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EFFECT OF TILLAGE SYSTEMS, HILL SPACES AND POTASSIUM LEVELS ON GROWTH AND PRODUCTIVITY OF FODDER BEET

Bassal, S.A.A.; A.A. Zohry and B.S. Farghaly

Field Crop Research Institute, Agric., Res. Cent., Giza, Egypt.

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ABSTRACT: Two field experiments were conducted at El-Serw Agricultural Research Station, Damiatta Governorate during 2000/2001 and 2001/2002 growing seasons. The objective was to study the effect of two tillage system, i.e. tillage and no-tillage, three hill spaces i.e. 15, 25 and 35 cm and four potassium fertilizer levels i.e. 0, 24, 48 and 72 kg K_2O/fad on growth, yield and its components as well as quality of fodder beet "cv. Roz-Saszinu Beta". The experimental design was a split-split plot with four replicates. The main findings could be summarized as follows.

All estimated characters of fodder beet were greater with performing tillage compared with no-tillage.

Root fresh yield /fad reached its maximal with sowing fodder beet plants on 25 cm apart between hills in both seasons.

Raising potassium fertilizer level up to 72 kg K_2O/fad resulted in a significant increase in all studied characters in both seasons, except crude protein percentage in tops and roots, compared with those of the control. Root fresh yield/fad was increased by increasing potassium fertilizer levels from 0 to 72 kg K_2O /fad. However, the differences between 48 and 72 kg K_2O/fad did not reach the level of significance in most traits.

The highest root dry yield /fad of fodder beet was obtained with the application of full tillage system and 25 cm between hills in the second season. Also, root dry yield/fad reached its maximal with sowing at 25 cm between hills and fertilized with 72 K_2O/fad in the first season.

Application of full tillage system and sowing fodder beet at 25 cm with adding 48 kg K_2O /fad could be recommended for raising fodder beet productivity under the conditions of El-Serw district.

INTRODUCTION

Fodder beet (*Beta vulgaris*, L.) is one of the important forage crops in Europe. Such crop is not common in Egypt, however, great success was gained when cultivated in the new reclaimed areas of northern Egypt as a winter forage crop. The root yield as well as the above ground parts are used either for feeding animals directly or for making silage. Fodder beet is not only recommended as a good source of energy for dairy cows (Gaivoronskii, 1981) but also for cultivation on marginal soils such as salt-affected soil (Abou El-Hassan *et al.*, 1971 and Rammah *et al.*, 1984). Therefore, great efforts have been directed towards the improvement of fodder beet crop through optimizing the agronomic practices as seed-bed preparation, hill spaces and potassium fertilization.

Several studies pointed out that seed-bed preparation is considered among the most important factors limiting root yield of fodder beet and its attributing variables. Cannell and Ellis (1978) found that the different cultivation methods have an effect on soil conditions and both plant root and growth. Dragovic *et al.* (1982) reported that deep plowing is necessary for growing sugar beet crop since it improves some physical properties of the soil. Frakinet and Grevy (1982) found that tillage operation creates favorable conditions for seed germination and plant growth through improving the physical, chemical and biological properties of the soil. Hegazy *et al.* (1991) indicated that seed yield and straw yield of faba been were significantly increased with tillage (chisel plough) as compared with no tillage. Abd El-All *et al.* (1996) stated that the estimated characters of wheat were greater with performing tillage compared with no tillage. Korany *et al.* (1998) found that deep tillage tends to improve the beet growth and root size (root length, diameter and volume) and also increased the root yield. El-Tantawy (2001) found that chisel plowing (three passes) followed by leveling by Zahhafa drag was the optimum seed-bed preparation for sugar beet crop.

Concerning hill spaces, Vavilov *et al.* (1977) stated that the denser spacings produced smaller roots in which the DM content was higher than in larger roots. Plant density affects yield and yield components of fodder beet, whereas, depressing plant density was associated with diminishing fodder beet yield. Storey and Barry (1979) found that 20 cm between hills gave good results in root yield of fodder beet than 10 or 30 cm apart between hills. Kamel *et al.* (1990) found that increasing plant spacing tended to reduce root fresh and dry yields, top fresh and dry yields as well as total fresh yield of fodder beet. Gomma (1997) indicated that productivity of the individual plant were enhanced under light density planting and under dense planting the single plant produced much less. Basha (1998 b) found that denser between hills (15 cm) tended to decrease each of root diameter and top weight/plant, while the maximum root weight/plant and root yield (ton/fad) of fodder beet were obtained from sowing at 35 cm between hills. Mahmoud *et al.* (1999) found that increasing the distance between hills from 15 to 20 cm significantly increased length, diameter and weight of individual roots as well as root and sugar yields/fad of sugar beet. Bassal *et al.* (2001) stated that each increase in hill spacing until 30 cm was associated with marked increase in length and diameter of roots, top and root fresh weights/plant, while top, root and sugar yields/fad were increased with increasing hill spacing until 20 cm.

With respect to potassium fertilizer effects, Pinzariue (1975), Timirgaziue (1975) and Tirue and Pascaru (1975) reported that root yields of fodder beet were increased by increasing K-fertilizer application. Ali *et al.* (1984) found that K-fertilization has a vital role in fodder beet production. They added that the application of 75 kg K_2O/fad at planting is quite enough for best production. Abdel-Aal (1990) stated that increasing K_2O from 20 up to 72 kg /fad increased root length and diameter and total plant weight and yield /fad. El-Khawaga and Zeiton (1993) found that application of potassium fertilizer up to 80 kg K_2O/fad significantly affected all studied traits and crude protein % in both roots and tops. Basha (1994) found that adding potassium fertilizer at a rate of 100 kg K_2O/fad significantly increased root length and diameter as well as root and top weights/plant. Anton *et al.* (1995) reported that increasing potassium levels from 24 up to 96 kg K_2O/fad significantly increased root length, root diameter, root dry matter/ plant, both fresh and dry roots of fodder beet as well as foliage yields (ton/fad). El-Shafie (1996) found that increasing potassium level up to 96 kg K_2O/fad significantly increased root length and diameter, number of leaves/plant as well as root, foliage and total yields (either fresh or dry weight, ton/fad of fodder beet). Abd El-Gawad *et al.* (1997) stated that fresh and dry matter yields/fad and crude protein of roots and tops were increased with increasing potassium level up to 90 kg K_2O/fad. Basha (1998 a) found that adding potassium fertilizer at rate of 48 kg K_2O/fad increased plant height, root diameter, top weight/plant, top yield/fad and protein percentage in roots and up to 72 K_2O/fad increased root weight/plant and root yield, ton /fad of fodder beet. El-Harriri and Mirvat, Gobarh (2001) concluded that applying K_2O at 48 kg/fad increased number of leaves/plant, root characters (length, diameter and fresh weight) as well as root and top yields/fad of sugar beet.

The present study aimed to compare the effect of tillage systems, different hill spaces and potassium fertilizer levels on the growth, productivity and quality of fodder beet.

MATERIALS AND METHODS

The present investigation was conducted at El-Serw Agricultural Research Station, Damietta Governorate in 2000/2001 and 2001/2002 winter seasons. The purpose was to study the effects of two tillage systems, i.e. tillage and no-tillage, hill spaces, i.e. 15, 25 and 35 cm and potassium fertilizer levels, i.e. 0, 24, 48 and 72 kg K_2O/fad on growth, yield and yield attributes of fodder beet cv Roz-Saszinu Beta.

A split-split plot design with four replicates was used. The main plots were occupied by the two tillage systems, while sub plots were assigned to hill spaces and potassium fertilizer levels were devoted to the sub-sub plots. Each sub-sub plot contained 6 ridges, 3.5 long and 60 cm apart (12.6 m^2). The field soil experiment was clay in texture. The mechanical and chemical analysis of soil are presented in Table 1.

Table 1: The mechanical and chemical analysis of the experimental soil in 2000/2001 and 2001/2002 seasons.

Soil contents	2000/2001	2001/2002
Mechanical analysis:		
Sand %	22.80	24.70
Silt %	18.28	19.32
Clay %	58.92	55.98
Texture class	Clayey	Clayey
Chemical analysis:		
Organic matter %	1.78	1.98
Available nitrogen ppm	24.35	27.12
Available phosphorus ppm	7.68	7.85
Available potassium ppm	279.0	269.0
Soil reaction pH (1:2.5)	7.8	8.2
E.C. m-mohes (1:5)	4.1	3.8

The preceding summer crop was cotton in both seasons. Seed balls of fodder beet were sown on 10 and 15th November in first and second seasons, respectively. After one month from sowing plants were thinned to one plant per hill. Calcium Super phosphate (15.5 P_2O_5) at rate of 200 kg /fad was added pre-planting. Nitrogen in the form of urea (46% N) at the rate of 90 kg N/fad and potassium fertilizer as potassium sulphate (48% K_2O) at the previously mentioned rates were added separately in two equal doses, after thinning and after one month from thinning, respectively. Other regular agronomic practices, except the studied factors were performed as recommended in fodder beet.

At harvest (after 190 days from sowing), ten plants from each sub-sub plot were randomly taken to determine the following parameters:

1- Plant height (cm). It was measured from soil surface to the top of the highest blade.

2- Number of leaves /plant.
3- Root length (cm)
4- Root diameter (cm).
5- Top and root fresh yields (ton/fad), were recorded for two inner ridges of each plot.
6- Top dry weight (ton/fad). It was calculated by multiplying the top fresh yield/fad by dry matter percentage.
7- Root dry yield (ton/fad). It was calculated by multiplying the root fresh yield /fad by dry matter percentage.
8- Crude protein percentage in tops and roots. It was calculated by multiplying nitrogen percentage by the factor 6.25. The nitrogen percentage was determined by using two modified micro-Kjeldahl method as described by Peach and Tracy (1956).

Obtained data were subjected to the statistical analysis as the usual technique of analysis of variance (ANOVA) of the split-split plot design. The treatment means were presented and compared using the least significant difference (LSD) procedure method as mentioned by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A- Effect of tillage systems:

Data presented in Tables 2, 3 and 4 show the effect of tillage systems on growth, yield and yield components as well as quality of fodder beet in the two seasons of 2000/2001 and 2001/2002. Tillage systems had significant effects on root length, top and root fresh yields/fad, root dry yield/fad and crude protein percentage in tops (in both seasons), root diameter and top dry yield/fad (in the first season), plant height, number of leaves/plant and crude protein percentage in roots (in the second season). In general, the values of fodder beet readings were higher with the full tillage and were lower with the no-tillage.

Root fresh yields increased from 28.889 and 31.623 ton/fad with no-tillage to 30.743 and 33.017 ton/fad with full tillage in the first and second seasons, respectively. This increase in root fresh yield /fad with the full tillage may be due to the well preparation of the soil through improving the physical, chemical and biological properties of the soil. Similar results were reported by various workers including Dragovic *et al.* (1982), Hegazy *et al.* (1991), Abd-El-All *et al.* (1996), Korany *et al.* (1998) and El-Tantawy (2001).

Table 2: Plant height (cm), number of leaves /plant, root length (cm) and root diameter (cm) of fodder beet as affected by tillage systems, hill spaces and potassium fertilization in 2000/2001 and 2001/2002 seasons.

Characters / Treatments	Plant height (cm)		No. of leaves /plant		Root length (cm)		Root diameter (cm)	
	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002
A- Tillage systems:								
No-tillage	42.6	44.9	21.6	23.3	27.1	29.0	10.4	10.8
Tillage	44.7	46.8	23.0	24.8	29.3	31.5	10.8	11.2
F-test	NS	**	NS	**	**	**	**	NS
B- Hill spaces (cm):								
15	45.3	47.3	20.4	22.9	26.5	28.6	9.0	9.4
25	43.2	45.5	22.7	24.4	28.6	30.6	11.0	11.5
35	42.6	44.7	23.8	24.8	29.4	31.6	11.7	12.1
F-test	**	**	**	**	**	**	**	**
LSD (5%)	1.4	1.1	0.8	0.5	0.9	0.8	0.4	0.1
C- Potassium fertilizer levels:								
0 kg K_2O/fad	41.0	43.1	21.0	22.5	26.2	28.0	9.6	10.0
24 kg K_2O/fad	42.6	45.0	21.9	23.6	27.4	29.7	10.6	11.0
48 kg K_2O/fad	45.2	47.5	22.8	24.7	29.2	31.5	10.9	11.5
72 kg K_2O/fad	45.9	47.8	23.5	25.4	29.9	31.8	11.2	11.6
F-test	**	**	**	**	**	**	**	**
LSD (5%)	0.8	0.7	0.6	0.7	0.6	0.6	0.2	0.2

Table 3: Top and root fresh yields (ton/fad) and top and root dry yields (ton/fad) of fodder beet as affected by tillage systems, hill spaces and potassium fertilization in 2000/2001 and 2001/2002 seasons.

Characters / Treatments	Top fresh yield (ton/fad)		Root fresh yield (ton/fad)		Top dry yield (ton/fad)		Root dry yield (ton/fad)	
	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002	2000/2001	2001/2002
A- Tillage systems:								
No-tillage	7.743	8.587	28.889	31.623	1.230	1.381	4.204	4.543
Tillage	8.108	8.884	30.743	33.017	1.324	1.433	4.403	4.855
F-test	**	**	**	**	**	NS	**	**
B- Hill spaces (cm):								
15	7.438	8.374	28.468	30.863	1.197	1.321	3.964	4.517
25	8.330	9.013	31.084	33.653	1.352	1.452	4.510	4.909
35	8.009	8.820	29.897	32.445	1.282	1.449	4.435	4.671
F-test	**	**	**	**	**	**	**	**
LSD (5%)	0.188	0.180	0.692	0.627	0.036	0.034	0.069	0.134
C- Potassium fertilizer levels:								
0 kg K_2O/fad	7.222	7.957	27.207	29.331	1.046	1.147	3.802	4.196
24 kg K_2O/fad	7.828	8.598	29.567	31.838	1.259	1.378	4.188	4.616
48 kg K_2O/fad	8.213	9.135	31.086	33.693	1.380	1.539	4.535	4.921
72 kg K_2O/fad	8.438	9.252	31.407	34.417	1.423	1.565	4.688	5.064
F-test	**	**	**	**	**	**	**	**
LSD (5%)	0.217	0.183	0.606	0.610	0.042	0.042	0.104	0.129

B- Effect of hill spaces:

Data in Tables 2, 3 and 4 show the effect of hill spaces on growth, productivity and quality of fodder beet in both seasons. Results revealed that all estimated characters were significantly affected by the hill space in the two seasons, except crude protein percentage in tops in the second season. Number of leaves/plant, root length and diameter and top and root dry yields/fad as well as crude protein percentage in tops and roots positively responded to the increase in hill space. The lightest population (35 cm between hills) gave more space to roots to grow horizontally and its root diameter was bigger than it the lowest hill spacing (15 cm). Meanwhile, plant height was detected with the increment of hill space up to 35 cm apart between hills. This decrease in plant height of fodder beet plants may be due to the competition for light. The highest value of root fresh yield/fad of fodder beet was produced with hill space of 25 cm apart between hills in both seasons. This increase in root fresh yield/fad at hill spacing 25 cm apart between hills may be attributed to the large size and weight of roots compared with growing at 15 cm apart between hills. Also, top fresh yield reached its maximal with sowing at 25 cm apart between hills in both seasons. These results agree with those obtained by Vavilov *et al.* (1977), Storey and Barry (1979); Gomma (1997); Basha (1998 b); Mahmoud *et al.* (1999) and Bassal *et al.* (2001).

C- Effect of potassium fertilizer levels:

Results presented in Tables 2, 3 and 4 indicate that potassium fertilization had significant effects on plant height, number of leaves/plant, root length and diameter, top and root fresh yields/fad and top and root dry yields/fad as well as protein percentage in tops and roots in both seasons. Increasing potassium levels up to 72 kg K_2O/fad markedly increased all studied characters in both seasons, except protein percentage in tops and roots which were decreased with the aforementioned level (72 kg K_2O/fad) compared with the addition of 48 kg K_2O/fad. Also, plant height, root length and diameter and root fresh yields/fad as well as top dry yield/fad reached their maximal values with the addition of 72 kg K_2O/fad. However, the differences in plant height (in both seasons), root fresh yield/fad (in the first season) and root length and diameter, top fresh yield/fad and top dry yield/fad of fodder beet (in the second season) did not reach the level of significance, compared with the addition of 48 kg K_2O/fad. The increase in root fresh yield/fad of fodder beet with increasing potassium levels may be due to the role of K_2O in nutrients uptake as well as the nutritional balance which the increase of organic compounds through photosynthesis. Similar results were obtained by Pinzariue (1975), Timirgaziue (1975), Tirue and Pascaru (1975), Ali *et al.* (1984), Abdel-Aal (1990), El-Khawaga and Zeiton (1993), Basha (1994), Anton *et al.* (1995), El-Shafie (1996), Abd El-Gawad *et al.* (1997), Basha (1998 a) and El-Harriri and Mirvat, Gobarh (2001).

Table 4: Crude protein percentage in tops and roots of fodder beet as affected by tillage systems, hill spaces and potassium fertilization in 2000/2001 and 2001/2002 seasons.

Characters	Crude protein % in tops		Crude protein % in roots	
Treatments	2000/2001	2001/2002	2000/2001	2001/2002
No-tillage	8.36	8.23	7.67	7.48
Tillage	8.50	8.35	7.71	7.56
F-test	**	**	NS	**
15	8.30	8.18	7.58	7.45
25	8.42	8.27	7.72	7.51
35	8.56	8.42	7.76	7.61
F-test	**	NS	**	**
LSD (5%)	0.13	---	0.11	0.11
0 kg K_2O/fad	7.53	7.36	6.67	7.45
24 kg K_2O/fad	8.64	8.51	7.79	7.71
48 kg K_2O/fad	8.86	8.74	8.20	8.06
72 kg K_2O/fad	8.69	8.55	8.08	7.88
F-test	**	**	**	**
LSD (5%)	0.10	0.10	0.13	0.12

D- Interaction effects:

The interaction between tillage systems and hill spaces had significant effect on root dry yield/fad in the second season. The highest value of root dry yield/fad of fodder beet was obtained with the application of full tillage system and sowing fodder beet on 25 cm apart between hills, as shown in Table 5.

The interaction between hill spaces and potassium fertilization had significant effect on root diameter in both seasons and root dry yield/fad in the first season. The highest means of root diameter of fodder beet was obtained from sowing fodder beet plants on 35 cm between hills and fertilized with 48-72 kg K_2O/fad, while the maximum root dry yield/fad was taken from the treatment of 25 cm hill space and the addition of 72 kg K_2O/fad as shown in Table 6.

Finally, it can be stated that application of full tillage system and sowing fodder beet on 25 cm between hills and fertilized with 48 kg K_2O/fad was the recommended treatment to increase fodder beet production under the conditions of El-Serw district.

Table 5: Root dry yield (ton/fad) of fodder beet as affected by the interaction between tillage systems and hill spaces in 2001/2002 season.

Characters / Treatments	Root dry yield (ton/fad)		
Hill spaces (cm) / Tillage systems	15	25	35
No-tillage	4.211	4.828	4.592
Tillage	4.823	4.990	4.751
F-test	**		
LSD (5%)	0.189		

Table 6: Root diameter (cm) and root dry yield (ton/fad) of fodder beet as affected by the interaction between hill spaces and potassium fertilization.

Characters / Treatments		Root diameter (cm)		Root dry yield (ton/fad)
Hill spaces (cm)	Potassium fertilizer levels	2000/2001	2001/2002	2000/2001
15	0 kg K_2O/fad	8.5	8.9	3.641
	24 kg K_2O/fad	8.9	9.2	3.894
	48 kg K_2O/fad	9.2	9.6	4.123
	72 kg K_2O/fad	9.5	9.8	4.201
25	0 kg K_2O/fad	10.0	10.4	3.964
	24 kg K_2O/fad	11.1	11.5	4.386
	48 kg K_2O/fad	11.4	12.0	4.696
	72 kg K_2O/fad	11.7	12.0	4.996
35	0 kg K_2O/fad	10.2	10.7	3.801
	24 kg K_2O/fad	11.8	12.2	4.286
	48 kg K_2O/fad	12.2	12.8	4.787
	72 kg K_2O/fad	12.4	12.9	4.868
F-test		**	**	**
LSD (5%)		0.4	0.4	0.180

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تأثير نظم الخدمة المزرعية ومسافات الزراعة والتسميد البوتاسى على نمو وانتاجيه محصول بنجر العلف

سامى عبد العزيز عبد الحميد بصل ــ عبد الحفيظ أحمد زهرى ــ بدر سعد فرغلى
معهد بحوث المحاصيل الحقلية ــ مركز البحوث الزراعية ــ الجيزة ــ مصر

أجريت تجربتان حقليتان فى محطة البحوث الزراعية بالسرو بمحافظة دمياط خلال موسمىالزراعة ٢٠٠٠/٢٠٠١ و ٢٠٠١/٢٠٠٢ لدراسة تأثير نظم الخدمة المزرعية (خدمة وبدون خدمة) ومسافات الزراعة (١٥، ٢٥ ، ٣٥ سم) ومعدلات السماد البوتاسي المختلفة (صفر ، ٢٤، ٤٨، ٧٢ كجم أكسيد بوتاسيوم) والتفاعل بينهم على النمو والمحصول وجودته لبنجر العلف صنف روزساسزينو بيتا وقد استخدم تصميم القطع المنشقة مرتين فى أربع مكررات وتتلخص أهم النتائج المتحصل عليها فيما يلى:

١ــ أثرت نظم الخدمة المزرعية معنويا على طول الجذر والمحصول الطازج للعروش والجذور والمحصول الجاف للجذور بالطن/فدان وكذلك نسبة البروتين الخام فى العروش خلال موسمى الزراعة وقطر الجذر والمحصول الجاف للعروش بالطن / فدان فى الموسم الأول وطول النبات وعدد الأوراق / نبات وكذلك نسبة البروتين الخام بالجذور فى الموسم الثانى وبصفة عامة فقد زادت قيم المتوسطات للصفات المدروسة عند إجراء عملية الخدمة بالمقارنة بعدم الخدمة.

٢ــ أشارت النتائج أن مسافات الزراعة قد أثرت معنويا على كل الصفات تحت الدراسة خلال موسمى الزراعة عدا صفة نسبة البروتين الخام فى عروش بنجر العلف فى الموسم الثانى وقد بلغ المحصول الطازج للعروش والجذور بالطن/فدان أقصاه عند زراعة بنجر العلف على مسافة ٢٥ سم بين الجور خلال موسمى الزراعة.

٣ــ كان للتسميد البوتاسى تأثيرا معنويا على كل الصفات تحت الدراسة خلال موسمى الزراعة ونتج عن زيادة معدل التسميد البوتاسى حتى ٧٢ كجم أكسيد بوتاسيوم / فدان زيادة معنوية فى كل الصفات المدروسة خلال موسمى الزراعة عدا صفتى نسبة البروتين الخام فى العروش والجذور وذلك بالمقارنة بمعاملة الكنترول وزاد المحصول الطازج للجذور من ٢٧,٢٠٧ إلى ٣١,٤٠٧ ومن ٢٩,٣٣١ إلى ٣٤,٤١٧ طن / فدان بزيادة معدل التسميد البوتاسى من صفر إلى ٧٢ كجم أكسيد بوتاسيوم/ فدان فى الموسم الأول والثانى على التوالى. ووجد أنه لا يوجد فرق معنوى بين إضافة ٤٨ أو٧٢ وحدة بوتاسيوم لمعظم الصفات تحت الدراسة.

٤ــ أوضح التفاعل بين عوامل الدراسة أن أعلى محصول جاف للجذور (طن/فدان) تم الحصول عليه من تطبيق نظام الخدمة المزرعية وزراعة نباتات بنجر العلف على مسافة ٢٥ سم بين الجور وكذلك بلغ قطر الجذر أقصاه عند الزراعة على مسافة ٣٥ سم بين الجور وإضافة السماد البوتاسى بمعدل ٤٨ ــ ٧٢ كجم أكسيد بوتاسيوم/ فدان بينما بلغ المحصول الجاف للجذور طن/فدان أقصاه عند الزراعة لنباتات بنجر العلف على مسافة ٢٥ سم بين الجور والتسميد البوتاسى بمعدل ٧٢ كجم أكسيد بوتاسيوم /فدان .

عموما توصى الدراسة بضرورة إجراء عملية الخدمة المزرعية والزراعة على مسافة ٢٥ سم بين الجور مع إضافة السماد البوتاسى بمعدل ٤٨ كجم أكسيد بوتاسيوم /فدان وذلك بهدف زيادة إنتاجية محصول بنجر العلف تحت ظروف منطقة السرو.