**IMPACT: International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS)**
**ISSN(E): 2321-8851; ISSN(P): 2347-4580**
**Vol. 2, Issue 4, Apr 2014, 67-72**


# INTERCROPPING OF *ATRIPLEX HALIMUS, SALSOLA VERMICULATA* AND BARLEY FOR SUSTAINABLE FEED PRODUCTION UNDER RANGELAND CONDITIONS IN JORDAN

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## ABSTRACT

The Jordanian rangeland has been deteriorated due to successive drought and human misuse. The present study was conducted at Al-Majjediah village during 2012 and 2013 and aimed to study the effect of intercropping fodder shrubs and barley in the grazing productivity and stocking rate using different cropping systems. The study was analyzed using Randomized Complete Block Design including planting methods. High significant differences had noticed of fresh and dry yield between years. Year 2012 was more productive than 2013. Survival % was higher for *Salsola*, and *Salsola*-barley compared with *Atriplex*, and *Atriplex*-barley systems. *Atriplex* and *Salsola* had more fresh and dry yield compared with *Atriplex*-barley, and *Salsola*-barley systems. In the other side, *Atriplex*-barley and *Salsola*-barley treatments showed high significant differences for biological yield, total dry yield and stocking rate. In addition, stocking rate was higher for *Atriplex*-barley and *Salsola*-barley in comparison with *Atriplex*, *Salsola* and barley systems. Intercrop barley with fodder shrubs isn't recommended under rangeland conditions or low rainfall areas. Further studies are required to investigate the effect of soil plowing for barley planting, supplemental irrigation and nutritive value improvement.

**KEYWORDS:** *Atriplex halimus*, Barley, Intercropping, Rangeland, *Salsola vermiculata*

## INTRODUCTION

The Jordanian rangeland have been deteriorated during the past fifty years due to successive drought and human misuse especially plowing for barley cultivation, early grazing and over grazing [1]. Restorations of rangelands are essential issues and they need different technical options [2]. One of these options is the re-establishment of native fodder shrubs by enhancing their natural regeneration or introduces them by plantations such as saltbushes mainly *Atriplex* spp. and Narrow-Leaved Salt worth mainly *Salsola* spp. [2]. Fodder shrubs play an important role in rangeland rehabilitation programs in the arid and semi-arid mediterranean zone, not only as a feed reserve but also for soil water conservation in the degraded regions [2]. Therefore, in the present study *Atriplex halimus*, *Salsola vermiculata* and barley (*Hordeum vulgare*) are intercropped together. *A. halimus* and *S. vermiculata* are shrubs with deep root system while, *H. vulgare* is an annual cereal with shallow root system. Barley is the most widely distributed field crop because of its tolerance to adverse climatic conditions. If moisture is a limiting growth factor, barley is the most productive of any cool-season cereal and tolerates high temperatures above $32^0$C. Also, its suit heavy soils with 7 – 8 pH degree and it is the most salt tolerance of the field crops [3].

Intercropping is the production of two or more crops simultaneously on the same field. Land use can be improved when using successful intercropping when compared with single cropping [4] [5]. Intercropping is widely practiced in

Latin America, Asia, and Africa as a means of increasing crop production per unit area with minimal risk of yield crop failure [6]. Farmers were growing shrubs in widely spaced rows and plant crops between them in large scale plantations in Libya and Spain [7]. *Atriplex* shrubs planting is recommended for rangeland rehabilitation, but growing barley between atriplex hedges may be the best compromise, providing complementary feed sources and soil protection against wind erosion [8]. In Syria, six years results showed little interaction between hedges and barley crop, but growing the two crops together tended to buffer total feed output against annual fluctuations due to rainfall variability [8].

The study indications that barley- *Atriplex* systems have the potential to provide sustainable production system in currently degraded steppe areas, but essential conditions for success will be full control of land access and skilled management of *Atriplex* shrubs [8]. Intercropping is one of the multiple cropping systems that has been practiced by farmers for many years in various ways and most areas, and has played a very important role in China [9]. High interaction between plant species is expected by using intercropping systems [10]. Intercropping systems may involve mixtures of annual crops with annuals, annuals with perennials, or perennials with perennials [11].

Barley is prefer to grow for local communities because of its quick returns and cash sales in favorable years and Bedouin codes of property rights respect crops but do not distinguish between planted shrubs and open access rangeland [12]. To the best of our knowledge no studies conducted in Jordan to study intercropping fodder shrubs with barley. Therefore the present study had been conducted. The objectives of this study were: 1) to study the effect of intercropping fodder shrubs and barley in the grazing productivity and 2) to investigate the stocking rate using different planting system.

## METHODOLOGY

The present experiment was conducted in Al-Majjediah village at Muwaqqar Province. It is located about 60 km South East Amman With an average annual rainfall of 150 mm. The experimental site land slope was 5%. Intercropping of barley planted between the fodder shrubs contour ridges was used. Fodder shrubs (*A. halimus* and *S. vermiculata*) form the deep root system plants and the local 2-rows barley (*H. vulgare*) form the shallow root system plants were used. Five treatments had been selected for the implementation of this study. The treatments were 1) *A. halimus*, 2) *S. vermiculata*, 3) *H. vulgare*, 4) *A. halimus-H. vulgare* and 5) *S. vermiculata-H. vulgare*. The area of each treatment was 0.1 ha. The shrubs were planted on 2008 using water harvesting technique in contour ridges. Spacing between contour ridges was 4 m while 2 m between shrubs. Barley seeds were planted on November for two years (2011 and 2012) between shrubs contour ridges. The barley seeds were broadcasting and plough by chisel plow with a seeding rate of 100 kg $ha^{-1}$.

### Plant Measurements

**Fodder Shrubs:** The shrubs yield of *A. halimus* and *S. vermiculata* was estimated using Reference Unit technique [13]. Recording size of sample shrubs was detected according to a selected branch for each type. Fifteen shrubs were randomly selected within each treatment and the following measurements were taken: Survival percentage (SU), fresh yield (FY) shrub growth weight of above ground, browse yield (BY) leaves and twigs less than 5 mm thin weight and dry yield (DY) BY weight after drying at $70^0$C for 48 hours. The allowable yield (AY) was calculated as a 50 % of DY.

**Barley:** Five samples of 1 $m^2$ were taken on April 2012 and 2013. Plant height was measured from land level to spike end without awns, tillers number per plant. Thereafter, samples were clipped and weighted for biological weight. Plants were threshed manually hereafter seeds separated and weighted to determine grain weight. Both biological yield

(BIY) and grain yield (GY) were calculated. The harvest index (HI) was calculated using the formula according to Stoskopf [4]:

**HI = (GY / BIY) * 100%**

Where,

**GY:** Grain weight.

**BIY:** Biological weight.

Based on total dry matter production (BIY and AY) and 2 kg sheep consumption/day, Stocking rate (SR) was calculated as the head number of sheep that can be grazed for 30 days $ha^{-1}$.

**Experimental Design and Statistical Analysis:** The experiment was planted using Randomized Complete Block Design (RCBD) with 3 replicates. Years were added as independent variable so data were analyzed using split block in RCBD arrangement. Years were in the main plots and the cropping systems were in the sub-plots. Number of replicates was three. A general linear model (GLM) procedure was used for analyzing the data [14]. The independent variables included in the model were years and cropping systems, while the dependent variables were SU, FY, BY, DY, TDY and SR.

## RESULTS

The rainfall amount was 104.2 and 61.4 mm during 2011/2012 and 2012/2013 growing seasons in Al-Majjediah village "Figure 1". It is forms 69.5 % and 40.9 % of the region average for 2011/2012 and 2012/2013, respectively.

### Main Effects

**Year Effect:** FY between years showed high significant differences (P>0.0001). They recorded 2114.9 and 988.4 kg $ha^{-1}$ for 2012 and 2013, respectively. Also, fodder shrubs DY showed high significant differences (P>0.0001). They were recorded 317.3 and 146.9 kg $ha^{-1}$ for 2012 and 2013 years, respectively.

**Cropping Systems Effects:** Barley-*Salsola* and *Salsola* cropping systems showed high survival % (P<0.0001) in comparison with *Atriplex* and barley-*Atriplex*. In addition, barley-*Atriplex* and barley-*Salsola* cropping systems showed high of FY and DY (P<0.05) compared with *Atriplex* and *Salsola* cropping systems "Table 1".

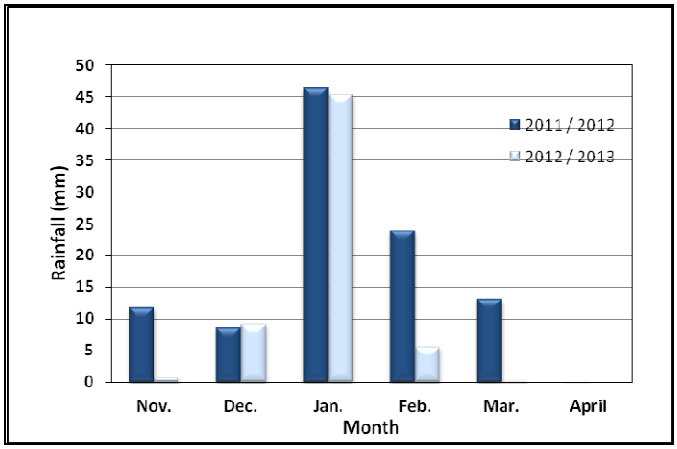


**Figure 1: Rainfall Amount and Distribution in Al-Majjediah Village on 2011/2012 and 2012/2013**

**Table 1: Means of Survival %, Fresh Yield and Dry Yield for *Atriplex*, *Salsola*, Barley-*Salsola*, Barley-*Atriplex* and Barley Cropping Systems Planted at Al-Majjediah Village on 2012 and 2013**

| Treatment* | *Atriplex* | *Salsola* | Barley+ *Salsola* | Barley+ *Atriplex* |
|---|---|---|---|---|
| Survival (%) | 66.7 c | 89.5 a | 85.1 ab | 71.9 bc |
| Fresh Yield (kg ha$^{-1}$) | 1543.8 bc | 994.5 c | 2140.2 ab | 2719.2 a |
| Dry Yield (kg ha$^{-1}$) | 201.45 b | 179.06 b | 385.34 a | 354.76 a |

Means with the same letter in the same row are not significantly different. *The treatment No. 5 (Barley) had no survival percent, fresh yield and dry yield

**Interaction Effects between Fodder Shrubs and Barley**

**Browse, Total Dry Yield and Stocking Rate for the Interaction between Years and Cropping System**

In 2012 the highest BY were recorded with *Atriplex* and *Salsola* treatments (P=0.04) when compared with 2013 with the same treatments (Table 2). The BY, TDY and SR were significantly different (P<0.0001) using *Atriplex*-barley and *Salsola*-barley treatments in 2012 as compared with 2013 “Table 2”.

## DISCUSSIONS

The Jordanian rangeland has been deteriorated due to successive drought and human misuse. Restorations of rangelands are essential issues and they need different technical options. One of these options is intercropping fodder shrubs (*Atriplex* and *Salsola*) and barley. In the present study 5 cropping systems were studied for 2 years (2012 and 2013) in order to study the effect of intercropping between fodder shrubs and barley in the grazing productivity and high SR using different cropping systems.

The year 2012 was more productive and SR due to the highest amount of rainfall (104.2 mm) in comparison with 2013 (61.4 mm). Agriculture can be improved by water harvesting through directing and concentrating rainwater runoff to the plants and other beneficial uses [15]. Barley treatment had the highest BIY due to the fact that the area was planted by barley was 100 % (for barley) and 87 % (for intercrop with fodder shrubs). Intercropping barley with fodder shrubs had been increased both TDY and SR. Those results contribute to planting spacing between contour ridges by barley.

The average of TDY of *Atriplex*-barley and *Salsola*-barley treatments was increased by 47% (compared to barley), 47% (compared to *Atriplex*) and 55% (compared to *Salsola*). In addition, average of SR (head ha$^{-1}$ 30 day$^{-1}$) of *Atriplex*-barley and *Salsola*-barley treatments was increased by 52% (compared to barley), 76% (compared to *Atriplex*) and 75% (compared to *Atriplex*). In the present study barley yield was very low in comparison with the annual productivity (about 811 kg ha$^{-1}$ grain and 811 kg ha$^{-1}$ straw) in the Jordanian field crops lands suit barley with annual rainfall greater than 250 mm [16]. Those results (barley yield) are in accordance with those of Al-Satari et al. [17]; they showed that the BIY was 517.5, 422.2 and 351.7 kg ha$^{-1}$ using water harvesting structures in rangeland named contour ridges, traditional, and strip method, respectively.

Reduction in fodder shrubs yield was contributed to the reduction in rainfall amount and to intercrop with barley. Results are in agreement with those of Sharaiha and Ziadat [18] who showed that runoff coefficients were decreased due to barley and vetches planting under contour strips intercropping. So, fodder shrubs and barley intercrop have good potential to satisfy sustainable yield system in rangeland area, but special conditions and management for success will be need of fodder shrubs and barley intercrop such as supplemental irrigation.

Those results were agreed with Jones and Arous results [8] and disagreed with Aguilar et al., [19] who proofed

that tillage operations resulted in sediment accumulation through erosional processes and mineralization losses of organic constituents. In addition, Geerken and Ilaiwi [20] identified that barley cultivation as one major reason for increased sand erosion or its downhill deposition.

**Table 2: Means of Browse Yield, Total Dry Yield, Biological Yield (kg ha$^{-1}$) and Stocking Rate for the Interaction between Cropping Systems and Years Planted at Al-Majjediah Village on 2012 and 2013**

| Treatment | Browse Yield | | Biological Yield | | Total Dry Yield | | Stocking Rate | |
|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| *Atriplex halimus* | 1742.2 a | 655.1 cd | 0.0 d | 0.0 d | 493.1 b | 216.4 c | 5.5 c | 2.5 c |
| *Salsola vermiculata* | 1300.1 ab | 473.7 ce | 0.0 d | 0.0 d | 516.5 b | 254.2 c | 5.7 c | 2.7 c |
| *Salsola & Barley* | 604.0 cd | 220.0 de | 870.8 a | 469.6 b | 1110.7 a | 587.6 b | 22.0 a | 11.8 b |
| *Atriplex & Barley* | 989.1 bc | 371.9 de | 906.7 a | 240.8 c | 1186.5 a | 363.5 bc | 23.3 a | 6.7 c |
| Barley | 0 e | 0 e | 489.3 b | 247.3 c | 489.3 b | 247.3 c | 10.8 b | 5.5 c |

Means with the same letter are not significantly different

## CONCLUSIONS

Intercrop barley with fodder shrubs isn't recommended under rangeland conditions or low rainfall areas. So, further studies are required in order to investigate the effect of soil plowing for barley planting, supplemental irrigation and nutritive value improvement as livestock feed.

## ACKNOWLEDGEMENTS

I would like to acknowledge the financial and technical support provided by the Arab Fund for Economic and Social Development (AFESD) and International Fund for Agricultural Development (IFAD) on Badia Benchmark Project in Jordan running by ICARDA. I am highly appreciated the efforts of colleagues from ICARDA and NCARE including water harvesting and field crops staff who prepared construction for present study and project consultant.

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