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Original Article

Effect of Different Biological and Organic Nutrition Systems on Intercropping of Smooth Vetch (*Vicia dasycarpa* Ten.) and Parsley (*Petroselinum crispum* L) Production

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ABSTRACT

Intercropping is one of the most important techniques to increase diversity in an agricultural ecosystem. To investigate the quantitative and qualitative characteristics of forage in additive intercropping of (*Vicia dasycarpa* Ten.) and (*Petroselinum crispum* L.) in the spring cultivation, a study was conducted at the Educational Research complex of Jihad University of Kermanshah in 2021. The experiment was conducted using a split plot design based on a randomized complete block design with three replications. The first factor was the different nutritional treatments at four levels: control (no fertilizer), biological fertilizer (BioNPK 100) which included nitrogen fixing biofertilizer (BioN), phosphorus biofertilizer (BioP), and potassium biofertilizer (BioK)), organic animal fertilizer (Mf 100), and 50% animal manure + complete biological fertilizer (Mf 50+BioNPK 50). The second factor was the sole and intercropping systems at three levels: sole cropping of 100% *V. dasycarpa* (V100), additive intercropping of 100% *V. dasycarpa* + 50% *P. crispum* (V100P50), and additive intercropping of 100% *V. dasycarpa* + 100% *P. crispum* (V100P100). The results showed that the highest dry yield of forage was obtained with intercropping of 100% *V. dasycarpa* + 100% *P. crispum* with the integrated use of 50% complete biological fertilizer + 50% animal manure (2853 kg/ha). Complete biological fertilizer in intercropping of 100% *V. dasycarpa* + 50% *P. crispum* gained the highest dry yield (2620 kg/ha). According to results using organic animal fertilizer (40000 kg/ha) + complete biological fertilizers (100 g/ha) were recommended for medicinal forage production in Kermanshah, Iran and similar areas.

INTRODUCTION

One of the indigenous farming systems compatible with sustainable agriculture is multiple cropping, which has advantages such as reducing production risks and damages caused by pests, diseases, weeds, leaching of nutrients, nitrate losses, and soil erosion, and can improve water and nutrient use efficiency [1, 2, 3, 4]. Parsley (*Petroselinum crispum* Mill.) is a well-known culinary vegetable native to the countries of the Mediterranean region. These days, it is cultivated across the globe and widely used as a flavoring and aromatic food additive [5, 6]. Additionally, it has been discovered that the bioactive constituents of parsley exhibit a wide range of pharmacological properties, ranging from antioxidant, hepatoprotective, brain protective, anti-diabetic, analgesic, spasmolytic, immunosuppressant, anti-platelet, gastroprotective, cytoprotective, laxative, estrogenic, diuretic, hypotensive, antibacterial to antifungal activity [7]. Intercropping of two varieties of white flower vetch and local was superior to their sole cropping and intercropping of white flower vetch with Maragheh vetch in a ratio of 3 to 2 were recommended for cold and arid conditions in Maragheh and similar regions [8]. Rashnu and *et al* reported that a mixed crop of vetch and barley with a ratio of 50% vetch and 50% barley at a density of 200 seeds per m-2 with the highest LER and highest dry forage production is the

best treatment for achieving high yield in this area [9].

Tosti *et al* showed that mixed cultivation of vetch and barley under Mediterranean conditions resulted in an improvement in the LER [10]. Alizadeh and Shahbazi, investigated the production of dry forage in different ratios of intercropping of two species of Vetch, Pannonica sp. and *Vicia villosa*, and found that the average yield of dry forage in sole cropping of the vetch was 1953 kg/ha [8]. In a study on the yield and profitability of intercropping of basil and corn, Bileh Savar and Salmasi, found that the highest yield of basil seed was obtained in sole cultivation, while the highest leaf area index of corn was obtained in mixed cultivation, and the cultivation of 75% basil with corn was generally the best cultivation method [11].

It has also been reported that the crude protein (CP %) in intercropped treatments is significantly higher than sole cropping in mixed copping of corn and beans [12]. Given the increasing need for medicinal plant production and the lack of sufficient information on the use of medicinal forage in animal nutrition, this study was conducted to determine the effect of different biological and systems on the quantitative and qualitative characteristics of forage-crop with mixed copping of vetch and parsley.

MATERIALS AND METHODS

This experiment was conducted in the educational research farm of the Jahad Daneshgahi Institute in Kermanshah in 2021. The region is located at (latitude 36○, 15' N, longitude 56○, 28' E and altitude 985 m) with an altitude of 1520 m asl. To determine the physical and chemical properties of the soil, an integrated soil sample was taken from a depth of 0-30 Cm. The results of the soil samples analysis are presented in Table 1.

This experiment was conducted in a split plot design based on a randomized complete block design with three replications. The first factor was the different nutritional treatments at four levels: control (no fertilizer), biological fertilizer (BioNPK 100 g/ha) which included nitrogen-fixing biofertilizer (BioN), phosphorus biofertilizer (BioP), and potassium biofertilizer (BioK), organic animal fertilizer (Mf100), and 50% animal fertilizer (40000 kg/ha) + complete biological fertilize (Mf50+BioNPK50). The second factor was the sole and intercropping systems at three levels: sole cropping of 100% *Vicia dasycarpa*n (V100), additive intercropping of 100% *V. dasycarpa* + 50% *P. crispum* (V100P50), and additive intercropping of 100% *V. dasycarpa* + 100% *P. crispum* (V100P100).

RESULTS AND DISCUSSION

Quantitative Traits

The results of analysis of variance on quantitative traits are presented in Table 2. The results of analysis of variance showed that the simple effect of intercropping, fertilizer and the interaction between fertilizer kinds and intercropping on the dry forage yield and weed biomass were significant (Table 2).

Table 1 Physical and chemical characteristics of the soil of the test site

Zn (ppm)	Fe (ppm)	M (ppm)	Cu (ppm)	K (ppm)	P (ppm)	Organic Carbon (%)	Saturated Acidity pH	Soluble solutes ($EC\times10^6$)	Neutralizing materials (%)	Soil texture	Soil depth (cm)
0.90	11.92	22.94	1.78	448	6.43	0.99	7.43	1.9ᵒ	25	silty - clay	0-30

Table 2 Names and abbreviation of the levels of factors A and B

Treatment	Abbreviation
Factor A: Nutrition Systems	
Control	No fertilizer
NPK biological fertilizer	BioNPK100
Animal manure,	Mf100
50% NPK biological fertilizer + 50% Animal manure	Mf50+BioNPK50
Factor B: Intercropping	
Pure cropping of 100% Vetch,	V100
Additive intercropping of 100% vetch + 50% parsley	V100p50
Additive intercropping of 100% vetch + 100% parsley	V100p100

In this experiment, different nutritional treatments were assigned to the main plots and mixed cultivation treatments were assigned to the sub-plots. After preparing the soil of the experimental site, it was divided into 3 blocks, with a distance of 2 m between each block. Each block included 4 main plots with dimension of 4.5 width and 4 1ength (18 m^2) which 72 kg organic manner was applied for its relevant plot while it was 0.18 g for BioNPK and each sub-plot had 6 rows of planting, spaced 25 cm apart and 4 m in length, with a total area of 6 m^2. A space of one row was left unplanted between the sub-plots. The distance between the main plots was set at 1 m. The total number of plots in the experiment was 36.

To prepare a suitable seedbed, land preparation was done in two stages of plowing and three stages of cross-disking on December 2021. After leveling and preparing the seedbed, planting lines were created 25 cm apart from each other using the farrow on the ground. The planting of vetch was done at the end of December on both sides of the furrows, and parsley seeds were planted in the middle of the furrows with densities of 50 and 100 % as an additive mixed cultivation. In treatments that used complete biological fertilizers, the seeds were inoculated with proper biological fertilizer before planting.

The amount of vetch seeds was 100 kg ha-1 and the amount of parsley seeds was considered as 10 kg ha-1. Seeds in complete biological fertilizers (100g per 20L water for 1 ha) were inoculated with the fertilizer (in the form of a solution) and then seeds sown. The organic manner (40000 kg/ha) was added to the soil according to the proposed treatments in the design, and planting was done simultaneously. Planting was done on December 23, 2021. The planting depth was 3 cm for vetch and 2-3 mm for parsley. At the same time, the irrigation system was implemented using drip tapes and pipes, and irrigation was immediately performed. Three planting lines were created on each furrow of mixed cultivation plots, with vetch planted on the sides and parsley planted in the middle row. To control the weeds that mainly consisted of Trogopogon graminifolius, Agropyron repens, Convolvulus dorycnium, Salvia officinalis, and Carthamus oxyacantha, weeding was done manually on 2/5/2022. Chemical herbicides were not used to achieve the goals of sustainable agriculture and the production of healthy forage. The samples were completely dried and milled and transferred to laboratory for estimating quality parameters of forage, using near infrared reflectance spectroscopy (NIR) device model 7200 as a rapid and reliable method to determine the (Acid detergent fiber (ADF), Total ASH, Crude Fiber (CF), Crude Protein CP, and Neutral detergent fiber (NDF).

The sampling was done simultaneously in all plots on March 15, 2022 from the northern half of each plot for a biological yield assessment. After removing the margins, 1 m^2 quadrats were used to collect samples from each plot. The total fresh weight was measured in the field and then a 2 kg sample was taken from each plot to measure the moisture content percentage and determine the dry weight of the forage in the laboratory. All samples were separately harvested and secured in paper bags. All samples containing fresh vetch and parsley were placed inside an oven at a temperature of 70 C° for 72 h until they were completely dry. The dried samples were weighed to reach dry matter yield of each treatment.

Notably, samples that were related to intercropping, a combination of both plants was selected for assessing all traits. Initially, the normality of the data was evaluated using the Minitab software, and a test of homogeneity of variances was performed on the data. Analysis of variance and comparison of means were also performed using SAS software. Graphs were plotted using Excel software. First, an analysis of variance was performed for the measured traits, and then the means of the studied traits were compared using the Duncan multiple range test ($p< 0.05$).

Dry Forage Yield (Combination of Both Plants)

The results showed that the highest dry forage yield (1080 kg/ha) was obtained in intercropping of V100P100 using an integrated fertilizer of Mf50+BioNPK50 (Fig. 1). It appears that intercropping and the use of integrated fertilizers have led to increased vegetative growth, resulting in higher dry yield. The different root systems and spatial arrangements of plants in intercropping result in increased use of accessible resources. In general, the overall experience from mixed cultivation experiments is that the yield of each plant in mixed cultivation is lower than in sole cultivation, but the potential for total production per unit area is usually higher in intercropping [13]. Abraham *et al*. also studied the effects of intercropping and found that it maximizes the use of environmental resources and nutrient uptake from the soil, leading to an increase

in grain yield [14]. The results of the current study are consistent with these studies. Studies have shown that biological fertilizers have significant advantages over chemical fertilizers, such as not producing toxic substances in the food chain, having the ability to self-replicate, and improving the physical and chemical properties of the soil [15]. Additionally, organic fertilizers, especially animal waste compost, contain high amounts of organic matter compared to chemical fertilizers and can be used as rich sources of nitrogen, phosphorus, and potassium nutrients [16].

Table 2 Analysis of Variance the effect of fertilizer treatment and intercropping on quantitative Forage traits

S.O.V.	df	MS
		Dry Forage Yield
Replication	2	59719
Fertilizer (A)	3	41585
Error a	6	26632
Intercropping (B)	2	58411 **
A*B	6	92154 **
Error b	16	7139
CV (%)	-	11.82

ns, * and **: no significant and significant at the 5% and 0.01% probability levels, respectively

Vetch Root Length and Volume

The results of the analysis of variance showed that the effect of intercropping on root length of vetch was significant ($p< 0.05$) (Table 3).

Root Length of Vetch

The main effect of intercropping on the root length of vetch was significant ($p< 0.05$). The highest root length was obtained in intercropping of 50% vetch + 50% parsley (18.67 cm) followed by 100% vetch + 100% parsley (18.08 cm) (Fig. 2).

Root Volume of Vetch

The results of the analysis of variance showed that the effect of intercropping on volume of vetch was significant ($p< 0.05$) (Table 3).

According to figure (3) the highest yield for vetch root volume was obtained in the control treatment (0.800 cm^3) and then in the complete biological fertilizer treatment in the cultivation of 100% vetch + 50% parsley (0.767 cm^3) and in the effect of using a combined fertilizer of 50% complete biological + 50% animal manure was created in the cultivation of 100% vetch and 100% parsley (0.733 cm^3). The results of the mentioned studies are consistent with the present study and it seems that mixed cultivation and especially the use of biological and organic fertilizers have tremendous effects on the quantitative characteristics of vetch.

Forage Quality Traits (Combination of Vetch and Parsley)

Crude Protein (CP)

The results of the analysis of variance showed that the effect of fertilizer treatments on CP % was significant ($p<0.05$) (Table 4).

The results showed that animal fertilizer (25.93%) and 50% complete biological fertilizer + 50% animal fertilizer produced the highest yield in terms of CP % (Fig. 4).

Means with similar letters in each column are not significantly different by Duncan's test ($p<0.01$). see full name of treatments in Table 1

Acid Detergent Fiber Percentage (ADF)

The results showed that the effect of fertilizer kinds on the percentage of ADF was significant ($p<0.05$) according to the analysis of variance (Table 4).

According to Figure 5, the full organic fertilizer (67.30) and the control treatment (without fertilizer) (47.29) showed the highest ADF%. Shahbazi *et al*. studied the effects of chemical and organic fertilizer treatments on the yield and quality of triticale and vetch under single and multiple cropping systems in dry conditions [17]. The results showed that biological fertilizers have a significant effect on all quality traits of forage. Therefore, the use of organic-biological fertilizer system is a suitable alternative to chemical fertilizers. On the other hand, the lowest ADF and NDF% belonged to the sole cropping treatments. Perhaps these differences in results can be attributed to different conditions in the studies as well as the variability of the plant species examined. It can be concluded that the use of organic fertilizers leads to a decrease in ADF.

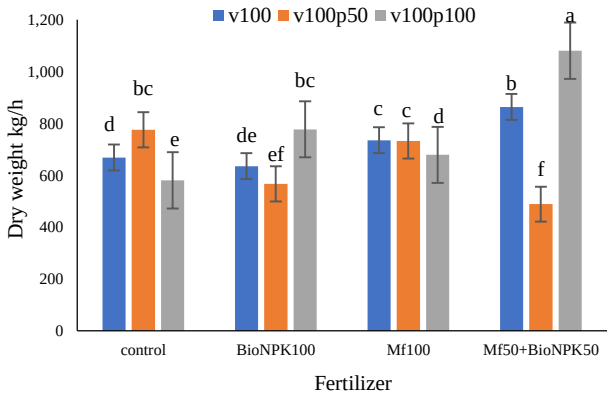

Fig. 1 The effect of fertilizer kinds and intercropping on dry fodder yield

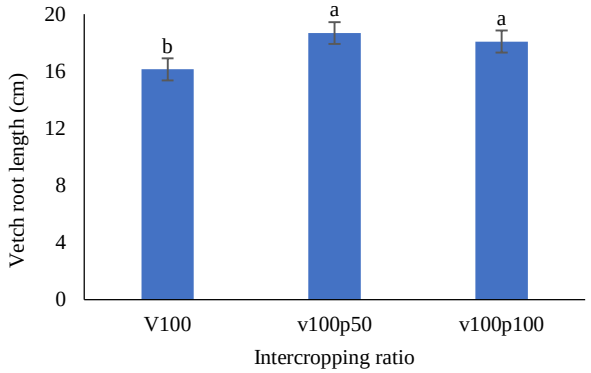

Fig. 2 Effect of intercropping on vetch root length

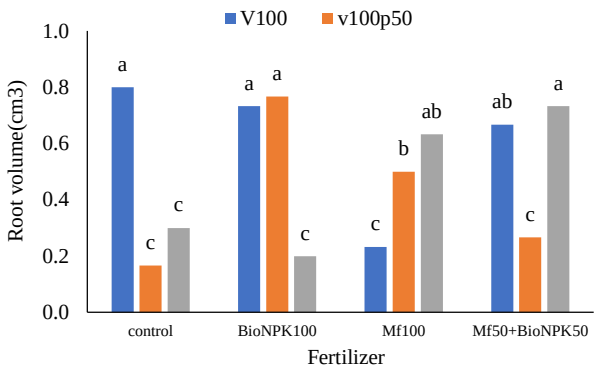

Fig. 3 Effect of intercropping on vetch root

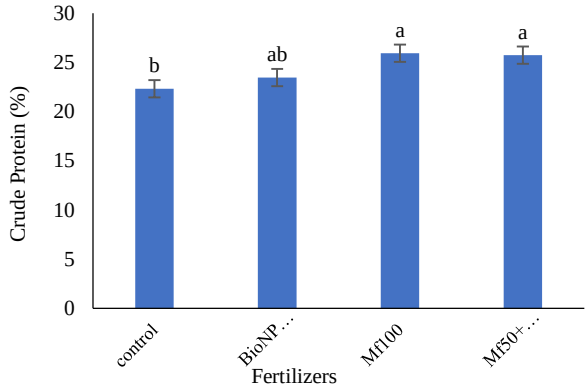

Fig. 4 Effect of fertilizer levels on CP%

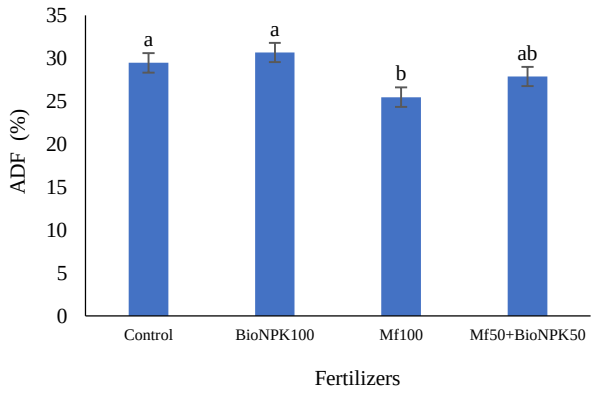

Fig. 5 The effect of fertilizer Kinds on ADF

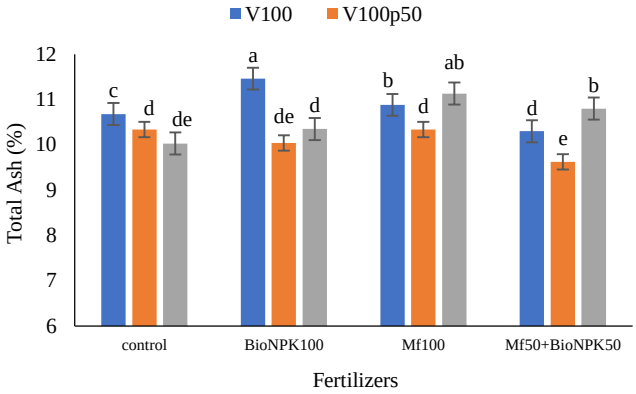

Fig. 6 Effects of Fertilizer Kinds and Intercropping on Total Ash

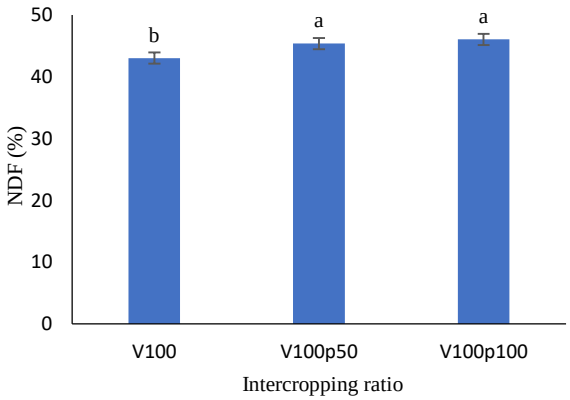

Fig. 7 Effect of intercropping on NDF%

Means with similar letters in each column are not significantly different by Duncan's test ($p< 0.01$). see full name of treatments in Table 1.

Table 3 Analysis of Variance the effect of fertilizer treatments and intercropping on root traits

S.O.V.	df	MS	
		Vetch root length	Vetch Root volume
Replication	2	1.646	0.008
Fertilizer(a)	3	4.063 ^{ns}	0.047 ^{ns}
Error a	6	5.646	0. 025
Intercropping (b)	2	21.27 *	0.111 **
A*B	6	10.71 ^{ns}	0.281 **
Error b	16	4.563	0.009
CV (%)	-	12.12	19.15

ns, * and **: no significant and significant at the 5% and 0.01% probability levels, respectively

Table 4 Analysis of Variance the effect of fertilizer treatment and mixed cultivation on Forage quality

S.O.V.	df	MS				
		CP	ADF	Total ash	CF	NDF
Replication	2	5.522 ^{ns}	19.15 ^{ns}	0. 054 ^{ns}	4.441 ^{ns}	19.14 ^{ns}
Fertilizer(A)	3	27.95 *	42.21 *	0.560 ^{ns}	6.891 ^{ns}	6.093 ^{ns}
Error a	6	4.771	7.043	0.227	9.067	7.195
Intercropping (B)	2	1.316 ^{ns}	2.488 ^{ns}	1.702 **	0.030 ^{ns}	30.18 **
A*B	6	1.431 ^{ns}	5.744 ^{ns}	0.601 **	6.209 ^{ns}	7.867 ^{ns}
Error b	16	3.913	5.465	0.141	5.243	4.369
CV (%)	-	8.12	8.24	3.58	8. 59	4.66

ns, $*$ and $**$: no significant and significant at the 5% and 0.01% probability levels, respectively

Total Ash

The results of the analysis of variance indicate that the interaction effect of intercropping and fertilization treatments is significant on the percentage of total ash ($p< 0.01$) (Table 4).

The highest percentage of total ash was observed in the sole cropping of vetch treated with complete biological fertilizer (11.46) followed by intercropping of 100% Vetch and 100% parsley treated with animal fertilizer (13.11) (Fig. 6). Jorgensen *et al* reported that the amount of ash in forage is influenced by the amount of nitrogen, such that an increase in nitrogen leads to a decrease in ash content in barley forage [18].

Crude Fiber (CF)

The effect of fertilizer treatments and intercropping on CF% was not significant (Table 4).

The results of the study by Naghizadeh and Galavi showed that both biological and chemical fertilizers had an effect on all the qualitative characteristics of the mixed corn and chickling pea forage but had no effect on the ash percentage [19]. However, in general, it can be concluded that with an increase in the levels of additive intercropping the ash percentage of the forage also increases.

Neutral Detergent Fiber (NDF)

The effect of intercropping on NDF% was significant ($p< 0.01$) (Table 4).

The highest NDF percentage was observed in intercropping of 100% vetch + 100% parsley (46.06) and in intercropping of 100% vetch + 50% parsley (38.45). It seems that intercropping had the most significant effect on the percentage of NDF compared to sole cropping. Naghizadeh and Galavi showed that intercropping and biological fertilizer have a significant effect on the NDF% [19].

CONCLUSION

Given the growing population and the increasing demand for adequate and acceptable quality food, the issue of providing forage for increasing livestock production and reducing pressure on natural pastures is always important. Today, the shortage of forage is one of the serious problems in agricultural systems in Iran, and therefore, necessary measures must be taken to increase the efficiency of forage production resources. The results of this study show that:

1.Intercropping of vetch and parsley as a medicinal forage combination improved both quantitative and qualitative traits.

2. The use of integrated organic (animal manure) and biological fertilizers (microbial bacteria and fungi) had positive effects on increasing dry fodder yield and CP% which is an ecofriendly agronomy technique for sustainable agriculture objects.

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