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Intercropping of Lentil (Lens culinaris) and Barley (Hordeum vulgare) under hydroponic system

الزراعه البينيه للعدس والشعير بنظام الزراعه المائيه

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Abstract: The purpose of this work was to examine the impact of hydroponic cultivation of legumes (lentils) and cereal (barley). Plant parameters such as length, chlorophyll content, fodder yield, and nutritive value were tested. Grains were purchased from a local market in Tulkarm. A hydroponic system was constructed using locally sourced materials and was kept under controlled temperature conditions of 22±1°C, with artificial light. Chemical analyses were performed to test plant composition. Plant length, biomass, and chlorophyll content were also measured. The results of this work demonstrated that intercropping legumes and cereals under hydroponic conditions resulted in improved plant biomass, length, percentage of chlorophyll, and nutritive value. Statistical analyses of the data showed that percent of protein in intercropping of lentil 700g/barley 300g showed a protein percentage of 38.7%, while in barley 700g/lentil 300g showed a protein percentage of 32.1%. The result showed that intercropping of barley 700g/lentil 300g group showed the highest fresh weight of 6.6 kg, while the group of lentil 700g/barely 300g showed the lowest fresh weight of 5.2 kg.

Keywords: barely, chlorophyll, hydroponic system, lentils, length, nutritive value, biomass.

المستخلص: الغرض من هذا البحث هو فحص تأثير الزراعة المائية للبقوليات (خاصة العدس) ونباتات الحبوب (الشعير) ، وكذلك تاثير الزراعة البينية لهذه المحاصيل على طول النبات ، الكلوروفيل ، انتاج العلف والقيمة الغذائية. تم الحصول على الحبوب من السوق المحلي الكائن في طولكرم. تم إستخدام نظام الزراعة المائية تحت ظروف تم التحكم في درجة الحراره والتي تراوحت بمعدل (22 ± 1 درجة مئوية) وايضا استخدام الاضاءة الصناعية. تم تصميم وبناء نظام الزراعة المائية المكون من إطار معدني باستخدام صواني محلية. تم اخذ القياسات التاليه :الطول ,الكتلة الحيوية ,الكلوروفيل والقيمة الغذائية للنبات. أظهرت النتائج أن زراعة البقوليات (العدس) بنسب مختلقه مع النجيليات(الشعير) بنظام الزراعة المائية أظهرت تحسنًا في القيمة الغذائية ، طول النبات ، الكتلة الحيوية للنبات ، ونسبة الكلوروفيل. أظهر التحليل الإحصائي للبيانات أن نسبة البروتين في الزراعة البينية من العدس 700 غم / الشعير 300 غم هي 38.7٪ ، بينما أظهرت نسبة الشعير 700 غم / العدس 300 غم ان نسبة البروتين هي 32.1%. أظهرت المجموعة التي استخدمت فيها الزراعه البينيه من الشعير 700 غم / العدس 300 غم اعطت أعلى وزن طازج 6.6 كغم ، بينما أظهرت المجموعة التي استخدمت فيها الشعير 300 غم / العدس 700 غم أقل وزن رطب 5.2 كغم

الكلمات المفتاحية: الزراعه المائيه,الشعير,العدس,الكلوروفيل,طول النبات,الكتله الحيويه,القيمه الغذائيه.

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INTRODUCTION:

Intercropping is an agro ecological approach that is widely implemented by smallholder farmers in many places including the developing countries to enhance sustainability in agricultural systems. This practice involves the simultaneous cultivation of two or more crops within the same field to maximize production benefits. Legume-cereal intercropping, with a particular focus on corn-beans intercropping, is a prevalent intercropping practice observed across various regions worldwide (Reddy et al. 1980). In addition to that, intercropping has historically been adopted by farmers as a mean of minimizing risk and maximizing the utilization of land and labor resources to ensure sufficient food production. In regions with arid climates, cowpea or groundnut are commonly grown together with beans in intercropping systems to optimize production outcomes (Chamkhi et al. 2022).

Intercropping can result in more efficient utilization of available resources, such as sunlight, moisture, and soil nutrients and potentially higher yields compared to single-crop plantation, particularly when the crops complement each other in terms of growth pattern, above-ground canopy, rooting system, water and nutrient requirements. This is because intercropping promotes an optimal use of resources, leading to a more productive use of land, and enhanced ecological intensification in agroecosystems (Ahmed and Rao 1982).

In environmentally controlled systems, filed crop grains such as barley, wheat, maize, alfalfa, oats, millets, rye, sunflower seeds, and lentils can be cultivated as a source of fodder. Utilizing hydroponic techniques in a controlled space, commercial fodder companies have reported that 1.0 kg of grain can produce 6-10 kg of fresh fodder within a 7-10 day period, provided that appropriate conditions of temperature, humidity, and light are maintained in the growing rooms (Dogrusoz 2021).

In Palestine barley is considered the main source of energy for the diets of animals and lentils is considered the main source of protein for the diets of animals. The total numbers of cultivation of both were decreased, so the intercropping approach is thought to be the finest solution for year-round availability of forages.

Hydroponic fodder production is a technique with roots tracing back to the 1800s or earlier. The fundamental principle of hydroponic fodder systems lies in the response of cereal grains to nutrient-rich solutions, including nitrogen, phosphorus, potassium, sulfur, and magnesium, for germination and rapid growth, ultimately leading to the production of green plants within a short period of time (6-9 days). One of the key advantages of this system is the absence of soil-borne disease and weed infestation, as nutrients are directly delivered to the roots of plants placed in trays of various dimensions (Ahmad et al. 2023).

The practice of intercropping legumes and cereals has gained popularity in recent times. Legumes are particularly suitable for intercropping with cereals as they have the ability to fix atmospheric nitrogen (N), reducing competition with the cereal crop for N. Interestingly, the presence of a cereal crop that exploits soil mineral N may even stimulate legumes to fix N more efficiently to assess the production efficiency of barley and lentils under hydroponic conditions (Ladha.1990).

The aims of the study

1-To compare the effect of intercropping of barley and lentils under hydroponic system on chlorophyll, plant length, nutritive value, and biomass of plant

2-To determine the percentage of chlorophyll, length, nutritive value, and biomass of lentils under hydroponic system

3- To determine the percentage of chlorophyll, length, nutritive value, and biomass of barley under hydroponic system

MATERIAL AND METHODS:

The Hydroponic System

A hydroponic system was set up in a growth chamber with controlled conditions of temperature (22 ± 1°C), artificial illumination, and a relative humidity of 65%. The growth chamber contained 10 planting shelves with a capacity to produce around one ton of green fodder per growing cycle in 8 days. For the cultivation of seeds, plastic trays (90 x 30 x 4 cm) were used.

Plant Material

Barley (*Hordeum vulgare*) and lentil (*Lens culinaris*) seeds were obtained from the local market in Tulkarm city, Palestine. The seeds were carefully cleaned to remove any debris and then subjected to surface sterilization for 30 minutes in a 20% sodium hypochlorite solution. Subsequently, the seeds were washed with water and soaked in tap water for 12 hours prior to planting. To ensure a sterile environment for the seeds to grow, the planting trays were also thoroughly cleaned and disinfected. Before planting, a germination test was carried out to assess the viability of the seeds.

Seed Planting and Irrigation

The seeds were mixed before distributed and sown in the planting trays. Drainage holes at the bottom of the trays to ensure the removal of excess water. Each tray contained 1000g of seeds, as follows: 1000g of lentils, 1000g of barley, a mixture of 700g of lentils and 300g of barley, or a mixture of 300g of lentils and 700g of barley. Manual irrigation was carried out twice a day (i.e early in the morning and late in the afternoon), with tap water at a rate of 500 ml per tray per day. Any excess water was collected in plastic containers placed beneath each planting tray, and the amount of water collected was measured and recorded to determine the total water used and water use efficiency. The trays were kept in the growth chambers for a period of 8 days, and the experiment was conducted in triplicates and repeated three times to ensure accuracy. Various measurements (mentioned bellow) were taken throughout the experiment to assess the performance of the plants.

Biomass

To assess the plant growth, the total fresh and dry weights of plants were measured. Plant samples of about 200 g from plant were harvested from each tray on days 8 for chemical analyses, and their fresh weights were recorded. Then, the samples were oven-dried at 70°C for 48 hours, and their dry weights were recorded. The moisture content of the samples was also determined. In addition, the lengths of shoots and roots were measured to evaluate the plant growth. The experiment was conducted in triplicate and repeated three times to ensure accuracy and reproducibility of the results.

Chlorophyll

The chlorophyll content of 20 seedlings was determined for each crop in each treatment using a SPAD (Soil Plant Analysis Development) device. The SPAD -502 plus is a compact meter designed to help users improve crop quality and increase crop yield by providing an indication of the amount of chlorophyll present in plant leaves. The chlorophyll content of plant leaves is related to the condition of the plant, and thus can be used to determine when additional fertilizer is necessary.

Chemical analysis

Hydroponic samples were collected and oven dried at 70° C for 48 hours, after that crude protein, crude fat, crude fiber, ash, and dry matter content were determined according to the procedure of (AOAC 2000).

Determination of moisture content

Hydroponic sample were prepared for determination of moisture contents as follows: dry the empty dishes and lid in the oven at 105°C for 3 h and transfer to desiccator to cool. Empty dishes were weighted. Weighted 3 g of hydroponic samples and added to the dishes. Spread the sample to the uniformity. Place the dishes with samples in the oven. Dry for 48 hours at 70°C. After drying, transfer the dishes with partially covered lid to the desiccator to cool. Reweigh the dishes and its dried sample, according to the procedure of (AOAC 2000).

Statistical analysis

Statistical analysis was conducted using XlStat (Adinosoft). Significant differences were computed after Tukey HSD test using ANOVA at $p < 0.05$. Means with different letters are significantly different.

RESULTS:

Effect of intercropping on moisture content (%)

The study revealed significant differences ($P < 0.05$) in moisture percentage between lentils and lentil 700g/barley 300g intercropping as compared to barley and barley 700g/lentil 300g intercropping. Lentils had a moisture percentage of 87.6% while the intercropping of lentil 700g/barley 300g had a moisture percentage of 87.4% (Figure 1).

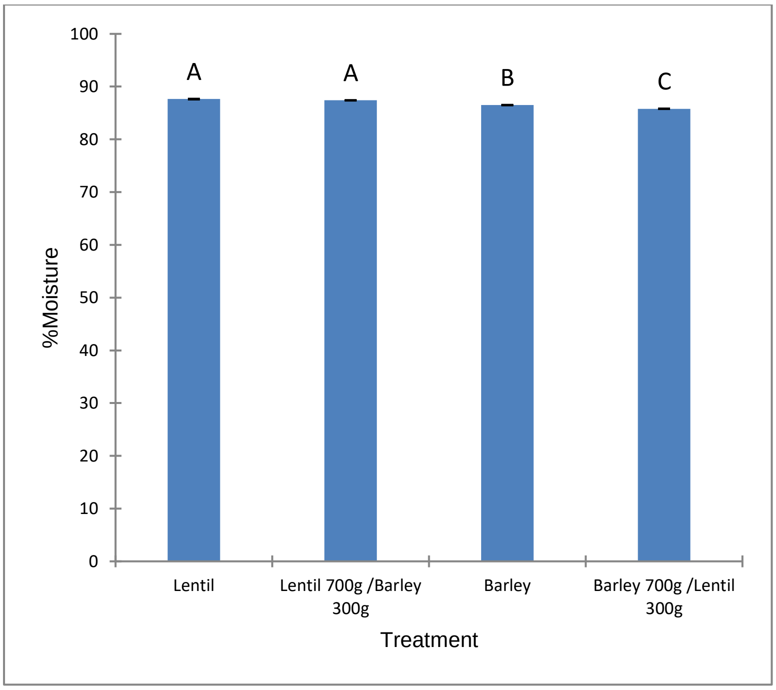

Figure 1: percentage of moisture content

Effect of intercropping on Organic matter

Significant differences (P < 0.05) were observed among all groups in terms of organic matter (Figure 2). Lentils had the highest organic matter content of 94.2 g, while lentils 700 g/barely 300 g had the lowest organic matter content of 90.8 g.

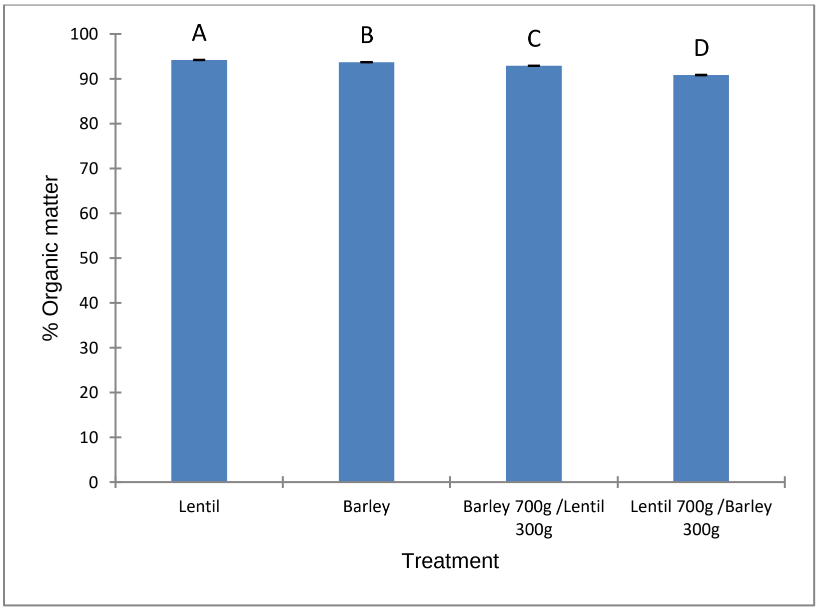

Figure 2: Percentage of organic matter

Effect of intercropping on Ash

The results indicate that the ash content was influenced by the type and ratio of crops in the intercropping system. There were significant differences (P < 0.05) in the percentage of ash among the groups (Figure 3). The group with 700 g of lentils and 300 g of barley had the highest ash content of 9.1% followed by the barley group 6.3%, the lentil group 5.8%, and the group with 700 g of barley and 300 g of lentils 7.1%.

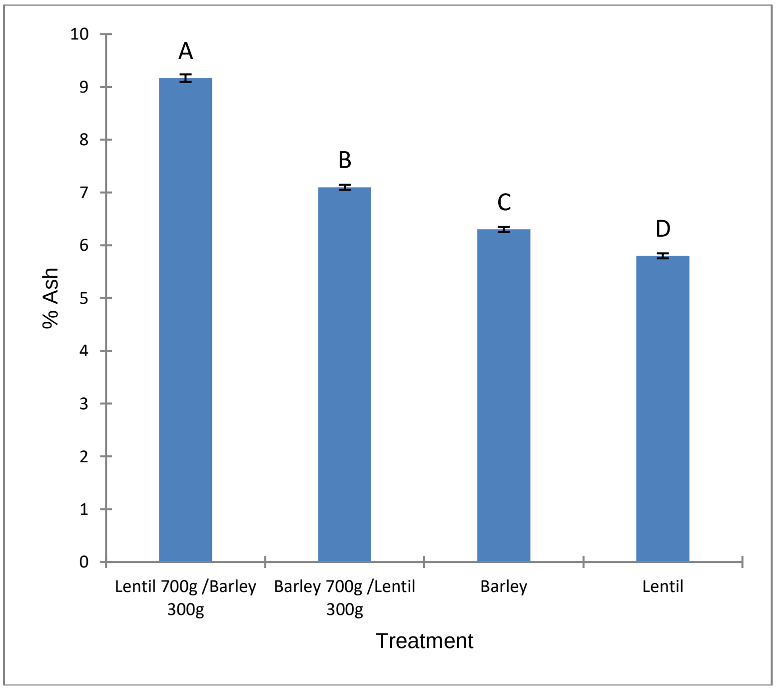

Figure 3: Percentage of ash content

Effect of intercropping on Fat

The results indicated that the group of lentils 700 g/barely 300 g had significantly (P < 0.05) lower fat percentage (1.7%) compared to the other three groups (Figure 4).

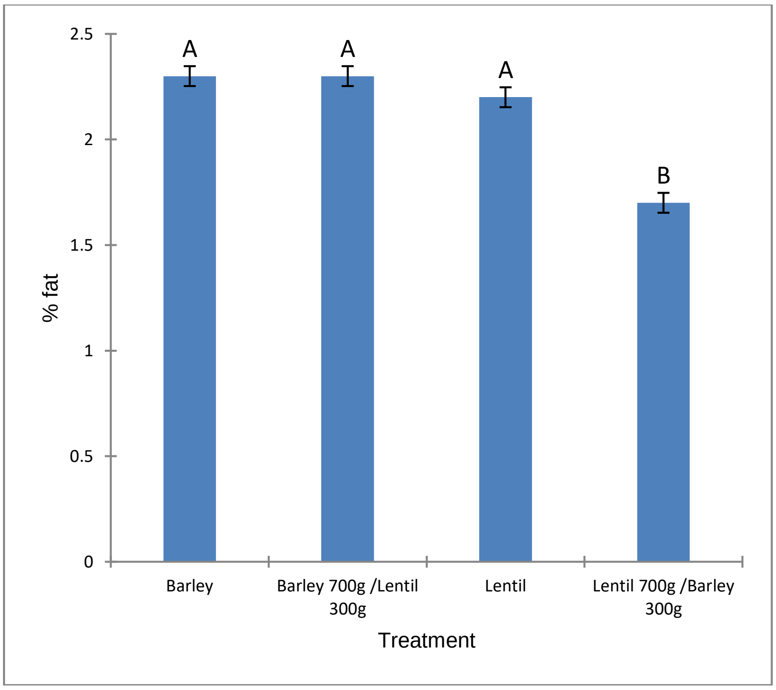

Figure 4: Percentage of fat content

Effect of intercropping on crude Protein

The results indicated that there were significant differences ($P < 0.05$) in the protein content of the lentil group compared to the other groups (Figure 5). The highest protein percentage was found in the lentil group, with a value of 43.6%, while the lowest was in the barley group, with a value of 23.9%. The intercropping ratio of lentil 700g/barley 300g showed a protein percentage of 38.7%, while the ratio of barley 700g/lentil 300g showed a percentage of 32.1%. Intercropping led to an increase in protein content compared to the barley group.

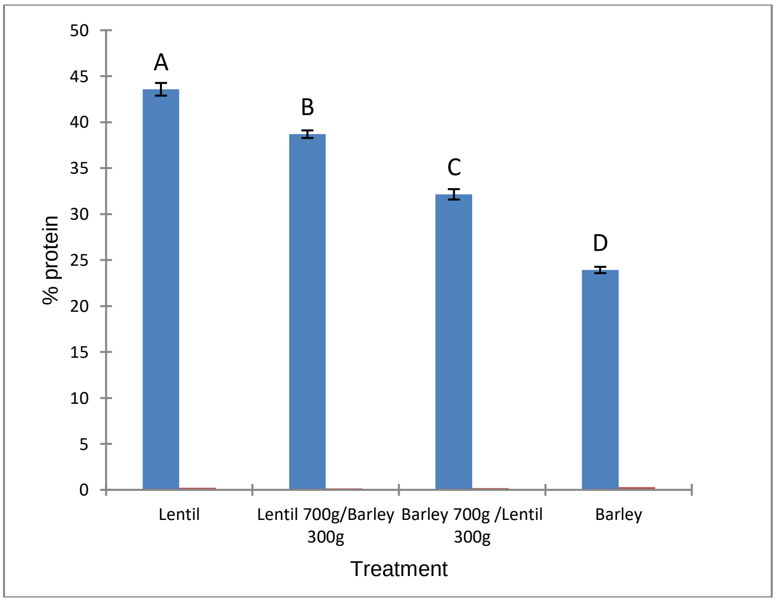

Figure 5: Percentage of protein content

Effect of intercropping on Fiber

The study showed that there were significant differences (P < 0.05) in the fiber percentage of the various crop groups. The highest fiber percentage was observed in the barley group (14%), while the lentil group had the lowest fiber percentage (9.4%). In the intercropping of 700g barely and 300g lentil, the percentage of fiber was 12.5, while in that of lentil 700g/barley 300g was 10.6 (Figure 6). Intercropping with barley led to an improvement in the fiber percentage compared to the lentil group.

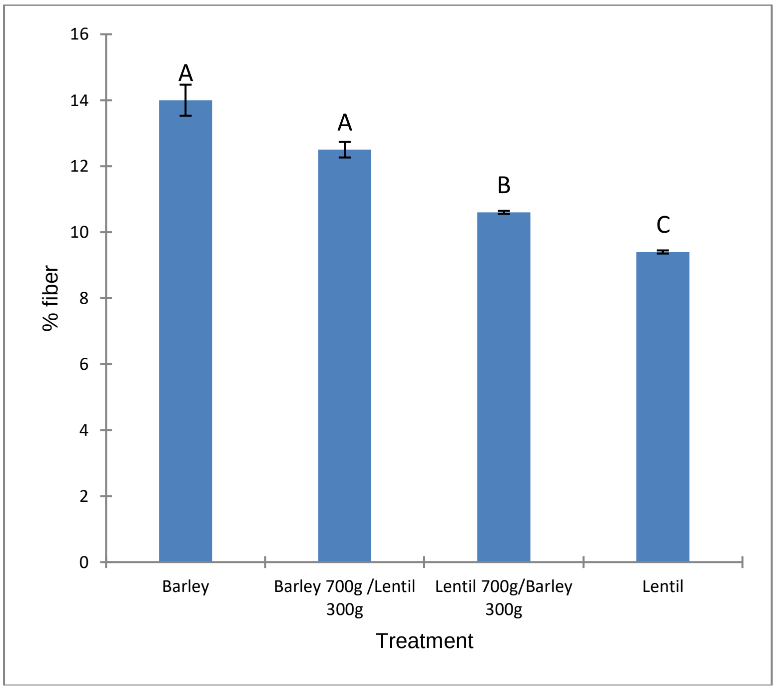

Figure 6: Percentage of fiber content

Effect of intercropping on chlorophyll

The results indicated significant differences (P < 0.05) in chlorophyll contents among the barley groups when compared to the lentil groups (Figure 7). However, no significant differences were observed within the barley groups or within the lentil groups.

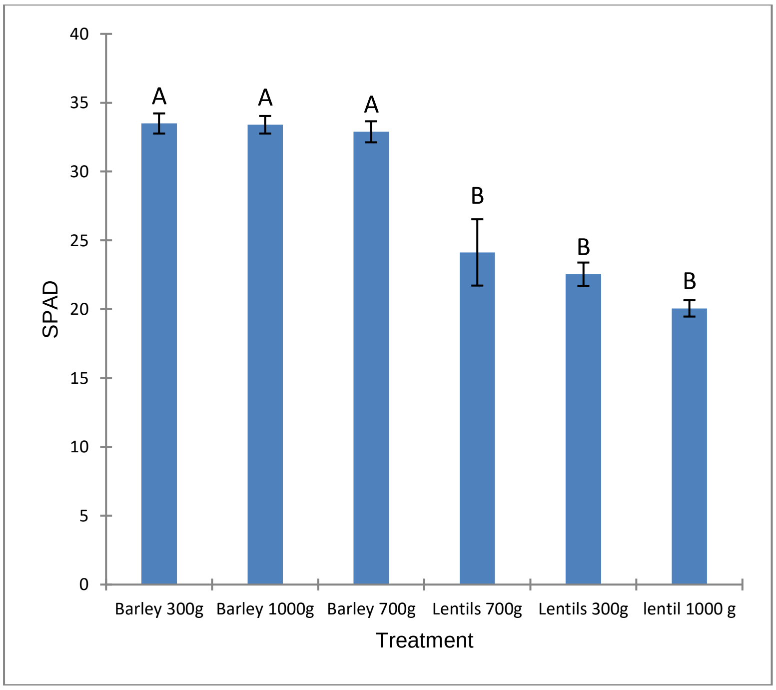

Figure7: Percentage of chlorophyll content

Effect of intercropping on plant length

The study results indicated that there were significant differences ($P < 0.05$) in the length of the plant between the groups of barley 1000g, barley 700g, and the other groups, but the lentil group of 1000g had the shortest plant length (Figure 8).

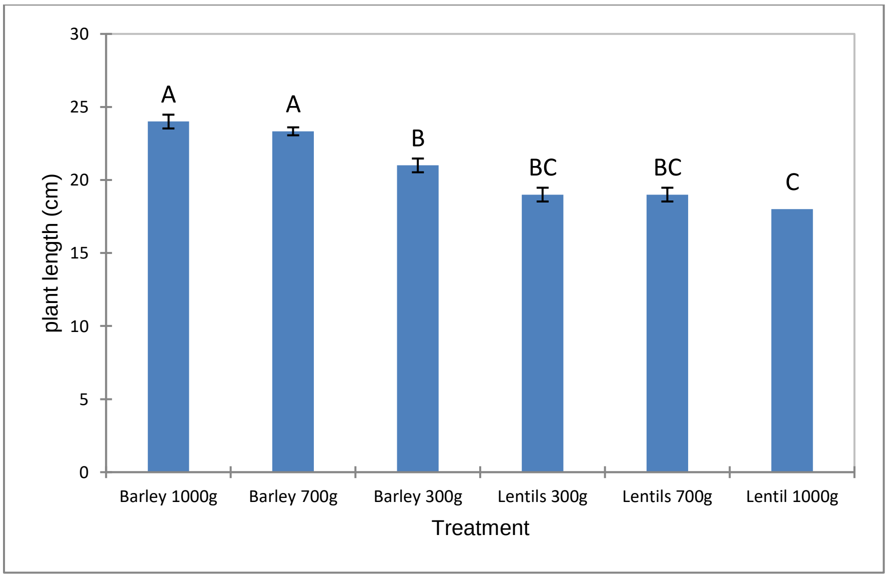

Figure 8: Plant length

Effect of intercropping on fresh weight

Significant differences were observed among all groups with respect to the fresh weight. Barley 700g/lentil 300g group showed the highest fresh weight of 6.6 kg, while the group of lentil 700g/barely 300g showed the lowest fresh weight of 5.2 kg (Figure 9).

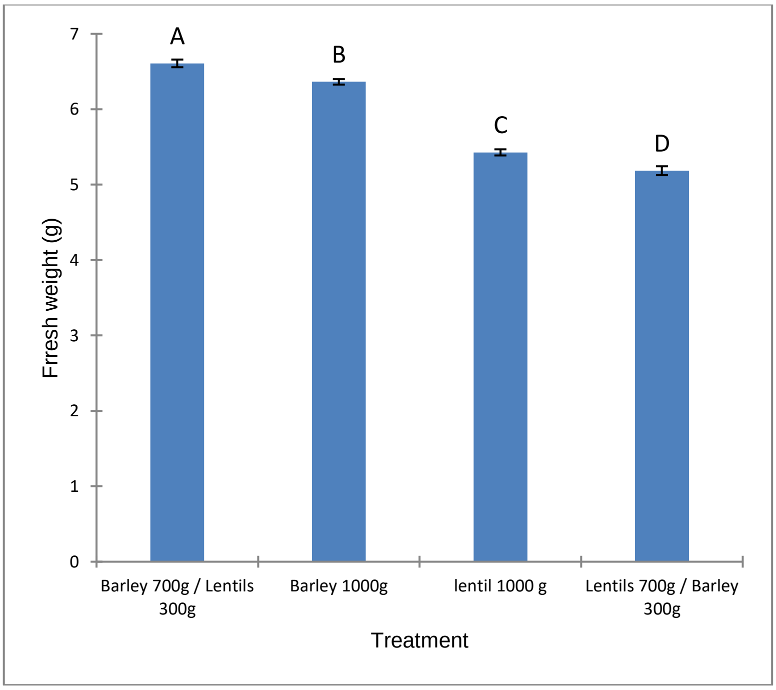

Figure9: Fresh weight content

DISCUSSION

Our results indicated that intercropping legumes and cereals under hydroponic conditions improved plant biomass, length, percentage of chlorophyll, and nutritive value. These results agree with Bacchi (2021) who reported that incorporating legumes in forage mixtures with grasses enhanced the overall quality of the biomass, particularly in terms of protein content. The results are also in agreement with Houshia et al., (2022) whom indicated that intercropping barley with common vetch improved the forage quality and increased the protein yield of barley without reducing dry matter yield

The combination of barley and lentil in intercropping improved the quality of forage and increased the protein yield of barley, while maintaining the dry matter yield. These findings suggest that cereal-legume intercropping is a feasible strategy for producing high-quality and quantity forage. However, successful implementation of intercropping requires proper training and further research to optimize its benefits. Sadeghpour et al. (2013) recommend that farmers should consider adopting this management strategy.

Our results indicated that the percentage of crude fat in all groups contains between 1.7-2.5% and these result agrees with Kir (2022) who indicated that high-quality forage resources could contain about 1,2 -5,8 % crude fat.

Fresh weight of intercropping was significantly different compared to other groups. These results agree with Loïc (2018) who indicated that intercropping of barley and lentils has shown promising crop yields with potential economic benefits. However, the protein data showed some variations in the yields, and it was difficult to determine the optimal ratio. This could be due to several factors such as temperature and the morphology of each plant. Other factors that could impact forage quality include harvest date, storage and harvesting methods, soil fertility, and cultivar.

Intercropping, which involves growing multiple plant species in the same field for a significant part of their growing season, offers numerous advantages for forage and grain production as well as improving forage quality. These benefits include more efficient utilization of environmental resources such as soil and atmospheric nitrogen sources, resulting in higher and more stable yields. Intercropping also promotes better land use efficiency, increases soil biological activities and fertility reduces pest and disease incidence, and helps regulate the climate by mitigating greenhouse gas emissions. These advantages have been demonstrated in numerous studies (Olivares et al. 2017, 2018a, 2018b, 2020; Olivares and Hernandez 2019a, 2020; Montenegro et al. 2021a, 2021b; Pitti et al. 2021; Bertorelli and Olivares 2020; Martinez et al. 2023).

Intercropping, which promotes an increase in plant diversity, is considered a potential solution for creating more resilient and sustainable cropping systems (Kebede 2021). Intercropping is a farming practice that is widely utilized in developing countries and gaining interest in developed countries for the ecological intensification of agriculture. In regions with limited rainfall or semiarid climates, such as certain parts of Palestine, intercropping becomes particularly important due to the decreasing availability of fresh water for animal feed crop cultivation with significant nutritional value. Intercropping of two or more crops on the same field has been adopted to optimize irrigation parameters and maximize product benefits. The integration of legumes is an essential aspect of agricultural and animal feed systems, and legume-cereal intercropping, such as corn-beans intercropping, is commonly practiced in many parts of the world (Houshia et al., 2022).

CONCLUSION

Intercropping is an effective way to optimize the use of agricultural resources and improve crop yields. Cereal-legume intercrops, in particular, provide a viable option for increasing home-grown protein sources and improving forage yield. In the case of barley and common lentil intercropping, the forage quality was enhanced, and protein yield was increased without any adverse effect on dry matter yield. These results demonstrate that cereal-legume intercropping is a promising management strategy for producing high-quality and high-quantity forage.

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