15	**14**	16	16	**16**	14	13	**13.5**
With	16	16	**16**	14	14	**14**	14	16	**15**	21	17	**19**	16	16	**16.0**
Mean	**14**	**13**	14	**14**	**13**	14	**14**	**16**	15	**19**	**17**	18	**15**	**15**	15
L.S.D. at 5% for :	Density (D) = NS			Species (S) = NS			Fertilizer (F) = 2.1								
	2nd season :														
Without	18	18	**18**	16	19	**18**	20	21	**21**	19	19	**19**	18	19	**18.5**
With	21	23	**22**	17	25	**21**	22	25	**24**	29	29	**29**	22	26	**24**
Mean	**20**	**21**	20	**17**	**22**	20	**21**	**23**	23	**24**	**24**	24	**20**	**23**	22
L.S.D. at 5% for :	D = NS			S = NS			F = 0.8								
	Combined (two seasons) :														
Without	15	14	**15**	15	16	**16**	17	18	**18**	18	18	**18**	16	17	**17**
With	19	20	**20**	16	20	**18**	18	21	**20**	25	23	**24**	20	21	**21**
Mean	**17**	**17**	17	**16**	**18**	17	**18**	**20**	19	**22**	**21**	21	**18**	**19**	19
L.S.D. at 5% for :	D = NS Years = 3.0			S = NS			F = 1.6								

+ sulphur was applied. Heights of shrubs were increased from 17 to 21 cm with significant increase of 24%. This increase was 19 and 30% in the first and second individual year, respectively (Table 11).

It should be pointed out that the obtained increase in the heights of *M. arborea* shrubs due to the applied phosphorus + sulphur treatment is a result of improving the soil characteristics from the phsical and chemical points of view in respect of plant growth and development. This is true since the height of shrubs is one of the growth components of the areal parts of the interplanted *M. arborea* shrubs.

Such favourable effect of the applied fertilizer treatment was obviously reflected on the fresh and dry yield of such shrubs previously discussed (Tables 9 and 10).

Also, over the two growing years, there was a significant interaction effect between the applied population densities of the interplanted *M. arborea* shrubs x the applied fertilizer treatment on the height of such shrubs (Table 11). The tallest plants (25 cm) were obtained when the population density was 400 shrubs/feddan that were fertilized with the applied phosphorus + sulphur treatment.

1.2.3. <u>Number of branches/shrub</u>:

Over the two years, the applied different population densities of the interplanted *M. arborea* shrubs did not affect the number of branches per shrub as shown from table (12). The variations in the intensities of *M. arborea* shrubs per unit area of land was not enough to create environmental variations to affect this studied character.

However, number of branches/shrub of *M. arborea* was slightly but significantly affected by the different interplanted herbaceous fodder crop. Number of branches of *M. arborea* shrubs was 12 branches/shrub when the interplanted herbaceous crop was barley compared to 15 branches/shrub when it was vicia with a significant increase of 25% (from the combined analysis, Table 12). Similar trends were obtained in the first and the second year. Such result showed the lower competition for the essential environmental requirements for growth and its components when the interplanted herbaceous fodder crop was vicia as compared with barley due to their different nature of growth.

Results in Table (12) showed slight significant increase in the number of branches/shrub of *M. arborea* due to the applied fertilizer treatment of phosphorus + sulphur as compared with the unfertilized treatment. The respective number of branches/shrub was 12 against 15 with 25%

Table (12): Number of branches /shrub of Medicago arborea as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Interplanted herbecious forage crops: Barley (B) or Vicia (V)														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	5	8	**7**	7	8	**6**	8	8	**8**	8	10	**9**	7	9	**8**
With	8	9	**9**	7	10	**8**	9	11	**10**	10	11	**11**	9	10	**10**
Mean	**7**	**9**	8	**7**	**9**	7	**9**	**10**	9	**9**	**11**	10	**8**	**10**	9
L.S.D. at 5% for :	Density (D) = NS			Species (S) = 1.5			Fertilizer (F) = 0.9								
2nd season :															
Without	12	14	**13**	14	15	**15**	16	17	**17**	18	19	**19**	15	16	**16**
With	14	18	**16**	14	19	**16**	18	22	**20**	19	21	**20**	16	20	**18**
Mean	**13**	**16**	15	**14**	**17**	16	**17**	**20**	19	**19**	**20**	20	**16**	**18**	17
L.S.D. at 5% for :	D = NS			S = 2.0			F = 1.4								
Combined (two seasons) :															
Without	9	11	**10**	11	12	**12**	12	13	**13**	13	15	**14**	11	13	**12**
With	11	14	**13**	11	15	**13**	14	17	**15**	15	16	**16**	13	16	**15**
Mean	**10**	**13**	12	**11**	**14**	13	**13**	**15**	14	**14**	**16**	15	**12**	**15**	14
L.S.D. at 5% for :	D = NS Years = 3.0			S = 1.2			F = 1.1								

difference as it is clear from the combined analysis and the individual year as well.

These results again, prove the same consept of the effect of phosphorus and sulphur in improving the soil characteristics and its natural status in favour of plant growth and production.

No interaction effect of the studied factors on this studied character was detected either for the combined analysis or the individual growing season (Table 12).

1.2.3. Crown volume:

Crown volume of *M. arborea* was significantly increased as the population density of such interplanted shrubs increased from 100 up to 400 shrubs/feddan (Table 13). Results of the combined analysis showed that Crown volume of *M. arborea* shrubs was 0.31 cubic meter at 100 shrubs/feddan, whereas, it was 0.60 cubic meter at the population density of 400 shrubs/feddan with a 94% difference. Similar trend with different magnitudes were obtained in the first and second growing years. This result could be attributed to the expansion tendency of the vertical growth due to the increase in the compitition for light and the other essential requirements for growth at the higher population densities of the grown shrubs.

Table (13) : Grown volume of Medicago arborea shrubs (m^3) as affected by the interplanted fodder plantations and phosphorus+sulphur application •

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	0.06	0.08	**0.07**	0.12	0.13	**0.13**	0.17	0.13	**0.15**	0.36	0.30	**0.33**	0.18	0.16	**0.17**
With	0.14	0.23	**0.19**	0.15	0.22	**0.19**	0.20	0.32	**0.26**	0.54	0.37	**0.46**	0.26	0.29	**0.28**
Mean	**0.10**	**0.16**	0.13	**0.14**	**0.18**	0.16	**0.19**	**0.23**	0.21	**0.45**	**0.34**	0.40	**0.22**	**0.23**	0.23
L.S.D. at 5% for :	Density (D) = 0.05			Species (S) = NS			Fertilizer (F) = 0.03								
	2nd season :														
Without	0.3	0.5	**0.40**	0.4	0.5	**0.45**	0.5	0.5	**0.50**	0.5	0.7	**0.60**	0.43	0.55	**0.49**
With	0.5	0.6	**0.55**	0.5	0.7	**0.60**	0.6	0.9	**0.85**	0.9	1.1	**1.00**	0.63	0.83	**0.73**
Mean	**0.4**	**0.55**	0.48	**0.45**	**0.60**	0.53	**0.55**	**0.7**	0.68	**0.7**	**0.9**	0.80	**0.53**	**0.69**	0.73
L.S.D. at 5% for :	D = 0.18			S = 0.15			F = 0.10								
	Combined (two seasons) :														
Without	0.18	0.29	**0.24**	0.26	0.32	**0.29**	0.34	0.32	**0.33**	0.43	0.50	**0.47**	0.30	0.36	**0.33**
With	0.32	0.42	**0.37**	0.33	0.46	**0.40**	0.40	0.61	**0.51**	0.72	0.74	**0.73**	0.44	0.56	**0.50**
Mean	**0.25**	**0.36**	0.31	**0.30**	**0.39**	0.35	**0.37**	**0.47**	0.42	**0.58**	**0.62**	0.60	**0.37**	**0.46**	0.42
L.S.D. at 5% for :	D = 0.08 Years = 0.22			S = 0.08			F = 0.07								

Results over the two growing years in Table (13) showed that crown volume of *M. arborea* was higher (0.46 cubic meter) when interplanted with vicia than barley (0.37 cubic meter) when the difference in crown volume was 24%.

In other words, vicia stimulated the increase in crown volume of interplanted *M. arborea* shrubs as compared with barley as shown from the combined analysis and the second growing year, whereas, the difference did not reach the level of significance in the first year.

Data in Table (13) proved the idea of the effect of the applied phosphorus and sulphur in improving the physical and chemical characteristics of the calcareous soil in favour of plant growth. Such fertilizer treatment increased crown volume of *M. arborea* by 52% compared to the unfertilized shrubs. The respective crown volume was 0.33 vrs 0.50 cubic meter averaged over the two years. Similar trends were obtained in the first and second growing years.

No interaction effect between the applied factors on this studied character was obtained (Table 13).

It could be generally concluded that the applied factors affected the studied morphological characteristics of the interplanted *M. arborea* shrubs as follows:

- Crown volume of the interplanted *M. arborea* significantly increased as the population densities of such shrubs increased per unit area of land. Whereas, height of plants and number of branches per plant were increased with no significant difference as its population densities per unit area of land increased.

- Crown volume and number of branches of the interplanted *M. arborea* per plant were significantly increased when the interplanted herbaceous crop was vicia as compared with barley. A similar trend was obtained for the height of *M. arborea* plants with no significant difference.

- The applied fertilizer treatment of phosphorus + sulphur significantly increased the morphological characters of the interplanted *M. arborea* shrubs such as the height of plants, number of branches/shrub and crown volume.

1.3. The interplanted herbaceous fodder crops:

Barley (*Hordeum vulgare*) and Vicia (*Vicia monantha*):

1.3.1. Fresh and dry fodder yield of the interplanted herbaceous/fodder crops:

Data in Tables (14 and 15) presented the response of the obtained fresh and dry fodder yield of the two interplanted herbaceous crops to the grown agroforestry plantation systems.

Response of fresh and dry fodder yield of the interplanted herbaceous fodder crops to the applied population densities of the interplanted *M. arborea* shrubs could be summarized from the combined analysis in the following chart:

Population densities of *M. arborea* (shrub/fed.)	Production of the interplanted herbaceous crops			
	Barley		Vicia	
	Fresh	Dry	Fresh	Dry
	(yield in ton/fed.)			
100	2.30	0.59	0.34	0.08
200	2.87	0.64	0.49	0.09
300	2.86	0.66	0.51	0.10
400	3.27	0.74	0.68	0.10
L.S.D. at 5%	0.21	NS	0.21	NS

Increasing population densities of the interplanted *M. arborea* shrubs from 100 to 200, 300 and 400 shrubs per feddan caused subsequent significant increases in fresh fodder yield for either of the two interplanted

Table (14) : Fresh fodder yield of barley and **vicia** (ton/fed) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	2.90	0.44	**1.67**	3.61	0.61	**2.11**	3.89	0.64	**2.27**	4.37	0.71	**2.54**	3.69	0.60	**2.15**
With	3.78	0.59	**2.19**	5.14	0.69	**2.92**	4.68	0.73	**2.71**	5.65	1.02	**3.34**	4.81	0.76	**2.79**
M e a n	**3.34**	**0.52**	1.93	**4.38**	**0.65**	2.52	**4.29**	**0.69**	2.49	**5.01**	**0.87**	2.94	**4.25**	**0.68**	2.47
L.S.D. at 5% for :	Density (D) = 0.32 S x F = 0.31			Species (S) =0.31			Fertilizer (F) = 0.22								
	2nd season :														
Without	1.16	0.11	**0.64**	1.27	0.20	**0.74**	1.37	0.28	**0.83**	1.39	0.45	**0.92**	1.30	0.26	**0.78**
With	1.34	0.21	**0.77**	1.43	0.28	**0.86**	1.48	0.36	**0.92**	1.66	0.53	**1.10**	1.48	0.34	**0.91**
M e a n	**1.25**	**0.16**	0.71	**1.35**	**0.24**	0.80	**1.43**	**0.32**	0.88	**1.53**	**0.49**	1.01	**1.39**	**0.30**	0.85
L.S.D. at 5% for :	D = 0.07			S = 0.05			F = 0.02			D x S x F = 0.05					
	Combined (two seasons) :														
Without	2.03	0.28	**1.16**	2.44	0.41	**1.43**	2.63	0.46	**1.55**	2.89	0.58	**1.74**	2.50	0.43	**1.47**
With	2.56	0.40	**1.48**	3.29	0.57	**1.93**	3.08	0.55	**1.82**	3.65	0.77	**2.21**	3.03	0.57	**1.80**
M e a n	**2.30**	**0.34**	1.32	**2.87**	**0.49**	1.68	**2.86**	**0.51**	1.69	**3.27**	**0.68**	1.98	**2.77**	**0.50**	1.64
L.S.D. at 5% for :	D = 0.21 S x F = 0.28			S = 0.21 Years = 0.15			F = 0.20								

Table (15) Dry yield of barley and vicia (Ton/fed) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	0.70	0.09	**0.40**	0.80	0.09	**0.45**	0.92	0.11	**0.52**	0.78	0.11	**0.45**	0.80	0.10	**0.45**
With	1.05	0.13	**0.59**	1.08	0.15	**0.62**	1.03	0.13	**0.58**	1.32	0.15	**0.74**	1.12	0.14	**0.63**
Mean	**0.88**	**0.11**	0.50	**0.94**	**0.12**	0.54	**0.98**	**0.12**	0.55	**1.05**	**0.13**	0.60	**0.96**	**0.12**	0.54
L.S.D. at 5% for :	Density (D) = NS S x F = 0.11			Species (S) =0.19			Fertilizer (F) = 0.08								
	2nd season :														
Without	0.29	0.03	**0.16**	0.25	0.05	**0.15**	0.29	0.05	**0.17**	0.39	0.07	**0.23**	0.28	0.05	**0.17**
With	0.29	0.07	**0.18**	0.42	0.07	**0.25**	0.39	0.08	**0.24**	0.44	0.07	**0.26**	0.39	0.07	**0.23**
Mean	**0.29**	**0.05**	0.17	**0.34**	**0.06**	0.20	**0.34**	**0.07**	0.21	**0.42**	**0.07**	0.25	**0.33**	**0.06**	0.20
L.S.D. at 5% for :	D = NS			S = 0.04			F = 0.02			D x S x F = 0.05					
	Combined (two seasons) :														
Without	0.50	0.06	**0.28**	0.53	0.07	**0.30**	0.61	0.08	**0.35**	0.59	0.09	**0.34**	0.56	0.08	**0.32**
With	0.67	0.10	**0.39**	0.75	0.11	**0.43**	0.71	0.11	**0.41**	0.88	0.11	**0.50**	0.75	0.11	**0.43**
Mean	**0.59**	**0.08**	0.43	**0.64**	**0.09**	0.37	**0.66**	**0.10**	0.38	**0.74**	**0.10**	0.42	**0.66**	**0.10**	0.37
L.S.D. at 5% for :	D = NS S x F = 0.07			S = 0.09 Years = 0.03			F = 0.05								

herbaceous crops. The respective increase in fresh fodder yield of barley was 25%, 24% and 42%, being 44%, 50% and 100% for vicia.

Such subsequent increase in either the fodder yield of barley or vicia by increasing plant population densities of the interplanted *M. arborea* shrubs could be due to the substantial improving of the harsh environmental desert condition within the plant canopies. The soft micro-environment was created mainly from the reduction of heat stress, radiation stress and the evapotranspiration losses of the limited amounts of soil moisture as well. In addition to the stimulation and production of the requisted useful soil microflora which generate a life fertile soil which is considered among the major factors in soil improving.

Moreover, it should be pointed out that the applied intensification of the interplanted *M. arborea* shrubs was not dense enough to cause any competition for the interplanted herbaceous crops especially at the very early stages of growth of the interplanted shrubs.

Such effect should be studied later at the advanced stages of growth and development of the perennial *M. arborea* shrubs. Further studies for identifying interlations between the components of the grown agroforestry plantations are very much needed especially for the advanced stages of growth and development of the grown plantations.

Neither dry yield of the interplanted herbaceous crops, barley nor vicia was affected by the applied population desnities of *M. arborea* shrubs where the differences did not reach the level of significance as seen in Table (15). This result was not true for the fresh yield previously discussed.

Fresh yield of the interplanted herbaceous crops was increased due to the increase in the population densities of *M. arborea* for its effect in creating better microenvironment for the growth of the herbaceous crops as previously menioned.

Fresh and dry fodder yield of the interplanted herbaceous crops barley and vicia are summarized in the following chart:

Years	interplanted herbaceous fodder crops			
	Barley		Vicia	
	Fresh	Dry	Fresh	Dry
	(yield in ton/fed.)			
First year	4.25	0.96	0.68	0.12
Second year	1.39	0.33	0.30	0.06
Combined	2.77	0.66	0.50	0.10
L.S.D. at 5%	0.21	0.09	0.21	0.09

Regarding interplanted herbaceous fodder crops, the creal crop (barley) produced fresh fodder yield of 2.77 ton/fed., whereas, the leguminous crop (vicia) produced 0.5 ton/fed. (Table 14). However, it is worth noting that the obtained fresh fodder yield of either barley or vicia was much higher in the first year (2.47 ton/fed.) compared to the second one (0.88 ton/feddan) with a significant difference. This could be due to the higher precepitation rates of the first year compared to the second year as well as the lower prevailing ambient temperature (Table 2). Such result proved the highest potentialities of barley in fresh fodder production as compared to vicia under the prevailing desert conditions of El-Qasr at Matruh.

Averaged over the two growing years results in Table (15) showed a very poor dry yield of vicia (0.10 ton/feddan) as compared to barley (0.66 ton/feddan) with significant differences. The respective dry yield of barley and vicia for the first year was 0.96 and 0.12 ton/feddan and for the second year was 0.33 and 0.66 ton/feddan. This prove the superiority of barley as compared with vicia for the arid area of Matruh under the circumstances of this experiment.

It is worth noting that this obtained result does not ignore the importance of vicia as a naturaly grown leguminous fodder crop in respect of its value in fixing its own requirement of nitrogen through its symbiotic bacteria. Moreover, vicia is considered one of the most high protein fodder crop naturaly grown in Matruh desert. In addition, barley as a rich source of carbohydrates could be mixed with vicia as a valuable source of protein to form nutritionally balanced desert feed. Such balanced feed is a vital factor from the animal nutrition point of view.

Here, it should be noted that under most cases barley produced higher fresh and dry fodder yield by almost 6 folds as compared to vicia. In other words, this result could be explained by the more tolerance and the higher potentialities of barley rather than vicia for tolerating the adverse desert condition.

On the combined analysis basis (Table 15), the applied fertilizer treatment of phosphorus + sulphur caused a significant increase in fresh fodder yield of barley by 21% and for vicia by 33%. Both of barley and vicia responded very well to the applied phosphorus + sulphur fertilization treatment as far as their fresh and dry yields are concerned.

Meanwhile, dry yield of barley was 0.75 ton/feddan for the phosphorus + sulphur treatment vrs 0.56 for the control, being 0.08 vrs 0.11 ton/feddan for vicia.

Among the researchers whom they found similar results concerning the effect of phosphorus in increasing fresh and dry yield of barley in similar desert condition were El-Bagouri *et al.* (1978); Orphanos (1987) and Rawal and Yadava (1988).

Also, Ivanic (1977); El-Maghraby (1988); El-Gala *et al.* (1989) and Wassif (1994) reported similar effect of sulphur in increasing fresh and dry yield potentialities of barley in similar arid conditions. In addition, Reuter *et al.* (1973) found similar effect of phosphorus + sulphur in increasing the productivity of barley.

Along the same line, Wassif (1994) confirmed the effect of sulphur in decreasing the pH of the soil which in turn increased the fodder productivity of barley.

However, it is worth noting that the obtained fresh fodder yield of either barley or vicia was much higher in the first year (2.47 ton/feddan) compared to the second one (0.85 ton/fed.) with a significant difference.

This could be due to the higher precepitation rates of the first year compared to the second year as it is clear from Table (14), as well as the lower prevailing ambient temperature of the first year as shown in Table (2).

The interplanted herbaceous fodder crops barley fertilized with phosphorus + sulphur formula exhibited a significant interaction effect on the fresh and dry yield of either barley or vicia (combined analysis, Tables 14 and 15). The obtained fresh and dry yield of barley was 3.03 and 0.75 ton/fed., respectively being 0.57 and 0.11 ton/fed. for vicia.

It could be concluded that the obtained effect of the applied fertilizer treatment of phosphorus + sulphur in increasing fresh and dry yield of the interplanted herbaceous crops may be due to the effect of such elements in correcting the physical and chemical properties of the calcareous desert soil for the sake of better plant growth and development as recorded by many of the previously mentioned researcher (El-Bagouri *et al.*, 1978) and Wassif, 1994).

In general, increasing population densities of the interplanted *M. arborea* shrubs caused significant increases in fresh and dry fodder yield of both of the interplanted herbaceous crops (barley and vicia). Also, barley proved to be a superior production fodder crop when compared with vicia as a fresh and dry fodder yields are concerned.

Moreover, the applied fertilization treatment of phosphorus and sulphur significantly increased fresh and dry fodder yields of interplanted herbaceous fodder crops.

So, the contribution of barley as a herbaceous fodder crop for interplanting within the interspaces of the perennial fodder shrubs and fertilized with adequate amounts of phosphorus + sulphur should be very well considered in the proposed agroforestry plantation systems. Such models should be recommended for the calcareous soil of arid environmental desert condition.

1.3.2. Height of plants for the interplanted herbaceous fodder crops:

The combined analysis (Table 16) showed that the applied plant population densities of the interplanted *M. arborea* shrubs did not exhibt any significant difference in the heights of either barley or vicia plants.

It is naturally true that barley plants were much taller (41.8 cm) than vicia (15.7 cm). This is due to the different nature of growth for barley as a cereal crop compared to vicia as a leguminous fodder crop. Such result was in a similar trend to what was obtained in each of the two growing years.

Table (16) Height of barley and vicia plants (cm) as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	47	15	31	48	16	32	44	17	30.5	60	15	37.5	49.8	15.8	32.8
With	53	16	34.5	55	18	36.5	57	19	38	64	17	40.5	57.3	17.5	37.4
Mean	50	15.5	32.8	51.5	17	34.3	50.5	18	34.3	62	16	39	53.6	16.7	35.1
L.S.D. at 5% for :	Density (D) = NS			Species (S) = 4.3			Fertilizer (F) = 3.0								
	2nd season :														
Without	31	10	20.5	25	15	20	30	10	20	28	12	20	28.5	11.8	20.2
With	31	22	26.5	29	18	23.5	33	11	22	31	14	22.5	31	16.3	23.7
Mean	31	16	23.5	27	16.5	21.8	31.5	10.5	21	29.5	13	21.3	29.8	14.1	22
L.S.D. at 5% for :	D = NS			S = 2.3			F = 1.8								
	Combined (two seasons) :														
Without	39	13	26	37	16*	26.5	37	14	25.5	44	14	29	39.3	14.3	26.8
With	42	19	30.5	42	18	30	45	15	30	48	16	32	44.3	17	30.7
Mean	40.5	16	28.3	39.5	17	28.3	41	14.5	27.8	46	15	30.5	41.8	15.7	28.8
L.S.D. at 5% for :	D = NS Years = 2.3			S = 3.2			F = 3.2								

The applied fertilization treatment of phosphorus + sulphur caused significant increases in the height of either barley or vicia plants as compared with their control. The respective heights of the fertilized vrs the unfertilized barley plants were 44.3 vrs 39.3 cm corresponding to 17.0 vrs 14.3 cm for vicia with a respective increase in plant height of 13% and 19% for barley and vicia. Such results could prove the role of phosphorus and sulphur in improving the calcareous soil characteristics physically and chemically for the sake of better plant growth and production where plant height is among the major components of the vegetation growth.

No interaction effect between the applied studied factors on the height of the interplanted herbaceous fodder crops proved to be significant.

1.3.3. Number of barley tillers and vicia branches per square meter of land:

As it is clear from the combined analysis of the two growing years (Table 17), increasing the interplanted population densities of *M. arborea* did not exert any significant effect on the number barley tillers or the number of vicia branches per square meter. Such results are very well acceptable since the applied population densities of the interplanted *M. arborea* especially at the very early stage of growth were not too great to affect the

Table (17) Number of barley tillers and vicia branches as affected by the interplanted fodder plantations and phosphorus + sulphur application .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barley (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	372	107	**240**	365	153	**259**	456	108	**282**	433	152	**293**	407	130	**269**
With	449	144	**297**	421	176	**299**	525	146	**336**	581	170	**376**	494	159	**327**
Mean	**411**	**126**	269	**393**	**165**	279	**491**	**127**	309	**507**	**161**	335	**451**	**145**	298
L.S.D. at 5% for :	Density (D) = NS S x F = 23			Species (S) = 53			Fertilizer (F) = 16.5								
	2nd season :														
Without	140	35	**88**	143	50	**97**	143	35	**89**	156	48	**102**	146	42	**94**
With	176	50	**113**	172	59	**116**	168	50	**109**	155	53	**104**	168	53	**111**
Mean	**158**	**43**	101	**158**	**55**	107	**156**	**43**	99	**156**	**51**	103	**157**	**84**	103
L.S.D. at 5% for :	D = NS D x F = 8			S = 6.7 S x F = 6			F = 4								
	Combined (two seasons) :														
Without	256	71	**164**	254	102	**178**	300	72	**186**	295	100	**198**	276	86	**181**
With	313	97	**205**	297	118	**208**	347	98	**223**	368	112	**240**	331	106	**219**
Mean	**285**	**84**	185	**276**	**110**	193	**324**	**85**	205	**332**	**106**	219	**304**	**96**	200
L.S.D. at 5% for :	D = NS S x F = 22			S = 35 Years = 25			F = 16								

environmental factors that can affect either number of tillers of barley or number of branches of vicia per square meter of land.

The combined analysis showed that the average number of tillers of barley per square meter was 304 and the average number of branches for vicia was 96.

Number of tillers of barley was significantly increased by the applied phosphorus + sulphur treatments as compared to the control. The respective number of tillers was 106 and 86 tillers/square meter with 19% decrease.

Meanwhile, number of branches/square meter of vicia was 331 vrs 276 for the fertilized treatment compared with the control with 17% decrease.

Along the same line, Ramos *et al.* (1989) reported a response of the number of tillers/square meter of barley to the applied sulphur to soil.

Again, the applied phosphorus + sulphur treatment exerted a favourable effect in improving the calcareous soil characteristics which stimulated some of the components of the fresh fodder yield of the interplanted herbaceous fodder crops. Similar trends were obtained for each of the two subsequent growing years (Table, 17).

Table (18) : Phosphorus content (%) of the component of the proposed fodder plantations.

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops : Barley (B) or Vicia (V)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	<u>Acacia saligna</u>														
Without	0.16	0.12	**0.14**	0.13	0.09	**0.11**	0.11	0.08	**0.10**	0.11	0.07	**0.09**	0.13	0.09	**0.11**
with	0.19	0.15	**0.17**	0.18	0.11	**0.15**	0.15	0.12	**0.14**	0.15	0.11	**0.13**	0.17	0.12	**0.15**
Mean	**0.18**	**0.14**	0.16	**0.16**	**0.10**	0.13	**0.13**	**0.10**	0.12	**0.13**	**0.09**	0.11	**0.15**	**0.11**	0.13
L.S.D.at 5% for:	Density (D) = 0.01 Years = 0.8			Species (S) = 0.02			Fertilizer (F) = 0.01								
	<u>Medicago arborea</u>														
Without	0.13	0.14	**0.14**	0.12	0.11	**0.12**	0.10	0.11	**0.11**	0.11	0.08	**0.10**	0.12	0.11	**0.12**
with	0.18	0.16	**0.17**	0.15	0.15	**0.15**	0.15	0.12	**0.14**	0.13	0.12	**0.13**	0.16	0.14	**0.15**
Mean	**0.16**	**0.15**	0.16	**0.14**	**0.13**	0.14	**0.13**	**0.12**	0.13	**0.12**	**0.10**	0.12	**0.14**	**0.13**	0.14
L.S.D.at 5% for:	D = 0.01 year = 0.01			S = 0.01			F = 0.01								
	<u>Herbaceous crops (Barley & Vicia)</u>														
Without	0.14	0.11	**0.13**	0.13	0.09	**0.11**	0.11	0.10	**0.10**	0.10	0.08	**0.09**	0.12	0.10	**0.11**
with	0.18	0.14	**0.16**	0.17	0.13	**0.15**	0.14	0.11	**0.12**	0.13	0.09	**0.11**	0.16	0.12	**0.14**
Mean	**0.16**	**0.13**	0.14	**0.15**	**0.11**	0.13	**0.13**	**0.10**	0.11	**0.12**	**0.09**	0.10	**0.14**	**0.11**	0.12
L.S.D.at 5% for:	D = 0.02 Years = 0.01			S = 0.01			F = 0.01								

the applied treatments on phosphorus content of the grown fodder materials of the proposed agroforestry plantations.

Phosphorus content for acacia and the interplanted *M. arborea* fodder materials was substantially decreased as the population density of the interplanted *M. arborea* increased from 100, 200, 300 and up to 400 shrubs per feddan. The respective phosphorus content was 0.16, 0.13, 0.12 and 0.11% for acacia and 0.16, 0.14, 0.13 and 0.12% for *M. arborea* with significant differences when comparing between the lowest density (100 shrub/feddan) with either of the two highest densities (300 and 400 shrubs/feddan). Such decrease in phosphorus content of acacia and *M. arborea* fodder materials by intensfying the population denisties of the later shrubs could be due to the inadequate available phosphorus that is requsted for the intense plantation especially under the calcareous soil conditions.

Regarding the effect of the interplanted herbaceous crops, phosphorus content of either acacia or *M. arborea* fodder was significantly higher when the interplanted herbaceous crops was barley rather than vicia. Phosphorus content was 0.15% and 0.11% for acacia when the interplanted herbaceous crop was barley and vicia, respectively. The corresponding phosphorus content for *M. arborea* with the interplanted barley and vicia was 0.14 and 0.13%, respectively. These results showed that both of acacia and *M. arborea* contained significantly higher phosphorus content when the interplanted herbaceous crop was barley as compared with vicia (Table 18, A_{1-2}).

Both of the interplanted herbaceous crops exhibited substantial decrease in its phosphorus as the population density of the interplanted *M. arborea* shrubs increased from 100 to 200, 300, and 400 shrubs/feddan. The respective phosphorus content was 0.16, 0.15, 0.13 and 0.11% for barley and 0.13, 0.11, 0.10 and 0.09% for vicia. Here it should be pointed out that such decrease in phosphorus content was due to the inadequancy of the available phosphorus in the soil resrvoir for the intensed population densities of the interplanted *M. arborea* shrubs and the interplanted herbaceous fodder cops of the gown agroforestry plantations.

In other words, barley contained more phosphorus than vicia. However, it is well known that leguminous crops usually contain more phosphorus than cereal crops. In such case the reason could be due to the shortest period of vicia duration in the field as compared with barley. This relatively short period of time could be insufficient to accumulate enough phosphorus in vicia tissues. Moreover, the vigority of barley growth compared to vicia may be another reason for extracting more of phosphorus in its tissues.

Acacia and *M. arborea* contained more phosphorus when the interplanted herbaceous crop was barley than vicia with significant differences as shown in Table (18, A_{1-2}).

Phosphorus content for acacia fodder material interplanted with barley was 0.15% and for acacia interplanted with vicia was 0.11%, being 0.14 and 0.13%, respectively for *M. arborea* fodder material. In general, the interplanted herbaceous crop barley contained 30% more phosphorus content as compared with vicia. The respective phosphorus content was 0.14 and 0.11%.

Results also showed that both acacia and *M. arborea* responded to the applied phosphorus + sulphur treatment where phosphorus content in their tissue was significantly higher as compared with the control plants. Fertilized acacia contained 0.15% phosphorus whereas the control ones contained 0.11%. The corresponding phosphorus content of *M. arborea* was 0.15% and 0.12% (Table 18, A_{1-2}).

Similar responses of the applied phosphorus + sulphur treatment were reflected on the interplanted herbaceous crops as a the phosphorus content of their fodder tissues is concerned. In comparing fertilized with the unfertilized herbaceous fodder crops, barley contained 0.16% phosphorus vrs 0.12% with 0.33% difference. Whereas, vicia contained 0.12% phosphorus vrs 0.10% with 0.20%

difference for the fertilizer treated crops compared to the untreated one (Table 18, A_3)..

In conclusion, phosphorus content on dry matter basis of the obtained fodder materials from acacia and interplanted *M. arborea*, decreased by increasing the population density per unit of land area.

Meanwhile, such fodder materials contained higher phosphorus content when the interplanted herbaceous crop was barley rather than vicia. Also, all of the grown plantation (acacia, *M. arborea*, barley and vicia) contained higher phosphorus content in their fodder materials when fertilized with phosphorus + sulphur as compared with the untreated plantations.

It is obviously clear that the applied fertilizer treatment exhibited its favourable impact on the grown plantation in respect of growth and production. This reslt confirmed the effect of such fertilizer treatment in improving the physical and chemical characteristics of the calcareous soil of El-Qasr at Matruh.

Also, it looks to be true that sulphur component of the applied fertilizer treatment was very much effective in strengthen the effect of phosphorus availability by the achieved decrease in soil pH. This decrease in the pH of such calcareous soil made the applied phosphorus as well as

Table (19) : Carbohydrates content (%) of the component of the proposed fodder plantations.

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	Acacia saligna														
Without	12.8	11.4	**12.1**	15.0	11.9	**13.5**	17.1	15.7	**17.4**	22.2	19.0	**20.6**	17.3	14.5	**15.9**
With	17.4	12.7	**15.1**	21.9	13.2	**17.6**	20.8	19.0	**19.9**	23.0	21.8	**22.4**	20.8	16.7	**18.8**
Mean	**15.1**	**12.1**	13.6	**18.5**	**12.6**	15.6	**20.0**	**17.4**	18.9	**22.6**	**20.4**	21.5	**19.1**	**15.6**	17.4
L.S.D. at 5% for :	Density (D) = 1.4 Years = 1.0			Species (S) = 1.4			Fertilizer (F) = 1.0			D x S x F = 2.9					
	Medicago arborea														
Without	29	25	**27**	30	27	**29**	31	30	**31**	34	33	**34**	31	29	**30**
With	37	31	**34**	37	33	**35**	38	35	**37**	41	36	**39**	38	34	**36**
Mean	**33**	**28**	31	**34**	**30**	34	**35**	**33**	34	**33**	**35**	37	**35**	**32**	33.5
L.S.D. at 5% for :	D = 1.4 D x S = 1.9			S = 0.9 D x F =			F = 1.4 Years = 0.9								
	Herbecious crops (Barley & Vicia)														
Without	35.3	21.0	**28.2**	37.5	24.0	**30.8**	39.0	30.0	**34.5**	40.5	34.5	**37.5**	36.2	27.4	**32.8**
With	34.5	19.5	**27.0**	34.5	21.0	**27.8**	36.0	27.0	**31.5**	36.8	33.0	**34.9**	35.5	25.1	**30.3**
Mean	**34.7**	**20.3**	27.6	**36.0**	**22.5**	29.3	**37.5**	**28.5**	33.0	**38.7**	**33.8**	36.2	**36.9**	**26.3**	31.6
L.S.D. at 5% for :	D = 1.3 S x F = 1.0			S = 1.3 Years = 0.9			F = 0.7								

the already fixed phosphorus available, in addition, the transformation of some fixed important micronutrients to the available form to the grown plants.

No significant interaction effect between the applied factors on the phosphorus content of the grown fodder plantation was detected.

2.2. Carbohydrates content (NFE):

It is clear from Table (19, A_{4-6}).) that the obtained fodder material of acacia, *M. arborea*, barley and vicia contained higher carbohydrates content on dry matter basis as the intensity of the interplanted *M. arborea* shrubs increased with significant differences. The highest carbohydrates content of any of the grown fodder was obtained at the highest population density of the interplanted *M. arborea* (400 shrubs/feddan) as shown in the following chart:

Population of *M. arborea* shrubs/fed.	Perennial shrubs		Winter herbaceous crops	
	Acacia	*M. arborea*	Barley	Vicia
		(CH_2O, %)		
100	13.6	31.0	34.9	20.3
200	15.6	32.0	36.0	22.5
300	18.9	34.0	37.5	28.5
400	21.5	37.0	38.7	33.8
L.S.D. at 5%	1.4	1.4	1.3	1.3

This result may be due to the creation of better micro-environmental conditions within the plant canopies by cutting off the unfavourable infra-red (IR) radiation on the expense of the photosynthetic active radiations (PAR) of more photon energy that stmulates photosynthesis operation which finally reflected on the accumulated carbohydrates content.

Also, the partial shade within the grown plant canopies could decrease the surrounded air temperature and the temperature inside the grown tissues itself. This decrease in the ambient desert temperatures could bring the photosynthesis activity close to the optimum which stimulates photosyntheis operation with its end product (carbohydrates).

Moreover, the obtained shade with the cut of the infra red radiation and the decrease in temperature would of course reduce the evapotranspiration and limit the moisture losses in plant and soil which used to be very limited under the rainfed desert agriculture. Such save of moisture could add another factor in increasing the photsynthesis activity and carbohydrate accumulation of the grown fodder tissues.

Any of the grown perennial fodder shrubs (acacia and *M. arborea*) contained slightly but significantly higher carbohydrate content when the interplanted herbaceous crop was barley as compared with vicia as it is clear from Table (19, A_{4-5}).). The obtained carbohydrates content for acacia fodder was 19.1% when the interplanted herbaceous crop was barley compared with 15.6% when the interplanted herbaceous crop was vicia. Similar trends were recorded for *M. arborea*, its carbohydrates content was higher (35.0%) when the interplanted herbaceous crop was barley as compared with vicia (32.0%).

Regarding the carbohydrate content of the interplanted herbaceous crops, results showed that the interplanted barley was significantly higher (36.9%) than vicia (26.3%) with 40% difference. This result is very well accepted since cereal fodder crop is considered of high energy source while leguminous fodder crops are of high protein content. This is due to the specific natural unique characeristics of barley and vicia.

Regarding the effect of the applied phosphorus + sulphur fertilization treatment on carbohydrate content, it was slightly but significantly higher as compared with the control for acacia (18.8 vrs 15.9%) and for the interplanted *M. arborea* (36.0 vrs 30.3%). Whereas, the carbohydrate content of the interplanted herbaceous crops was slightly but significantly lower for the control treatment as compared with the fertilized one. This is an opposite trend that what was reported in crude protein content which will be discussed later (Table 20, A_{7-9})..

The presence of phosphorus + sulphur may increase the available phosphorus and release the required essential micronutrients that may cause synergestic effect for activating photosynthetic operation and carbohydrate accumulation in the grown tissue.

Generally, as the population densities of the interplanted *M. arborea* shrubs increased, carbohydrate content of its fodder material was significantly increased. Such effect was significantly detected in acacia fodder and any of the interplanted herbaceous fodder crops (barley and vicia). In other words, carbohydrate content of each component of the grown plantations (acacia, *M. arborea*, barley and vicia) was significantly increased as the population densities of the interplanted *M. arborea* increased (Table 19, A_{4-6})..

The interplanted herbaceous crop barley was significantly higher in its carbohydrate content than vicia. Also, either acacia or *M. arborea* fodder material contained higher carbohydrate content when the herbaceous interplanted crop was barley rather than vicia.

Carbohydrate contents of either acacia or *M. arborea* fodder material were significantly higher when fertilized with the applied phosphorus + sulphur formula as compared with the control.

2.3. Crude protein content (CP):

Crude protein content of acacia fodder was slightly but significantly decreased as the population of the interplanted *M. arborea* increased from 100 up to 400 shrubs/feddan. As it is clear from the combined analysis (Table 20, A_7).), at the lowest and highest population density of *M. arborea*, crude protein content of acacia fodder was 18.4% and 17.1%, respectively.

Meanwhile, fodder materials of *M. arborea* shrubs was not significantly affected by increasing its population density per unit area of land. In other words, population densities of *M. arborea* shrubs did not exert clear trend on its fodder crude protein content.

As the population densities of the interplanted *M. arborea* increased from 100 up to 400 shrubs/feddan, crude protein content of each of the interplanted herbaceous crops tended to decrease without significant differences (Table 20, A_9). This was not the case for the carbohydrate contents of such herbaceous crops previously discussed, where the carbohydrate contents were significantly increased as the population densities of the interplanted *M. arborea* increased (Table 19, A_8)..

On the other hand, the increase in population densities of *M. arborea* did not exert clear effect on the protein content of their produced fodder material.

Table (20) : Crude protein content (%) of the component of the proposed fodder plantations.

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	Acacia saligna														
Without	15.3	18.7	**17.0**	15.6	16.8	**16.2**	13.4	18.1	**15.8**	13.3	17.6	**15.5**	14.4	17.8	**16.1**
With	18.9	20.5	**19.7**	21.5	19.0	**20.3**	17.5	19.7	**18.6**	17.2	20.1	**18.7**	18.7	19.8	**19.3**
Mean	**17.1**	**19.6**	18.4	**18.6**	**17.9**	18.3	**15.5**	**18.9**	17.2	**15.3**	**18.9**	17.1	**16.6**	**18.8**	17.7
L.S.D. at 5% for :	Density (D) = 0.4 S x F = 0.5			Species (S) = 0.4 Years = 0.3			Fertilizer (F) = 0.3								
	Medicago arborea														
Without	15.6	16.3	**16**	17.5	16.7	**17.1**	15.8	15.1	**15.5**	15.6	14.9	**15.3**	16.1	15.8	**16.0**
With	21.1	19	**20.1**	18.7	18.1	**18.4**	15.7	18.8	**18.8**	17.9	16.5	**17.2**	19.1	18.1	**18.6**
Mean	**18.4**	**17.7**	18.1	**18.1**	**17.4**	17.9	**17.3**	**17.0**	17.2	**16.8**	**15.7**	16.3	**17.6**	**17.0**	17.3
L.S.D. at 5% for :	D = NS D x S = 47			S = NS S x F = 1.1			F = 0.6 Years = 0.4			D x S x F = 1.6					
	Herbecious crops (Barley & Vicia)														
Without	16.3	17.9	**17.1**	12.4	16.7	**14.6**	12.2	15.0	**13.6**	12.8	19.7	**16.3**	13.4	17.3	**15.4**
With	19.3	24.7	**22.0**	14.8	19.6	**17.2**	14.5	18.5	**16.5**	15.1	21.2	**18.2**	15.9	21.0	**18.5**
Mean	**17.8**	**21.3**	19.6	**13.6**	**18.2**	15.9	**13.4**	**16.8**	15.1	**14.0**	**20.5**	17.3	**14.7**	**19.2**	17.0
L.S.D. at 5% for :	D = NS			S = 0.6			F = 1.0			D x S x F = 40					

Combined analysis (Table 20, A_7).) showed that acacia crude protein content was significantly lower when the interplanted herbaceous crop was barley (16.6%) as compared with vicia (18.8%). This is completely opposite to what was obtained for the carbohydrates content previously disscussed (Table 19, A_4).). Of course, the interplanted leguminous vicia fodder crop contained significantly higher crude protein content (19.2%) as compared with cereal barley (14.7%). This is due to the unique constituents of such crop that differ in its nature and characteristics.

Fertilization of acacia and *M. arborea* shrubs with the applied phosphorus + sulphur formula exerted its effect in increasing crude protein content of its fodder material. In comparing the fertilized with the unfertilized plots, the respective crude protein content for acacia fodder was 19.3% vrs 16.1% and for *M. arborea* was 18.6% vrs 16.0%.

Again such obtained result in crude protein content was in an opposite trend than what was obtained with carbohydrate content as previously mentioned. These results are very well accepted since carbohydrate and crude protein are very much related and forming most of the dry matter content. In other words, any increase in one of the two components will be on the expense of the other.

Also, the obtained data in Table (20) clarified the effect of the applied phosphorus + sulphur ferilization formula on the crude protein content of the interplanted herbaceous fodder crops (barley or vicia). This fertilization treatment caused significant increases in crude protein content by 19% for barley and by 21% for vicia as compared with their control. The obtained crude protein content of barley was 15.9% for the fertilized treatment and 13.4% for the unfertilized one. Respective crude protein content for vicia was 21.0 and 17.3% (Table 20, A_9).

In this respect, it is clear that the applied phosphorus + sulphur fertilization treatment exerted its effect in improving the calcareous soil characteristics for stimulating growth of better qualities that is reflected in increasing crude protein content of the grown fodders.

The highest crude protein content of acacia fodder, was obtained when the interplanted herbaceous crop was vicia fertilized with the applied phosphorus + sulphur formula, where the interaction effect was significant for *M. arborea*. There was a significant interaction effect of its population densities (100 shrubs/feddan), when the interplanted fodder crop was barley fertilized with the applied phosphorus + sulphur treatment (Table 20, A_7).

It could be generally concluded that as the population densities of the interplanted *M. arborea* increased from 100 to 400 shrubs/feddan, crude protein content of acacia fodder decreased significantly. Such densities tended to decrease crude protein content of the interplanted *M. arborea* and the interplanted herbaceous crop barley or vicia. When the interplanted herbaceous crop was vicia, crude protein content of acacia fodder was significantly higher than when it was barley.

Also, crude protein content of *M. arborea* fodder was not affected by any of the interplanted herbaceous crops (barley or vicia). Moreover, the interplanted herbaceous crop vicia was always and significantly higher in its crude protein content as compared with barley. This is of course due to their nature of growth as leguminous and cereal crops (Table 20, A_{5-9}).

The applied fertilizer formula of phosphorus + sulphur significantly increased crude protein content of he obtained fodder maerials for all of the components of the grown plantaion (acacia, *M. arborea*, barley and vicia) as shown in Table 20, A_{7-9}).

2.4. Crude fiber content:

Data in Table (21, A_{10-12}) present the effect of the applied treatments on the crude fiber content for each component of the grown fodder plantations.

Table.(21) : Crude fiber content (%) of the component of the proposed fodder plantations.

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	Acacia saligna														
Without	23	22	**23**	22	23	**23**	25	23	**24**	29	24	**27**	25	23	**24**
With	21	17	**19**	20	20	**20**	22	21	**22**	23	20	**22**	22	20	**21**
Mean	**22**	**20**	21	**21**	**22**	22	**24**	**22**	23	**26**	**22**	25	**24**	**22**	23
L.S.D. at 5% for :	Density (D) = NS D x F = 1.6			Species (S) = 1.7 Years = 1.2			Fertilizer (F) = 0.8			D x S x F = 40					
	Medicago arborea														
Without	17	11	**14**	19	16	**18**	20	17	**19**	21	19	**20**	19	16	**18**
With	11	9	**12**	16	14	**15**	18	15	**16**	17	16	**17**	16	14	**15**
Mean	**16**	**10**	13	**18**	**15**	17	**19**	**16**	18	**19**	**18**	19	**18**	**15**	17
L.S.D. at 5% for :	D = 1.3 D x S = 1.9			S = 1.1 Years = 0.9											
	Herbecious crops (Barley & Vicia)														
Without	25.2	18.3	**21.8**	25.1	18.7	**21.9**	27.9	20.0	**24.0**	27.8	22.2	**25.0**	26.5	19.8	**23.2**
With	19.5	16.0	**17.8**	23.2	16.8	**20.0**	22.0	17.5	**19.8**	23.9	17.0	**20.8**	22.2	17.0	**19.6**
Mean	**22.4**	**17.2**		**24.2**	**17.8**	20.9	**25.0**	**18.8**	21.9	**25.9**	**19.9**	22.9	**24.4**	**18.4**	21.4
L.S.D. at 5% for :	D = 1.0 S x F = 20			S = 1.0 Years = 0.7			F = 0.5								

Results showed that crude fiber content of acacia was not affected by the applied population densities of the interplanted *M. arborea* (100 to 400 shrubs/feddan). However, crude fiber content of *M. arborea* shrubs was increased by increasing its population density with significant differences as shown from the combined analysis. Crude fiber content was 13%, 18% and 19% at population densities of 100, 300 and 400 shrubs/feddan. This result matches real well with the increase in crown volume previously disccused (Table 13). Such effect is more likely a result of the competition of the densed *M. arborea* plantation for the essential growth requirements especially light which led to elongation of its plant organs that caused the increase in its crude fiber content as a mechanical component for supporting such growth.

Similar results for the effect of the intensed population densities of *M. arborea* on the interplanted herbaceous crop were noticed as far as its crude fiber content is concerned. In other words, crude fiber content of barley and vicia increased as the population densities of *M. arborea* increased (Table 21, A_{12}).

The obtained crude fiber content was 22.4, 24.2, 25.0 and 25.9% for barley while it was 17.2, 17.8, 18.8 and 19.9% for vicia at the respective population densities of 100, 200, 300 and 400 of *M. arborea* shrubs per feddan with a significant difference between the lowest and the highest densities. This obtained increase in Crude fiber content of the interplanted herbaceous crops by increasing population densities of the interplanted *M. arborea* shrubs could be mainly due to the competition effect for light and the essential requirements of growth at the intense plantation previously discussed.

Also, either acacia or *M. arborea* fodder material contained significantly higher crude fiber content when the interplanted herbaceous fodder crop was barley rather than vicia. Crude fiber content of acacia fodder was 24% and 22% when the interplanted fodder crop was barley and vicia, respectively. The corresponding crude fiber content for *M. arborea* fodder was 18 and 15%. This result could be also attributed to the more erected nature of growth of barley compared to the postulated growth of vicia that stimulate upright growth and elongation of the inter planted small young shrubs of acacia and *M. arborea* which in turn increased its crude fiber content.

Regarding the interplanted herbaceous fodder crops, barley contained 24.4% crude fiber while vicia contained 18.4% with significant difference of 33%. This result is very well accepted since cereal crops naturally contained more crude fiber content as compared with the leguminous crops (Table 21, A_{12}).

interplanted poulation density of 300 or 400 shrubs per feddan when the interplanted herbaceous crop was barley and not vicia. It could be generally concluded that increasing the interplanted population densities of *M. arborea* fodder shrubs did not significantly affect crude fiber content of acacia, but increased its own crude fiber content and caused an increase in the crude fiber content of any of the interplanted herbaceous fodder crops (either barley or vicia).

Acacia or *M. arborea* fodder materials contained higher crude fiber content when interplanted with barley as compared with vicia. of course barley contained significantly higher crude fiber content than vicia due to its unique nature of growth and specifications.

The applied phosphorus + sulphur treatment significantly reduced crude fiber content for the components of the grown plantation (acacia, *M. arborea*, barley and vicia) as shown in Table (21, A_{10-12}).

2.5. <u>Ether extract</u>:

Results obtained for the ether extract content of each fodder component of the grown fodder plantations was not affected by the applied agroforestry systems under study (Table 22, A_{13-15}). Differences were of narrow ranges and flactuated with no specific trend.

Table (22) : Ether Extract (%) of the component of the proposed fodder plantations.

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
Acacia saligna															
Without	3.7	3.6	3.7	3.1	2.5	2.8	2.9	2.6	2.8	2.6	2.4	2.5	3.1	2.8	3.0
With	4.1	4.0	4.1	3.4	3.3	3.4	3.3	3.0	3.2	2.8	2.7	2.8	3.4	3.3	3.4
Mean	3.9	3.8	3.9	3.3	2.9	3.1	3.1	2.8	3	2.7	2.6	2.7	3.3	3.1	3.2
Medicago arborea															
Without	3.3	3.4	3.4	3.0	3.3	3.2	2.6	3.0	2.8	2.2	1.8	2.0	2.8	2.9	2.9
With	3.5	3.5	3.5	3.3	3.4	3.4	2.9	3.2	3.1	2.4	2.2	2.3	3.0	3.1	3.1
Mean	3.4	3.5	3.5	3.2	3.4	3.3	2.8	3.1	3.0	2.3	2.0	2.2	2.9	3.0	3.0
Herbecious crops (Barley & Vicia)															
Without	5.0	5.6	5.3	6.0	5.3	5.7	5.8	5.5	5.7	6.6	6.6	6.6	5.9	5.8	5.9
With	5.8	6.8	6.3	6.4	6.8	6.6	6.6	7.2	6.9	7.4	8.2	7.8	6.6	7.3	7.0
Mean	5.4	6.2	5.8	6.2	6.1	6.2	6.2	6.4	6.3	7.0	7.4	7.2	6.3	6.6	6.5

This is because of the obtained narrow limits of ether extract component of the grown fodder components as indicated below:

Limits	Leguminous shrubs		Herbaceous crops	
	Acacia	*M. arborea*	Barley	Vicia
	(% on dry matter basis)			
Maximum	4.1	3.5	7.4	8.2
Minimum	2.4	1.8	5.0	5.3

3. **Nutritive potentialities**:

3.1. **Total fresh and dry fodder production**:

Fresh fodder production for each of the grown fodder component are added up in order to estimate the total fresh and dry fodder production for each set up of the proposed agroforestry plantaions.

Results in Table (23) indicated that total fresh fodder production of the grown agroforestry plantation (acacia + *M. arborea* + barley + vicia) was significantly affected by the applied intensities of the interplanted *M. arborea* shrubs. The various population densities of 100, 200, 300 and 400 shrubs per feddan affected the production of the relevant set up of plantation that produced 1.57, 1.92 and 2.21 ton/feddan with significant differences. So, it could be concluded that the highest total fresh fodder

Table (23) : Total fresh fodder production (ton / fed) for the proposed fodder plantations (Acacia + M. arborea + Barley or vicia).

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
	1st season :														
Without	3.04	0.63	**1.84**	3.78	0.85	**2.32**	4.06	0.80	**2.43**	4.53	0.87	**2.70**	3.85	0.79	**2.32**
With	3.98	1.00	**2.49**	5.39	0.99	**3.19**	4.91	0.95	**2.93**	5.85	1.27	**3.56**	5.03	1.05	**3.04**
Mean	**3.51**	**0.82**	2.16	**4.59**	**0.92**	2.76	**4.49**	**0.88**	2.68	**5.19**	**1.07**	3.13	**4.44**	**0.92**	2.68
L.S.D. at 5% for :	Density (D) = 0.42 S x F = 0.3			Species (S) = 0.31			Fertilizer (F) = 0.2								
	2nd season :														
Without	1.31	0.37	**0.84**	1.45	0.43	**0.94**	1.57	0.51	**1.04**	1.62	0.67	**1.15**	1.49	0.50	**1.00**
With	1.51	0.67	**1.09**	1.65	0.72	**1.19**	1.80	0.65	**1.23**	1.97	0.85	**1.41**	1.73	0.73	**1.23**
Mean	**1.41**	**0.52**	0.97	**1.55**	**0.58**	1.07	**1.69**	**0.58**	1.14	**1.80**	**0.76**	1.28	**1.61**	**0.62**	1.12
L.S.D. at 5% for :	D = 0.13 D x S x F = 0.09			S = 0.05			F = 0.02								
	Combined (two seasons) :														
Without	2.18	0.50	**1.34**	2.62	0.64	**1.63**	2.82	0.66	**1.74**	3.08	0.77	**1.93**	2.68	0.64	**1.66**
With	2.75	0.84	**1.80**	3.52	0.86	**2.19**	3.36	0.80	**2.08**	3.91	1.06	**2.49**	3.39	0.89	**2.14**
Mean	**2.47**	**0.67**	1.57	**3.07**	**0.75**	1.92	**3.09**	**0.73**	1.91	**3.50**	**0.92**	2.21	**3.04**	**0.77**	1.90
L.S.D. at 5% for :	D = 0.19 S x F = 0.28			S = 0.2 Years = 0.14			F = 0.19								

production with its all components was obtained by intensifying the population density of *M. arborea* up to the maximum level (400 shrubs/feddan). Such set up of fodder plantation could be the best fit for creating a reasonable and favourable microenvironmental conditions for growth and development and obtaining the atmost fodder production per unit area of land at Matruh desert.

Similar results were obtained for the dry fodder yield production (Table 24). Total production of 0.42, 0.45, 0.46 and 0.50 ton/feddan was produced for the previously mentioned set up of plantation with populaion densities of 100, 200, 300 and 400 shrubs/feddan, respectively. This is definitely due to the added up and the accumulation of each extra shrub in the set of a particular agroforestry plantation.

It is obviously clear that fresh and dry fodder production (Tables 23 and 24) for the whole components of the grown agroforestry plantation (acacia + *M. arborea* averaged over the applied densities + barley or vicia) varied significantly according to the grown species of the interplanted herbaceous fodder crops. Here, it is very well noticed that barley was drastically superior than vicia in exerting its effect on the fodder production of 3.04 ton/feddan when barley was the interplanted herbaceous crop component and 0.77 ton/feddan when vicia is that one with

Table (24) : Total dry fodder production (ton / fed) for the proposed fodder plantations (Acacia + M. arborea + Barley or vicia).

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
1st season :															
Without	0.75	0.14	**0.45**	0.86	0.15	**0.51**	0.97	0.17	**0.57**	0.83	0.16	**0.50**	0.85	0.16	**0.51**
With	1.11	0.23	**0.67**	1.15	0.22	**0.69**	1.10	0.20	**0.65**	1.34	0.23	**0.81**	1.19	0.22	**0.71**
Mean	**0.93**	**0.19**	0.56	**1.01**	**0.19**	0.60	**1.04**	**0.19**	0.61	**1.11**	**0.20**	0.66	**1.02**	**0.19**	0.61
L.S.D. at 5% for :	Density (D) = 0.31			Species (S) = 0.02			Fertilizer (F) = 0.12								
2nd season :															
Without	0.34	0.11	**0.23**	0.33	0.14	**0.24**	0.35	0.13	**0.24**	0.46	0.14	**0.30**	0.37	0.13	**0.25**
With	0.37	0.25	**0.31**	0.53	0.19	**0.36**	0.49	0.19	**0.34**	0.54	0.18	**0.36**	0.48	0.20	**0.34**
Mean	**0.36**	**0.18**	0.27	**0.43**	**0.17**	0.30	**0.42**	**0.16**	0.29	**0.50**	**0.16**	0.33	**0.43**	**0.17**	0.30
L.S.D. at 5% for :	D = NS			S = 0.02			F = 0.10								
Combined (two seasons) :															
Without	0.56	0.12	**0.34**	0.60	0.14	**0.37**	0.67	0.15	**0.41**	0.65	0.15	**0.40**	0.62	0.14	**0.38**
With	0.74	0.24	**0.49**	0.84	0.20	**0.52**	0.79	0.20	**0.50**	0.97	0.21	**0.59**	0.84	0.21	**0.53**
Mean	**0.65**	**0.18**	0.42	**0.72**	**0.17**	0.45	**0.73**	**0.18**	0.46	**0.81**	**0.18**	0.50	**0.73**	**0.18**	0.46
L.S.D. at 5% for :	D = NS Years = 0.2			S = 0.02			F = 0.09								

significant differences of 3-fold production. The corresponding dry fodder yield was 0.73 and 0.18 ton/feddan.

This result confirmed that barley is the best fit to be interplanted with acacia + *M. arborea* averaged over its applied densities compared with vicia as far as the total fresh and dry fodder production of the proposed agroforestry plantations is concerned.

Along the same line, Pressland (1976); Ahuja *et al.* (1978) and Bakhshish *et al.* (1980) reported a higher productivity of herbaceous crop if interplanted with acacia. Meanwhile, Shekhawat (1988) found no effect on acacia production for such interplanting.

Fresh and dry fodder production of the proposed plantations (acacia + *M. arborea*, averaged over the applied population densities + barley or vicia) was significantly higher when fertilized with phosphorus + sulphur fertilization treatment during soil preparation at early winter. The obtained fresh fodder production was 2.14 ton/feddan for the fertilized treatments and 1.66 ton/feddan for the control treatment with a significant difference, being 0.53 and 0.38 ton/feddan for the relevant dry production, respectively.

This result proved the favourable effect of the applied phosphorus + sulphur in improving the calcareous soil condition in respect of its physical and chemical structure for the sake of growth and development of each component of the proposed agroforestry plantations.

In conclusion, the appropriate productivity of agro-forestry fodder plantation consisted of 200 acacia shrubs interplanted with 400 *M. arborea* shrubs and interspaces grown with winter herbaceous crops as barley or vicia fertilized with 300 kg superphosphate (15.5% P_2O_5) + 500 kg mineral sulphur/feddan. Components of such plantation model is recommended in Matruh desert. This is for the sake of highest fodder production, better use of natural resources, creating nice clean micro and macroenvironment and building sustainable desert development system.

3.2. <u>Total digestable nutrients (T.D.N.)</u>:

As it is known the total digestable nutrients (T.D.N.) represent the net output of the implemented set up of the grown planations in respect of animal nutrition point of view. So, such parameter is of great value for animal production in North Western Coast of Matruh area.

The effect of the applied agroforestry fodder plantation on the total digestable nutrients of each of the grown fodder component as well as the total digestable nutrients for the whole proposed plantations will be discussed in this section.

Results in Table (25, A_{15}) showed that the various applied densities of the interplanted *M. arborea* did not affect the T.D.N. of acacia fodder material. However, the T.D.N. of *M. arborea* slightly varied according to the applied population densiies in T.D.N. accompanied by the increase in the population densities of the interplanted *M. arborea* shrubs from 100 up to 400 shrubs/feddan with a respective T.D.N. values of 45 and 49% with a significant increase of 9%. This obtained increase in the T.D.N. of *M. arborea* fodder may be due to the obtained increase in the carbohydrates and fiber contents of such fodder materials as discussed earlier (Tables 19 and 21).

The T.D.N. of barley (58%) was slightly higher than vicia (52%) with a significant difference. This result may be due to the higher carbohydrates and fiber contents of barley (Tables 19 and 21) as compared with vicia.

Results also showed that each component of the grown plantation exhibited an increase in its T.D.N. due to the applied phosphorus + sulphur fertilization treatment as compared with the control. Averaged over the two years, T.D.N. content for each component of the grown plantation for the applied phosphorus + sulphur treatment compared to

Table (25) : Total digestable nutrients (TDN) of the component of the proposed fodder plantations .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot														
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M			Grand Mean		
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
Acacia saligna															
Without	43	41	42	41	37	39	39	41	40	41	41	41	41	40	41
With	45	41	43	48	40	44	43	43	43	44	42	43	45	42	44
Mean	44	41	43	45	39	42	41	42	42	43	42	42	43	41	42
L.S.D. at 5% for :	Density (D) = NS D x F = 1.6			Species (S) = NS			Fertilizer (F) = 0.8								
Medicago arborea															
Without	41	43	42	46	45	46	45	46	46	46	46	46	45	45	45
With	48	46	47	50	49	50	50	50	50	51	49	50	50	49	50
Mean	45	45	45	48	47	48	48	48	48	49	48	49	48	47	48
L.S.D. at 5% for :	D = 1.9 S x F = 1.4			S = NS			F = 0.9								
Herbecious crops (Barley & Vicia)															
Without	56	50	53	57	47	52	59	50	55	61	60	60	57	52	55
With	57	51	54	57	49	53	57	53	55	61	60	61	58	53	56
Mean	57	51	54	57	48	53	58	52	55	61	60	61	58	52	55.5
L.S.D. at 5% for :	D = 1.3			S = 1.2			F = 0.6								

the control was 44 vrs 41% for acacia, 50 vrs 45% for *M. arborea*, 58 vrs 57% for barley and 53 vrs 52% for vicia. This increase in T.D.N. for each fodder component of the grown plantation by the applied phosphorus + sulphur treatment compared to the control matches real well with the increase in the carbohydrates and fiber contents as discussed in Tables 19 and 21 .

It should be pointed out that the applied phosphorus + sulphur fertilization treatment to the calcareous soil of high pH and some nutrients limitations exerted its effect in correcting such situation which was reflected on the productivity and quality of the proposed set up of the agroforestry fodder plantation system.

The ultimate target of this study is to increase the productivity and quality of the grown fodder materials (perennial shrubs and the interplanted herbaceous fodder crops) per unit area of land. Also, it i of great important to estimate the total fresh and dry production for the whole grown fodder components per unit area of land as previously discussed.

Along the same line, average T.D.N. for each of the grown fodder components will give an appropriate estimate for the quality of any of the grown plantations in general. This particular parameter will refer to the net out put of

T.D.N. and the low quality fodders will be improved if interplanted with relatively higher quality one as it is clear from Table (26).

It should be pointed out that data in Table (27) are presented to show the average T.D.N. for the components of the grown plantations whether it was fertilized with phosphorus + sulphur treatment or not. Minimum and maximum limits of the obtained T.D.N. were also presented.

It could be concluded that under the arid desert conditions of calcareous soil through intensification and interplanting of fodder shrubs and herbaceous fodder crops properly fertilized we could achieve the following: 1. Higher fresh and dry fodder production; 2. Higher quality of balanced fodders; 3. Upgrading the quality of the low quality fodder material such as acacia when interplanted with other higher quality fodders (*M. arborea*, vici or barley); 4. Better platability fodder production from the annual point of view from interplanted different fodder plntations; 5. Creating soft macro and microenvironment within the different plant canopies; 6. Generating better symbiotic and synerggestic relations within the components of the grown fodder plantations; 7. Better use of the available natural resource especially water and land; 8. Supply of fodder materials through the

Table (26) : Average TDN for each set up of the proposed fodder plantations .

(P + S) Fertilization treatment	Density : No of acacia (A) + M. arborea (M)/plot												Grand Mean		
	200 A + 100 M			200 A + 200 M			200 A + 300 M			200 A + 400 M					
	Interplanted herbaceous forage crops: Barlev (B) or Vicia (v)														
	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean	B	V	Mean
Acacia saligna															
Without	44	41	42.5	46	42	44	46	45	45.5	48	49	48.5	46	44	45
With	48	45	46.5	50	46	48	49	48	48.5	51	51	51	50	48	49
Mean	46	43	44.5	48	44	46	47.5	46.5	47	49.5	50	49.8	48	46	47
Medicago arborea															
Without	49	47	48	49	44	46.5	49	46	47.5	51	49	50	50	47	48.5
With	52	47	49.5	53	46	49.5	51	49	50	52	50	51	52	48	50
Mean	50.5	47	48.8	51	45	48	50	47.5	48.8	51.5	49.5	50.5	51	47.5	49.3
Herbecious crops (Barley & Vicia)															
Without	47	45	46	48	43	45.5	48	46	47	49	49	49	48	46	47
With	50	46	48	52	46	49	50	49	49.5	52	50	51	51	48	49.5
Mean	48.5	45.5	47	50	44.5	47.3	49	47.5	48.3	50.5	49.5	50.0	49.5	47	48.3

Table (27): Total digestable nutrients (TDN) for each component of the proposed fodder plantations as well as its average for whole plantations.

	Component of fodder plantation					Fertilizer (P + S)		T.D.N. from the combined analysis (%)				
	Fodder shrubs			herbaceous crops								
	Acacia	(+)	*M. arborea*	Barley or	vicia	Without	With	Acaci	*M. arborea*	Barley	Vicia	Average
1	200	+	100	*		*		43	41	56	--	47
2	200	+	200	*			*	45	48	57	--	50
3	200	+	300		*	*		41	43	--	50	45
4	200	+	400		*		*	41	46	--	51	46
1	200	+	100	*		*		41	46	57	--	48
2	200	+	200	*			*	48	50	57	--	52
3	200	+	300		*	*		37	45	--	47	43
4	200	+	400		*		*	40	49	--	49	46
1	200	+	100	*		*		39	45	59	--	48
2	200	+	200	*			*	43	50	57	--	50
3	200	+	300		*	*		41	46	--	50	46
4	200	+	400		*		*	43	50	--	53	49
1	200	+	100	*		*		41	46	61	--	49
2	200	+	200	*			*	44	51	61	--	52
3	200	+	300		*	*		41	46	--	60	49
4	200	+	400		*		*	42	49	--	60	50
Minimum								37	41	56	47	
Maximum								48	51	61	60	
Average								42	47	58	53	

whole year and using the surplus of fodder production during winter seasons; 9. Implementation of sustainable desert development system in Matruh desert; 10. Upgrading the potentialities of animal production in the desert using its own natural feed production in an efficient balanced manner; 11. Maintaing a nice clean environment for the settlers of desert communites in Matruh desert; and 12. The economical viability aspect of the proposed agroforestry fodder plantation could be very well achieved and accepted.

SUMMARY

This experiment was conducted at El-Qasr area in Matruh during two growing seasons of 1991/92 and 1992/93. The soil is calcareous in nature of pH 8.0 - 8.5.

The study included sixteen treatments which were the combination of 4 population densities of Medicago arborea (100, 200, 300 and 400 shrubs/feddan) within the acacia shrubs (200 shrubs/feddan); 2 herbaceous fodder crops (Barly and Vicia) were interplanted at the interspaces of acacia and arborea shrubs, and 2 fertiliztion treatments of a mixture from 300 kg calcium superphosphate (15.5 P_2O_5) + 500 Kg mineral sulphur per/feddan and the control.

Experimental design was split-split plot, with three replications. The population densities of *Medicago arborea* were randomly arranged in main plot, the 2 herbaceous crops (Barley and Vicia) were assigned randomly in the sub-plots, and fertilization treatments were located in the sub-sub plots.

The main results could be summarized as follows :

Acacia Saligna :

1. Fresh and dry fodder yields of acacia were significantly decreased as the population densities of the interplanted M. arboria increased from 100 up to 400 shrubs/feddan. The highest fresh (215 kg/feddan) and dry (71 kg/fedan) fodder yields of acacia shrubs, were obtained when the population density of

the interplanted *M. arboria* was 100 shrubs/feddan. Whereas, the lowest fresh (154 kg/feddan) and dry (55kg/feddan) fodder yield of acasia were obtained at the densest population (400 shrubs/feddan).

2. Number of branches per acacia shrubs and its crown volume were significantly increased in value as the number of the interplanted *M. arborea* shrubs increased from 100, 200, 300 and up to 400 shrubs/ feddan.

3. Height of shrubs of acacia was not significantly affected by the applied population densities of the interplanted *M. arborea* shrubs. However, its stem diameter decreased but did not reach the level of significance.

Fresh and dry fodder yields of acacia were significantly higher when the interplanted herbaceous crop was vicia rather than barley. The obtained fresh fodder yield of acacia was 206 kg/feddan when the interplanted herbaceous crop was vicia compared to 160 kg/feddan where the interplanted crop was barley. The respective dry yield was 66 and 58 kg/feddan. A reduction of 29 and 14% for fresh and dry yield were obtained, respectively.

5. Number of branches of acacia shrubs and stem diameter were slightly but significantly increased when the interplanted herbaceous crop was vicia and not barley.

6. Height of plants and crown volume of acacia shrubs were not significantly affected by the different interplanted herbaceous species.

7. Fertilization treatment of phosphorus + sulphur (300 kg calcium super phosphate : 15.5% P_2O_5 + 500 kg mineral sulphur /feddan) caused a significant increase in fresh fodder

yield of acacia shrubs (216 kg/feddan) as compared with the control (150 kg/feddan) with 44% increase. A similar behaviour was obtained for dry yield which was 73 kg/feddan for the fertilized shrubs compared with 51 kg/feddan for the control with 43% difference..

8. Height, number of branches per acacia shrub as well as its stem diameter and crown volume were significantly higher for the fertilized shrubs compared to the control. The respective values were 79 cm, 5.5 branches, 1.7 cm, and 9.7 m^3 for the fertilized shurbs compared to 6.4 cm, 4 branches, 1.3 cm and 5.8 m^3 for the infertilized ones.

The interplanted *Medicago arborea* shrubs:

9. Fresh and dry fodder yields of the interplanted M. arborea were continuously and significantly increased as the number of the shrubs increased. As the interplanted *M. arborea* shrubs increased from 100, 200, 300 and up to 400 shrubs/feddan, fresh yield was 34.7, 54.7, 65.0, and 76.7 kg/feddan. The respective dry yield was 9.1, 15.0, 18.9 and 22.8 kg/feddan.

10. Crown volume of the interplanted *M. arborea* shrubs was significantly increased with the increase in its population density per unit area of land. However, height of plants and number of branches/shrub were not significantly affected by the applied population densities of the interplanted *M. arborea* shrubs.

11. Fresh and dry fodder yields of the interplanted *M. arborea* shrubs were significantly higher when the interplanted herbaceous crop was vicia compared with barley.

12. Number of branches per shrub of *M. arborea* and its crown volume were significantly higher when the interplanted herbaceous crop was vicia rather than barley with no significant difference for the height of M. arborea shrubs.

13. The application of phosphaorus + sulphur fertilization treatment produced the highest fresh and dry fodder yield of the interplanted *M. arborea* shrubs. The obtained fresh and dry yield was 71.2 and 20.5 kg/feddan respectively for the fertilized treatments being 44.3 and 12.0 kg /feddan for the dry fodder yield.

14. Height, number of branches per shrub and crown volume of M. arborea shrubs were significantly higher for the fertilized treatment as compared with the control.

The interplanted herbaceous fodder crops:

Barley :

15. Increasing population densities of the interplanted M. arborea shrubs from 100 to 400 shrubs/feddan caused significant increase in fresh fodder yield of the interplanted barley from 2.30 to 3.27 ton/feddan. This result was not true for the dry yield since the difference was not significant.

16. Neither height of plants nor the number of tillers/sq. meter of the interplanted barley were affected by the applied population densities of the interplanted *M. arborea* shrubs.
17. Fresh and dry fodder yield of the interplanted herbaceous crop barley were significantly increased by the applied phosphorus + sulphur fertilization treatment as compared with the control. Fresh fodder yield was 3.03 vrs 2.50, and the dry yield was 0.75 vrs 0.56 ton/feddan for the fertilizer treatment vrs the control, respectively.
18. Height of plants and number of tillers/sq meter of barley were significantly increased by the applied fertilization treatment as compared with the control.

Vicia

19. Fresh fodder yield of the interplanted vicia was very much low compared to barley.
20. As the number of the interplanted *M. arborea* fodder shrubs increased from 100 to 400 shrubs/feddan, fresh yield of the interplanted herbaceous crop vicia was doubled with significant difference. This was not the case for dry fodder yield, where the difference did not reach the level of significance.
21. Height of vicia plants and the number of branches/plant were not significantly affected by increasing population densities of the interplanted *M. arborea* shrubs from 100 up to 400 shrubs/feddan.
22. Fresh and dry fodder yields of the interplanted herbecious crop vicia were significantly higher for the applied phosphorus + sulphur fertilization treatment compared with the control.

23. Height of the interplanted vicia plants and its number of branches/sq meter were significantly higher for the fertilized treatment as compared with the unfertilized one.

24. In comparing fresh and dry fodder yield of the two interplanted herbaceous crops, it was obviously clear that barley was of great superiority in production than vicia when interplanted with *M. arborea* and acacia shrubs .

25. Fresh and dry fodder yield of barley was 3.77 and 0.66 tons/feddan, respectively, being 0.66 and 0.11 tons/feddan for vicia. In other words, barley produced fresh and dry fodder yield of 5 folds higher as compared with vicia when interplanted with *M. arborea* and acacia shrubs.

26. Heights of the interplanted barley plants (41.8 cm) were significantly much taller than those of vicia (15.7) due to their different nature of growth.

27. The interaction effect of the applied population densities of the interplanted *M. arborea* shrubs x the interplanted herbaceous fodder species x the applied phosphorus + sulphur fertilization treatment on its fresh and dry fodder yield was significant, So, the highest fresh and dry fodder yields of acacia were produced when acacia was interplanted with the highest population density of *M. arborea* shrubs (400/feddan) and the interspaces were interplanted with the herbaceous fodder crop barley where the whole plantation was fertilized with phosphorus + sulphur treatment. Such interaction effect of the above factors was significant.

28. The interaction effect of the above three factors had also significant effects on the height of acacia plants, and its crown volume.

29. The highest fresh and dry yields of *M. arborea* were obtained when the interplanted herbaceous fodder crop was barley and the whole plantation was fertilized with phosphorous+ sulphur treatment. The same interaction had a significant effect on fresh and dry yield of the interplanted herbaceous fodder crops.

30. Chemical constituents and the total digestable nutrients (TDN) of the grown fodder components of the proposed agroforestry plantations as affected by the interplanted population densities of M. arborea could be summarized as follows :

M. arborea Shrubs/feddan	P	CH_20	CP	CF	EE	TDN
			(%)			
Acacia saligna						
100	0.16	13.6	18.4	21	3.9	43
200	0.13	15.6	18.3	22	3.1	42
300	0.12	18.9	17.2	23	3.0	42
400	0.11	21.5	17.1	25	2.7	42
L.S.D. at 5%	0.01	1.4	0.4	N.S.	N.S.	N.S.
Medicago arborea						
100	0.16	31	18.1	13	3.5	45
200	0.14	32	17.9	17	3.3	48
300	0.13	34	17.2	18	3.0	48
400	0.12	37	16.3	19	2.2	48
L.S.D. at 5%	0.01	1.4	N.S.	1.3	N.S.	1.9
Barley (*Hordium vulgare*)						
100	0.16	34.9	17.8	22.4	5.4	57
200	0.15	36.0	13.6	24.2	6.2	57
300	0.12	37.5	13.4	25.0	6.2	58
400	0.11	38.7	14.0	25.9	7.0	61
L.S.D. at 5%	0.02	1.3	N.S.	1.0	N.S.	1.3
Vicia (*Vicia monatha*)						
200	0.12	20.3	21.3	17.2	6.2	51
400	0.11	22.5	18.2	17.8	6.1	48
600	0.10	28.5	16.8	18.8	6.4	52
800	0.08	33.8	20.5	19.9	7.4	60
L.S.D. at 5%	0.02	1.3	N.S.	1.0	N.S.	1.3

31. Chemical constituents and the total digestable nutrient (TDN) of the interplanted herbaceous fodder crops as affected by the proposed agroforestry plantations systems could be summarized as follows :

M. arborea Shrubs/feddan	P	CH_20	CP	CF	EE	TDN
			(%)			
with Acacia saligna						
Barley	0.15	19.1	16.6	24	3.3	43
Vicia	0.11	15.6	18.8	22	3.1	41
L.S.D. at 5%	0.02	1.4	5.4	1.7	N.S.	N.S.
with Medicago arborea						
Barley	0.14	35	17.6	18	2.9	48
Vicia	0.13	32	17.0	15	3.0	47
L.S.D. at 5%	0.01	0.9	N.S.	1.1	N.S.	N.S.

32. Chemical constituents and the total digestable nutrient (TDN) for the components of the grown agroforestry plantations as affected by the applied phosphorus + sulphur fertilization treatment are summarized as follows :

M. arborea Shrubs/feddan	P	CH_20	CP	CF	EE	TDN
			(%)			
Acacia saligna						
Control	0.11	15.9	16.1	24	3.0	41
Fertilizaed	0.15	18.8	19.3	21	3.4	44
L.S.D. at 5%	0.01	1.0	0.3	0.8	N.S.	0.8
Medicago arborea						
Control	0.12	30	16	18	2.9	45
Fertilized	0.15	36	18.6	15	3.1	50
L.S.D. at 5%	0.01	1.4	0.6	0.9	N.S.	0.9
Barley (*Hordium vulgare*)						
Control	0.12	38.2	13.4	26.5	5.9	57
Fertilized	0.15	35.5	15.9	22.2	6.6	58
L.S.D. at 5%	0.01	0.7	1.0	0.5	N.S.	0.6
Vicia (*Vicia monatha*)						
Control	0.09	27.4	17.3	19.8	5.8	52
Fertilized	0.11	25.1	21.0	17.0	7.3	53
L.S.D. at 5%	0.01	0.7	1.0	0.5	N.S.	0.6

33. Total fresh and dry fodder yield per feddan were estimated and recorded from the added up of the productivity of each component of the proposed agroforestery plantation Acacia + *M. arborea* at the different population densities + Barley or Vicia). properly fertilized with phosphorus + sulphur. This parameter is of great importance in evaluating the total productivity per unit area of land for the different agroforestery plantation systems.

34. The applied agroforestry plantation systems may be of great value for selecting the best fit one regarding the requisted fodder yield and quality.

35. Proposed agroforestry plantation systems seems to be economically viable, socially accepted, environmentally feasable, and matches with the consept for sustainable desert development.