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Research article

EFFECT OF DIFFERENT INTERCROPPING PATTERNS ON SHOOT PARTS OF DILL AND FENUGREEK

Jalil Shafagh-Kolvanagh and Behzad Shokati *

University of Tabriz, Faculty of Agriculture, Department of Plant Eco-physiology, Tabriz, Iran
*Corresponding author, E-mail: Behzad.Shokati66@gmail.com

ABSTRACT : The importance of intercropping in farming practices has long been recognized. Due to ever increasing pressure on cultivated land for food and commercial crops, it may not be possible to increase the area under medicinal plants. One of the potential opportunities to meet the medicinal plants demand is by inclusion of medicinal plants in intercropping systems. In this sense, the field experiment was conducted during 2011at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran, based on randomized complete blocks design (RCBD) in 3 replications. In this study two types of medicinal plants involved Dill (*Anethum graveolens* L.) and Fenugreek (*Trigonella foenum- graecum*) in different additive ratio (1:20, 1:40, 1:60) and different replacement ratio (1:1, 1:2, 1:3) were intercropped. Dill by enough using of space and better using of N which were fixed by fenugreek root, in additive ratio could grow better than replacement ratio and have significant dry weight, stem dry weight, height and number of umbel where 1:20 and 1:60 ratio had highest records. But fenugreek as same as dill because of having enough space in replacement ratio could grow better and had significant dry weight, secondary fertile branch, stem dry weight and main stem number where in 1:3 and 1:2 ratio had highest record respectively. Fenugreek as a medicinal, forage and legume crop could promote dill grows characters and could be an effective plant in intercropping systems.
Key words: Additive ratio, Replacement ratio, *Anethum graveolens*, *Trigonella foenum- graecum*, intercropping

INTRODUCTION

Intercropping is claimed to be one of the most significant cropping techniques in sustainable agriculture. Much research and many reviews attribute to its utilization a number of environmental benefits, from promoting land biodiversity to diversifying agricultural outcome. Though, intercropping is thought to be a useful means of minimizing the risks of agricultural production in many environments, including those typical of under-developed or marginal areas [1]. Multiple cropping (i.e. intercropping or mixed cropping) plays an important role in agriculture because of the effective utilization of resources, significantly enhancing crop productivity compared with that of monocultured crops [2]. Interspecific competition and facilitative interactions which may occur when two crops are grown together have been extensively investigated [3, 4], and are attracting increasing interest. Interspecific root interactions have an important role in nutrient acquisition in mixed stands of plants [2]. Facilitative root interactions in mixed cropping systems are most likely of importance for the nutritional improvement of crops grown in nutrient poor soils and low-input agroecosystems [5]. In this sense, agricultural specialists suggest intercropping as a useful means for enhancing yields for one or all the consociated species, thanks to the ability of the consociated systems to reduce weeds and pests [6, 7, 8].

There are many different kinds of species that can be used for intercropping such as annuals, e.g. cereals and legumes, perennials, including shrubs and trees or a mixture of the two (annuals and perennials). In ecological terms, resource complementarity minimizes the niche overlap and the competition between crop species, and permits crops to capture a greater range and quantity of resources than the sole crops [9] for example intercropping maize with cowpea has been reported to increase light interception in the intercrops, reduce water evaporation, and improve conservation of the soil moisture compared with maize alone [10]. Nitrogen transfer from legumes to cereals has been extensively studied [11]. However, benefits of a legume intercrop with respect to nitrogen are direct transfer of nitrogen from the legume to the cereal during the current intercrop and residual effects when the fixed nitrogen becomes available on the sequential crops after the senescence of the legume and the decomposition of residues [12].

The species of family *Apiaceae* are well known source of many important herbal products [13]. Dill (*Anethum graveolens* L.) is an annual and sometimes biennial herb, which is native south-west Asia or south-east Europe and has been cultivated since ancient times [14]. The use of dill as a condiment or for medicinal purposes dates back to Egyptian times [15]. Dill herb and dill fruits are still commonly used for flavouring meat, fish, pastries and cucumbers, among others. It is used as carminative, an aromatic and an antispasmodic [16] and as an inhibitor of sprouting in stored potatoes [17].

The other species that studied in this research was Fenugreek (*Trigonella foenum-graecum* L.) which is an annual crop belonging to the legume family. This crop is native to an area extending from Iran to northern India, but is now widely cultivated in China, north and east Africa, Ukraine and Greece [18].

Fenugreek leaves and seeds have been used extensively to prepare extracts and powders for medicinal uses [19]. Over the past ten years, LRC researchers have shown that fenugreek can be a very useful legume crop for incorporation into short-term rotations [20]. Fenugreek is reported to have anti-diabetic, anti-fertility, anticancer, anti-microbial, anti-parasitic and hypocholesterolaemic, effects [21]. Fenugreek plant has an erect growth habit with a height of 0.5–0.8 meters, mainly tap rooted with one main stem. Stems have alternating branches up to 0.4 meters with alternating compound pinnate trifoliate leaves 2–3 cm long. Flowers are axillary and cream in color (1 cm long), developing into long slender (15 cm) green then yellow-brown pods [22].

Individual plant dry weights of wheat, chickpea and lentil in the glasshouse experiment, and vegetative shoot dry weight of intercropped wheat in the field experiment were significantly increased by the associated plant species as compared with their monoculture [23].

In order to validate this hypothesis intercropping system of fenugreek and dill was conducted.

MATERIAL AND METHODS

The field experiment was conducted during 2011at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (38°5N, 46°E). The area is located at an altitude of 1360 m with the annual rainfall of 285 mm. The experiment was based on randomized complete blocks design (RCBD) in 3 replications. In this study two types of medicinal plants involved Dill (*Anethum graveolens* L.) and Fenugreek (*Trigonella foenum-graecum*) in different additive ratio (1:20, 1:40, 1:60) and different replacement ratio (1:1, 1:2, 1:3) intercropped. The main and secondary crops were fenugreek and dill respectively. As dill seeds are sensitive to seed bed, though soft and smooth seed bed prepared and covered by thin layer of sand. Each plot consists of 10 rows, planted 20 cm apart and 1-2 cm deep. Optimum density for dill and fenugreek were 100 and 50 plant/m^2 respectively. Since planting no *Rhizobium* bacters were used, though nitrogen (N) fertilizer added in 2 times (25 kg/ha) during the growing period. Till to the plant's good establishment and ideal canopy formation, weeds control were regularly performed by hand. Both plants were harvested after completely ripening and laboratory measurements performed.

The measurement factors were dry weight (DW), fresh weight (FW), height, main stem nods (MSN), stem diameter (SD), stem dry weight (SDW), secondary fertile branch (SFB), dry leaf weight(DLW) and number of umbel and umbellule.

Data analysis was calculated by MSTATS and SPSS16.0 softwares.

RESULTS AND DISCUSSION

It is revealed from the present study that among all the studied factors for dill plant, fresh weight, dry weight and umbel were significant ($p \leq 0.05$) and the strong significant relation were found in height and stem dry weight factors ($p \leq 0.01$) but no significant relation were observed in main stem nod numbers and stem diameter characters (Table 1). Alizadeh *et al*, [24] also in the study of bean and basil intercropping revealed that the highest bean height was in intercropping of 2 row for basil and 4 row for bean, although in 4 row for basil and 2 row for bean the least height obtained. Though it's probably that dill height was affected by using of N, which were fixed by fenugreek root's *Rhizobium* bacteria . So consequence by using of N, plant had enough time for growing and for this reason stem weight was increased.

Table 1. Analysis of variance of the data for Dill shoot component

Source	df	FW	DW	Height	MSN	SD	SDW	Umbel	Umbellule
R	2	0.922	0.022	1.200	0.163	0.008	0.063	1.190	370.574
T	6	2.713*	1.908*	23.364**	0.237ns	0.052ns	1.088**	2.597*	274.813ns
Ea	12	0.788	0.563	3.370	0.267	0.022	0.053	0.549	215.312
Total	20								
C.V		19.01	23.79	3.29	7.66	9.60	15.88	12.30	22.03

**, *: significant at $p \leq 0.01$ and $p \leq 0.05$, respectively., Fresh Weight (FW) Dry Weight (DW), Height, Main Stem Nods (MSN), Stem Diameter (SD), Stem Dry Weight (SDW), and number of Umbel and Umbellule.

In this case the highest plant height were observed in 1:60 and 1:20 treatments (Table 2). Shafshak *et al*, [25] find that in sunflower and soybean intercropping, the lowest high were observed in highest density which is accord to our results that in pure and replacement ratio where dill density was high, plants height were lower than additive ratio.

Table 2. Means of the Dill shoot component

Treatment	FW (g/per plant)	DW (g/per plant)	Height (cm)	SDW (g)	Umbel
1(1:1)	4.603bc	2.883cd	54.67b	1.402bc	5.633cd
2(1:2)	4.930b	2.827cd	53.40b	1.341bcd	6.500abc
3(1:3)	3.520c	2.135d	54.57b	0.8980e	4.667e
4(1:20)	3.953bc	4.475a	59.47a	1.508b	6.733ab
5(1:40)	6.513a	3.163bc	53.60b	1.148cde	5.967bcd
6(1:60)	4.360bc	3.934ab	60.20a	2.734a	7.400a
7(pure dill)	4.823b	2.662 cd	55.07b	1.112de	5.267de

Fresh Weight (FW), Dry Weight (DW), Stem Dry Weight (SDW), and number of Umbel

Number of umbel in additive ratio (1:60, 1:20) was higher than the rest which is agree with Boroomandzadeh *et al*, [26] and Gill *et al* [27] who that mentioned by increasing of density, the number of umbel was decreased. Dill in additive ratio including 1:20, 1:60 and 1:40 had highest dry weight respectively (Table 2). This may cause by enough using of environmental conditions where there were low density of plants.

According to table 3, the fresh weight, dry weight, dry leaf weight and stem dry weight of fenugreek were meaningful ($p \leq 0.05$) and secondary fertile branch and had strong meaningfulness ($p \leq 0.01$) but the plant height was not significant.

Mirhashhemi *et al*, [28] results showed that different intercropping systems had no effect on plant height, primary branches, number of pods per plant, number of umbels per plant, number of umbellule per umbel, number of seeds per umbellule and 1000 seed weight, but secondary branches, seed yield and biological yield of organs in both Ajowan and Fenugreek plants and also dry weight per plant and harvest index in Ajowan were affected by intercropping systems.

Table 3. Analysis of variance of the data for Fenugreek shoot component

Source	df	FW	DW	Height	SFB	MSN	DLW	SD	SDW
R	2	19.493	0.267	8.131	2.053	1.232	0.010	0.094	0.147
T	6	22.914*	0.894*	35.929ns	2.580**	8.129**	0.094*	0.087ns	1.636**
Ea	12	5.962	0.276	12.453	0.201	0.773	0.020	0.056	0.215
Total	20								
C.V		17.32	13.00	6.17	11.03	5.34	18.73	7.99	21.68

**, *, : significant at $p \leq 0.01$ and $p \leq 0.05$, respectively. Fresh Weight (FW), Dry Weight (DW), Height, Secondary Fertile Branch (SFB), Main Stem Nods (MSN), Dry Leaf Weight (DLW), Stem Diameter (SD) and Stem Dry Weight (SDW).

According to this point that in 1:3 treatment numbers of fenugreek plants were low, then the plant could grow enough and the highest dry weight and dry leaf weight were obtained from this treatment (Table 4). In addition about fenugreek, the highest rank of both stem dry weight and secondary fertile branch were obtained in 1:2 treatment and 1:3 treatment was in second grade.

By determining of correlations between dill characters, a negative correlation between height and stem dry weight with fresh weight were found. Although a strong positive correlation between height, number of umbel and stem dry weight with dry weight were found but number of nod had no correlation with other factors. Stem diameter also had correlation with number of umbel and umbellule (Table 5).

Table4. Means of the Fenugreek shoot component

Treatment	DLW (g)	MSN	SFB	MSN	DLW(g)	SDW (g)
1(1:1)	13.35 a	3.045 d	4.100c	17.83b	0.7400b	1.506d
2(1:2)	16.10 a	4.420 abc	5.600a	19.57a	0.770b	3.706a
3(1:3)	13.706a	4.640 a	4.750b	15.80c	1.040a	2.126bc
4(1:20)	15.93 a	3.953 bc	4.000c	14.90c	1.113a	2.175b
5(1:40)	8.500 b	3.835 c	3.167d	15.60c	0.6970b	1.571cd
6(1:60)	15.22 a	3.900 bc	2.833d	15.90c	0.6530b	1.857bcd
7(pure dill)	13.33 a	4.513 ab	4.000 c	15.57c	0.9000b	2.030 bcd

Fresh Weight (FW), Dry Weight (DW), Secondary Fertile Branch (SFB), Main Stem Nods (MSN), Dry Leaf weight (DLW) and Stem Dry weight (SDW).

In about fenugreek according to table 6, although fresh weight had a negative correlation with plant height but it had positive correlation with secondary fertile branch. In addition plant high had negative correlation with SFB, MSN, DLW and SD whereas SFB had a strong correlation with MSN and SDW (Table 6).

Table 5. Dill component correlations

	FW	DW	Height	MSN	SD	SDW	Umbel	Umbellule
FW	1	.041	-.333	.059	.035	-.106	.132	.171
DW	.041	1	.667**	-.124	.315	.563**	.793**	.419
Height	-.333	.667**	1	.243	.208	.715**	.663**	.177
MSN	.059	-.124	.243	1	.069	.058	.052	.099
SD	.035	.315	.208	.069	1	.355	.477*	.613**
SDW	-.106	.563**	.715**	.058	.355	1	.715**	.143
Umbel	.132	.793**	.663**	.052	.477*	.715**	1	.405
Umbellule	.171	.419	.177	.099	.613**	.143	.405	1

**.* correlation is significant at the 0.01 and 0.05 level respectively (2-tailed). Dry Weight (DW), Fresh Weight (FW), Height, Main Stem Nods (MSN), Stem Diameter (SD), Stem Dry Weight (SDW), Secondary Fertile Branch (SFB), Dry Leaf Weight (DLW) and number of Umbel and Umbellule

In this study focused on shoot part of plants where there are a few researches about medicinal plant intercropped characters and their correlations with each other. In comparison of two intercropping planting method, additive ratio because of having enough space for dill plant growing, it could grow suitability and had highest records in this method whereas fenugreek in replacement ratio where there were low density of plants, so it had optimal condition for growing and highest records were obtained from this method (table 4). It should be mentioned. in compare of replacement ratio systems, both dill and fenugreek plants had highest record in 1:2 treatment .

Intercropping with legumes is an excellent practice for controlling soil erosion and sustaining crop production [29]. Legumes enrich soil by fixing the atmospheric nitrogen changing it from an inorganic form to forms that are available for uptake by plants. Biological fixation of atmospheric nitrogen can replace nitrogen fertilization wholly or in part. When nitrogen fertilizer is limited, biological nitrogen fixation is the major source of nitrogen in legume-cereal mixed cropping systems [31]. Moreover, because inorganic fertilizers have contributed to environmental damage such as nitrate pollution, legumes grown in intercropping are regarded as an alternative and sustainable way of introducing N into lower input agroecosystems [31].

Table 6. Fenugreek component correlations

	FW	DW	Height	SFB	MSN	DLW	SD	SDW
FW	1	.141	-.019	.510*	.129	.076	.348	.370
DW	.141	1	-.065	.217	-.083	.067	.370	.312
Height	-.019	-.065	1	-.396	-.115	-.017	-.041	.058
SFB	.510*	.217	-.396	1	.588**	-.235	.488*	.664**
MSN	.129	-.083	-.115	.588**	1	-.779**	.076	.499*
DLW	.076	.067	-.017	-.235	-.779**	1	.189	-.444*
SD	.348	.370	-.041	.488*	.076	.189	1	.459*
SDW	.370	.312	.058	.664**	.499*	-.444*	.459*	1

Fresh Weight (FW), Dry Weight (DW), Height, Main Stem Nods (MSN), Stem Diameter (SD), Stem Dry Weight (SDW), Secondary Fertile Branch (SFB) and Dry Leaf Weight(DLW).

CONCLUSION

In conclusion dill plant for suitable growing needs to enough space and in additive ratio which there were just 20, 40 and 60 percent of optimum density highest performance abtained. It could be suggested that using effect of N fertilizer which were fixed by *Rhizobium* bacteria and using of enough space for plant growing, let dill to be suitable plant for intercropping and this article showed that fenugreek could be an effective plant in intercropping system and could promote dill grows characters whereas there is a few study about two medicinal plant intercropping specially intercropping with medicinal leguminous plants such as fenugreek.

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