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Effect of Intercropping Barley and Berseem on vegetative growth and productivity

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تأثير زراعة الشعير والبرسيم على النمو الخضري والإنتاجية

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Abstract
The field experiment was conducted at Abu Hadi area-Sirte city, during the winter season 2022-2023 to study the effect of humic acid on vegetative growth and productivity of three cuts of sole barely, sole berseem and their mixture. The experimental design was spilt-spilt plot Design with three replicates: the main plot were allocated to forage crops with sole barley (*Hordeum vulgare*, L.*)* cv., Giza 2000, at rate 123.55 kg/ha, berseem (*Trifolium alexandrinum*, L.) cv., Giza 6, at rate 61.78 kg/ ha, and mixture plants (65% berseem +35 barley) with rate 46.33 kg berseem/ ha + 30.89 kg barley/ ha, the seeds of barley and berseem were mixed at the previous rate and planted by broadcasting on the surface. Three levels of humic acids by rate 3 ,6 and 9 kg/ha, occupied in sub-plot as ground application during the preparing of sowing and three cuts were distributed in sub-sub plot which were taken in season after 60, 90 and 120 day from sowing. Studied characters were vegetative growth i.e. (plant height, number of tillers- branches /m^2, fresh weight (kg/ha) and dry weight (kg/ha) and yield quality (grain yield (kg/ha), straw yield (kg/ha), biological yield (kg/ha), protein and carbohydrates percentages. Results showed mixture of forage plants produced the best values in all vegetative characters under studied, also, humic acid at 9 kg/ha recorded highest all vegetative growth and 3rd cut surpassed 1st and 2nd cuts in 2022-2023 season. Whereas, Sole barley gave the highest grain yield, while, mixture of forage plants gave the height values of straw yield, biological yield, protein and carbohydrates percentages. Humic acid at 9 kg/ha recorded highest all vegetative characters and yield quality were studied. The highest value for all parameters (vegetative growth and yield quality) were observed under mixture forage plants in the third cut with humic acids at rate 9 kg/ha. The interactions among forage crops and humic acid was highly significantly, also, forage crops and cuts was highly significantly, humic acid and cuts was highly significantly and interaction between forage crops, humic acid and cuts was highly significantly on all vegetative growth and yield quality characters.

Keywords: Barley (*Hordeum vulgare L,*), berseem (*Trifolium alexandrinum*) humic acid, vegetative growth, yield quality.

الملخص
أجريت التجربة الحقلية بمنطقة أبو هادي – مدينة سرت خلال الموسم الشتوي 2022-2023 لدراسة تأثير حامض الهيوميك علي النمو الخضري والإنتاجية لثلاث حشات من الشعير والبرسيم وخليطهما. كان التصميم التجريبي هو تصميم القطع المنشقة مرتين بثلاث مكررات: القطع الرئيسية خصصت للمحاصيل العلفية من الشعير (*Hordeum vulgare*) صنف، الجيزة 2000 بمعدل 123.55 كجم/هكتار، البرسيم (*Trifolium alexandrinum*). صنف جيزة 6 بمعدل 61.78 كجم/هكتار، نباتات الخليط (65% برسيم +35 شعير) بمعدل 46.33 كجم برسيم/ هكتار + 30.89 كجم شعير/ هكتار، تم خلط بذور الشعير والبرسيم في المرحلة الأولى وزرعها عن طريق البدار على السطح. ثلاثة مستويات من حمض الهيوميك بمعدلات 3، 6 ، 9 كجم/ هكتار تم شغلها في القطع تحت الرئيسية كإضافة أرضية أثناء تجهيز البذارة وتم توزيع ثلاث حشات في القطع تحت تحت الرئيسية التي أخذت في الموسم بعد 60، 90، 120 يوم من البذر. الصفات المدروسة هي النمو

الخضري (ارتفاع النبات، عدد الأشطاء-الأفرع/ م^2، الوزن الرطب (كجم/هكتار) والوزن الجاف (كجم/هكتار) وجودة المحصول (محصول الحبوب (كجم/هكتار)، محصول القش (كجم/هكتار) والمحصول البيولوجي (كجم/هكتار) والنسبة المئوية للبروتين والكربوهيدرات أظهرت النتائج أن خليط النباتات العلفية أعطى أفضل القيم في جميع الصفات الخضرية المدروسة، كما سجل حامض الهيوميك بمعدل 9 كجم/هكتار أعلى جميع النمو الخضري و الحشة الثالثة مقارنة بالشحة الأولى والثانية في موسم 2022-2023. حيث أعطى الشعير أعلى إنتاجية للحبوب، بينما أعطي خليط النباتات العلفية أعلى القيم لمحصول القش والمحصول البيولوجي والنسبة المئوية للبروتين والكربوهيدرات. كما سجل حامض الهيوميك بتركيز 9 كجم/هك أعلى جميع الصفات الخضرية وجودة المحصول المدروسة. وقد لوحظ أعلى قيمة لجميع العوامل (النمو الخضري وجودة المحصول) تحت نباتات العلف المخلوط في الشحة الثالثة مع الأحماض الدبالية بمعدل 9 كجم/هكتار. كان التداخل بين محاصيل العلف وحامض الهيوميك عالي المعنوية، كما كان التداخل بين محاصيل العلف والحشات عالي المعنوية، وكان حامض الهيوميك والحشات عالي المعنوية وكان التداخل بين محاصيل العلف وحامض الهيوميك والحشات عالي المعنوية في جميع صفات النمو الخضري وجودة المحصول.

الكلمات المفتاحية: الشعير (.L *Hordeum vulgare*)، البرسيم *(Trifolium alexandrinum)*، حمض الهيوميك، النمو الخضري، جودة المحصول.

Introduction

After maize, rice, and wheat, barley (*Hordeum vulgare* L.) is the world's fourth-most significant cereal crop. In certain nations, like Libya, it is utilized for food, feed, and the malt industry. For the most part, barley is the most significant winter crop in Libyan soil types. While the global acreage of this crop was 47.9 million hectares with an average yield of around 2.9 t/ha, Libya's farmed area was 136247 ha, with an average yield of approximately 0.5 t/ha [27] **.**

Most nations cultivate a lot of barley because of its excellent nutritional value and high protein content. In addition to being utilized as grains in many industries, barley is fed to animals as green manure [1]**.**

Compared to oat forage, barley forages were shown to have a greater CP, a lower acid detergent fibre (ADF), and a higher digestible dry matter (DM) content [43]**.** Comparing Egyptian clover and barley intercropping to Egyptian clover and oat or Egyptian clover and triticale intercropping, the overall seasonal CP was greater [6]**.** Better growth was also obtained by interseeding grass species with Egyptian clover [54]**.** Furthermore, [18] . found that intercropping Egyptian clover with barley yielded a better forage production than intercropping Egyptian clover with oats.

According to [58] . berseem clover (*Trifolium alexandrinum* L.) should be interplanted with grains to increase the quality of the feed, prevent cattle bloat, and reduce the need for fertilizer. Intercropping's multifunctional profile enables it to perform a wide range of additional functions in the agroecosystem, including increased weed competition, resilience to disturbances, enhanced product quality, and a decrease in the adverse environmental effects of arable crops [27] [36]**.**

The most significant forage legume crop in various parts of the world is berseem clover, especially in places with lengthy winters and cold to mild temperatures. According to [2] . it is either grown in a monoculture or in combination with other grasses including ryegrass, barley, and oat.

Berseem clover has a low dry matter content, particularly in the first cut, despite having a high yield and protein content. Consequently, berseem clover intercropping with forage grasses is a low input approach that improves the nutritional value and productivity of the forage in numerous beneficial ways [20]**.** Selecting beneficial mixes has various benefits; for example, mixed yields are typically higher than those of legumes or grass alone. Additionally, legumes give legume-grass mixes their nitrogen, which could lead to a higher production of feed than grasses grown by themselves. Compared to grasses grown in pure stands, the yield of such mixes may be higher. Legumes with a greater percentage of protein also include grasses. Combinations of grasses and legumes offer a helpful example of an improved diet for animals. The ideal combination should be chosen among these fodder crops that complement one another in terms of growth distribution and ecological niche, have complementary maturity and harvesting schemes, and do not significantly compete with one another for resources necessary for development and survival [30]**.**

Although intercropping practices have many benefits, a better knowledge of the ecological mechanisms underlying planned spatial diversity, including additional benefits linked with related variety, is necessary to maximise the benefits that are already realised [33] .Through allelopathy or competition for light, water, nutrients, and space, weeds seriously disrupt crops [27] [34]**.** Numerous studies have shown that intercropping patterns, although they vary widely in their efficiency, suppress weeds more effectively than mono cropping [44]**.** Moreover, studies on sustainable agricultural weed management strategies such intercropping are being directed against herbicides due to their detrimental impacts on the environment [23] [44]**.**

An effective technique to diversify crop systems and increase agricultural productivity while using less herbicides and fertiliser is through yearly intercropping. Although a number of studies have demonstrated that the genotypes utilised affect intercrop performance, the available data has not been combined in a comprehensive analysis [17]**.**

Enhancing yield through intercropping could be associated with decreased weed growth, less damage from pests and diseases [50] **.** increased growth rate, and more efficient use of available resources [28] .

Agronomic factors such as cutting interval have a significant impact on the field's microclimate, which in turn affects agricultural crop yields and quality indices. Increased total dry matter (DM) yields, better pasture quality, less need for fertilizer, and higher yields of the following crop are some advantages of intercropping berseem clover with cereal crops [53]**.**

Intercropping between two or more crops may result in competition for nutrients and solar energy. According to [57]. the land equivalent ratio (LER) can be used to assess the yield advantage of intercropping systems. The LER method enables the intense production of several crops on little acreage with minimal external input requirements and allows an efficient comparison of yields from the same surface of each intercrop compared with its solo stand.2. In intercropping, production efficiency is crucial, particularly for small-scale farmers in regions with short growing seasons [3] **.**

Because of the variations in resource use, intercropping can lead to increased growth rates, decreased levels of weeds, pests, and diseases, and more efficient use of resources [22]**.** Furthermore, intercropping's components have complementing impacts on one another, and as a result of their decreased competition, productivity rises [35] **.** Farmers are choosing to use various cropping techniques on the same agricultural land because artificial fertilizer and better seed are scarce and expensive these days [13] .An effective technique to diversify crop systems and increase agricultural productivity while using less herbicides and fertiliser is through yearly intercropping. Although a number of studies have demonstrated that the genotypes utilized affect intercrop performance, the available data has not been combined in a comprehensive analysis [17] .

The compound known as humic acid (HA) is a heterogeneous mixture of several substances, including weak aliphatic and aromatic organic acids. It is soluble in alkaline water but insoluble in acidic water [46] . and it affects soil properties and plant growth in different ways [55] . Commercial HA production aims to fertilise with organic matter. Through a variety of internal plant and soil mechanisms, its constituents stimulate plant growth and yield, improve soil fertility, and increase the availability of nutrients [40]**.**

As an organic material, humic acid (HA) has many benefits, including phytohormone-like activities that affect various aspects of plant physiology, such as improving photosynthesis and, in turn, promoting vegetative growth, root system growth, seedling growth, and enhanced seed germination [24]**.** Furthermore, humic acid promotes development by quickening the division of plant cells and by increasing root respiration and arrangement [8] **.**

Thus, this work aimed study the effect of Intercropping Barley and Berseem on vegetative growth and productivity

Material and methods

The field experiment was conducted at Abu Hadi area-Sirte city, during the winter season 2022-2023 to study the effect of organic manure on productivity of three cuts of sole barely, sole berseem and their mixture. The experimental design was spilt-spilt plot Designwith three replicates: the main plot were allocated to forage crops with sole barley (*Hordeum vulgare,* L.*)* cv., Giza 2000, at rate 123.55 kg/ha, berseem (*Trifolium alexandrinum,* L.) cv., Giza 6, at rate 61.78 kg/ ha, and mixture plants (75% berseem +25 barley) with rate 46.33 kg berseem/ ha + 30.89 kg barley/ ha, the seeds of barley and berseem were mixed at the previous rate and planted by broadcasting on the surface. Three levels of humic acids by rate 3 ,6 and 9 kg/ha, occupied in sub-plot as ground application during the preparing of sowing and three cuts were distributed in sub-sub plot which were taken in season after 60, 90 and 120 day from sowing

The plot area was 10.5 m^2 (3.5 m length ×3 m width). Sowing dates were planted at the first week of November in the two growing seasons. The irrigation system used was developed surface irrigation. All recommended common agricultural practices i.e. irrigation, fertilization were adopted throughout the experimental season till harvest for the experiment. The preceding summer crop was maize. First irrigation was applied at 15 days after sowing and then plants were irrigated every ten days till the cutting then irrigation and mineralization shall be carried out immediately after cutting.

All plots were hand–harvested at a cutting height of approximately 10 cm. i.e., 60 days (1st cut), 90 days (2^{nd} cut) and 120 days (3^{rd} cut) from sowing, the growth periods of sole barley plants were 150 and 165, sole berseem plants were 160,165 and mixture were 165, 170 days after sowing in 2022-2023 growing seasons, respectively.

The remaining time of the crop after the third cut to produce the yield were (40 and 45), (50 and 55), (55 and 60) for barley, berseem and mixture in 2022-2023 season. Three replicates were used for growth determinations yield and its component, as well as chemical composition at growth for mixture plants and seed-grains after harvest.

Data studied

A) Vegetative growth

- Plant height (cm).
- Number of tillers-branches/m^2
- Fresh weight (Kg/ m^2)
- Dry weight (Kg/ m^2)

B) Yield quality

- Grain yield (Kg/ ha)
- Grain yield (Kg/ ha)
- Biological yield (Kg/ ha)
- Protein (%)
- Carbohydrates (%)

Statistical analysis:

Results of the measured parameters were subjected to computerized statistical analysis using SAS statistical software version 9.0, for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to [49]**.**

Results and discussion

A) Vegetative growth

Results presented in **Table (1) and Fig. (1)** explained that the main effect of each forage crops, humic acid and cut number had marked impact on vegetative growth. Planting forage crops as a mixture led to significantly increased all growth characters studied i.e. plant height (cm), number of tillers- branches/plant and fresh and dry weights (54.93 cm, 7.75, 4675.32 Kg/ ha and 905.41Kg/ ha). On the other hand, humic acid at rate 9 kg/ha with mixture of forage crops significantly increased plant height (63.72 cm), number of tillers-branches/plant (8.99) and fresh weight (5423.37 Kg/ ha) and dry weight (1050.27 Kg/ ha), respectively, as compared to the other humic acid rates. In another side, results illustrated that 3rd cut of forage crops characters significantly increased of plant height (52.93 cm) number of tillers-branches/plant (7.79), fresh weight (4269.15 Kg/ ha) and dry weight (1152.35 Kg/ ha), respectively, as compared to 1st and 2nd cuts.

The interactions among forage crops and humic acid was highly significantly, also, forage crops and cuts was highly significantly, humic acid and cuts was highly significantly and interaction between forage crops, humic acid and cuts was highly significantly on all vegetative growth characters.

[48] showed similar benefits of combining berseem clover with cereal crops, including higher total dry matter yields and higher-quality fodder. Furthermore, research on the same topic [10] .came to the conclusion that crop production's sustainability and profitability depend heavily on the mixing of crops system. This effect may be the consequence of more effective utilization of the surrounding environmental conditions, such as increased habitation of deeper soil layers by the various berseem root systems and the establishment of more canopy cover in the area due to the various flora types of both clover and lucerne.

[48] they reported the benefits of mixture berseem clover with cereal crops, increased total dry matter yields, improved forage quality. Moreover, in the same concern [] [29] **.** concluded that mixing crops system is an important role in profitability and sustainability in crop production Such effect might be due to the more efficient use of the surround environmental condition such as more occupation of deeper layers of the soil by the different root systems of berseem as well as the foundation of more canopy cover in the space as a result of the different vegetation types of both alfalfa and clover. This will therefore lead to increased soil nutrient absorption efficiency, increased light energy interception at various levels, and ultimately increased photosynthetic rate, or improved photosynthesis translocation from source to sink. This is the reason that the cultivation of pure berseem produced the lowest quantities when compared to mixtures, and it also favourably influenced the increased dry matter buildup. According to [15] **.** barley is a crop component that shows promise when added to certain legume-cereal mixes for the production of hay and fodder during the winter months when rain is falling.

The first cut had the lowest value across all the metrics examined for the characters. Assist me in this: [52] investigated blends of berseem and grass, as well as berseem and barley. The results showed that the mixtures produced a much higher yield of pure berseem in the first cut. Solo berseem out yielded all blends in the second and third cuts in both years. This could be because leaf area development was developing slowly before to the first cut. However, due to the cereal contribution in Cut-1 and the subsequent multiple cutting of clover, the total seasonal DM production from the choice of cereal-clover mixture surpasses that of both cereal and legume monocultures [5]. who reported that while clover provides the production stability in mixture, cereals dominate early season DM. [48] obtained similar results. The DM yield of re-growth clover herbage and the first cut of cereal herbage are negatively correlated.

The reason for this could be that adding organic manure to soils has been a widely accepted conventional practice. Research has shown that doing so boosts soil fertility and enhances crop production and quality [41]. The findings of [20]. were comparable.

By promoting root growth and increasing vegetable crops' uptake of water and nutrients, HA has a significant impact on plants [12]. Additionally, it has been shown to affect cell division [11] . and improve protein synthesis [19] [45] . both of which increase the amount of protein in plants overall [42] Additionally, HA increases the synthesis of hormones and plant enzymes and offers growth regulators to govern and regulate hormone levels in plants [42][37]. According to [42] it also improves the processes of respiration and photosynthesis and promotes enzyme catalysis. These mechanisms discuss how HA directly affects plants, and it also has a significant impact on soil fertility [25] . It occurs as a result of improved soil physical, chemical, and biological characteristics that raise water retention capacity [38] [42] [39]. Additionally, it stimulates the activities of enzymes, which provides beneficial soil organisms with an excellent source of energy [9] . HA is applied in soil reclamation projects [32] [4].

Table (1): Effect of intercropping barley and berseem on vegetative growth.

Treatments	Plant height (cm)	No. of Tillers-branches / plants/ m^2	Fresh weight (Kg/ ha)	Dry weight (Kg/ ha)
A) Forage crops				
Barley	46.33	5.13	2769.26	449.07
Berseem	43.16	4.51	3731.34	753.02
Mixture	54.93	7.75	4675.32	905.41
$LSD_{(0.05)}$	4.87	0.32	140.46	49.00
B) Humic acid				
3 kg/ha	50.07	5.95	3212.36	520.93
6 kg/ha	53.74	5.23	4328.35	873.51
9 kg/ha	63.72	8.99	5423.37	1050.27
$LSD_{(0.05)}$	5.65	0.37	162.92	56.84
C) Cuts				
1st cut	37.76	4.43	2534.43	604.60
2nd cut	48.39	4.73	3651.12	748.72
3rd cut	52.93	7.79	4269.15	1152.35
$LSD_{(0.05)}$	3.62	0.22	130.35	43.00
Interaction				
A*B	**	**	**	**
A*C	**	**	**	**
B*C	**	**	**	**
A*B*C	**	**	**	**

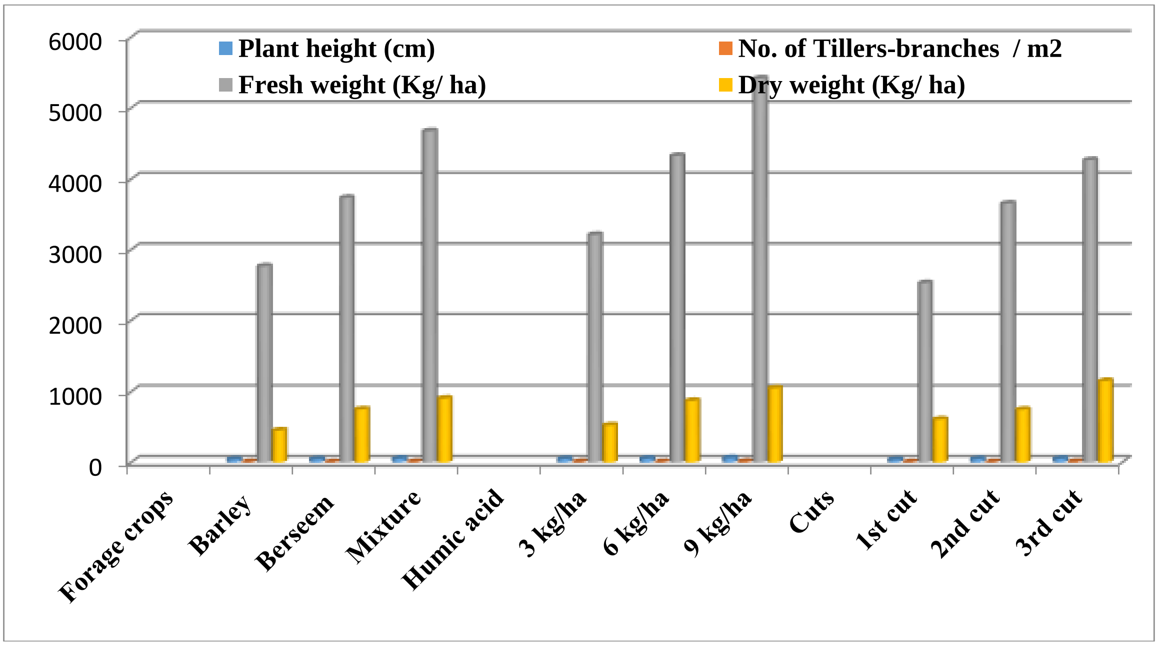

Figure. (1): Effect of intercropping barley and berseem on vegetative growth.

B)Yield quality

Results presented in **Table (2) and Fig. (2)** illustrated that the main effect of each forage crops, humic acid and cut number had marked impact on yield components and quality. Planting forage crops as a mixture led to significantly increased all yield components and quality studied i.e. grain yields (kg/ha), straw yields (kg/ha), biological yields (kg/ha), protein (%) and total carbohydrate (%). However, barley recorded the higher grain yield **(**710.44 kg/ha), mixture recorded the lower straw yield **(**1438.35 kg/ha), mixture recorded the higher biological yield **(**2030.26kg/ha), berseem recorded the higher protein (13.98 %) and barley recorded the higher total carbohydrates (20.12 %), respectively. On the other hand, humic acid at rate 9 kg/ha with mixture of forage crops significantly increased grain yields (824.11 kg/ha), straw yields (1668.49 kg/ha), biological yields (2355.11 kg/ha), protein (16.22 %) and total carbohydrate (23.34 %). Whereas, results showed that 3rd cut of forage crops characters significantly increased of grain yields (681.08 kg/ha), straw yields (1571.13 kg/ha), biological yields (2127.79 kg/ha), protein (13.95 %) and total carbohydrate (19.97 %), respectively, as compared to 1st and 2nd cuts.

The interactions among forage crops and humic acid was highly significantly, also, forage crops and cuts was highly significantly, humic acid and cuts was highly significantly and interaction between forage crops, Meanwhile, humic acid and cuts was highly significantly on all yield components and quality studied.

Numerous studies have looked into the use of intercropping in the production of fodder. The crude protein (CP) content of maize-soybean intercropping was found to be substantially higher than that of monocropped maize, according to [56] . When compared to maize monoculture, all intercropping compositions enhanced the dry matter yield and crude protein production of the fodder, according to [31] . who experimented on intercropping maize with various legumes. According to [14]**.** intercropping cowpea with maize produced a higher amount of crude protein and more digestible dry matter than maize grown on its own. Additionally, humic acid was reported to significantly improve biological yield by [16] . and to significantly increase grain output by[47]**.** Similar results were obtained by [60]. who studied the performance of mixing barley with berseem and found that the protein percentage of the pure stand legumes was much higher than the mixtures. In both seasons, sole berseem produced the highest value of protein percentage as increasing percentage compared with mixture. [7]**.** reported similar outcomes.

Table (2): Effect of intercropping barley and berseem on productivity

Treatments	**Grain yields (kg/ha)**	**Straw yield (kg/ha)**	**Biological yield (kg/ha)**	**Protein (%)**	**Total Carbohydrates (%)**
A) Forage crops					
Barley	710.44	1012.24	1722.65	6.71	18.72
Berseem	694.40	1031.12	1725.49	13.98	14.01
Mixture	591.93	1438.35	2030.26	11.80	20.12
$LSD_{(0.05)}$	69.83	64.94	72.53	0.83	0.73
B) Humic acid					
3 kg/ha	686.64	1174.19	1998.28	7.78	16.25
6 kg/ha	805.50	1196.09	2001.57	13.69	21.72
9 kg/ha	824.11	1668.49	2355.11	16.22	23.34
$LSD_{(0.05)}$	81.00	75.32	84.14	0.96	0.85
C) Cuts					
1st cut	556.66	912.97	1594.06	6.71	14.76
2nd cut	670.61	1085.70	1756.31	13.19	18.14
3rd cut	681.08	1571.13	2127.79	13.95	19.97
$LSD_{(0.05)}$	65.29	63.09	74.63	0.79	0.62
Interaction					
A*B	**	**	**	**	**
A*C	**	**	**	**	**
B*C	**	**	**	**	**
A*B*C	**	**	**	**	**

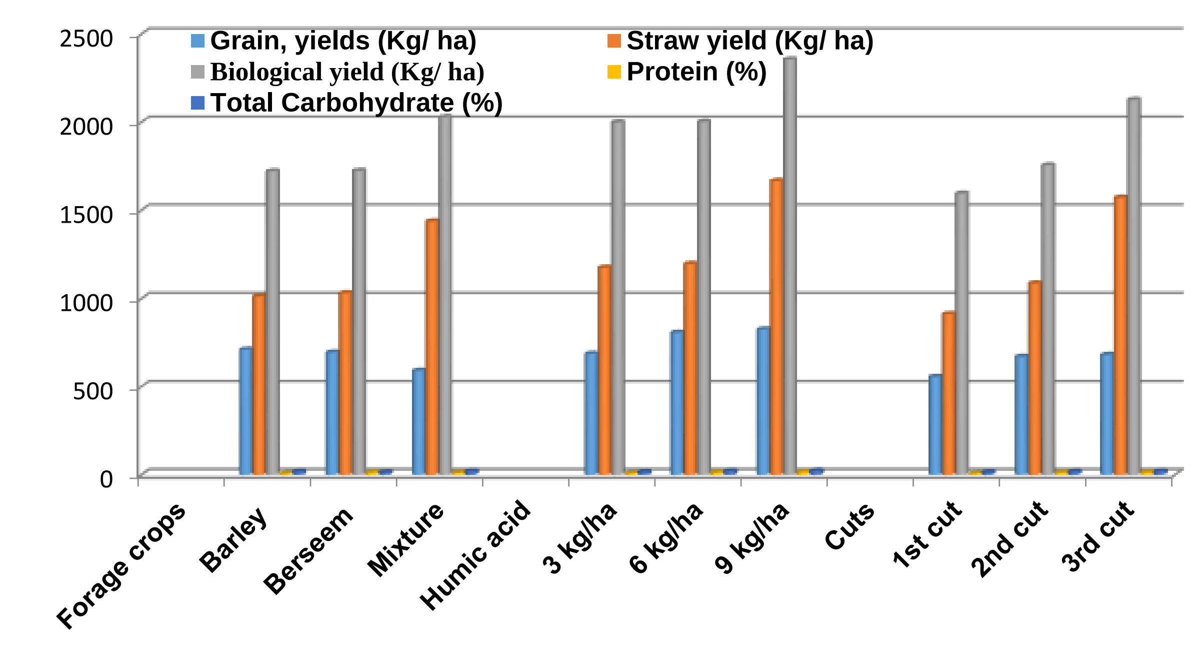

Figure. (2): Effect of intercropping barley and berseem on productivity.

Conclusion

According to the study's findings, intercropping barley with berseem clover during sowing had the biggest benefits in terms of protein output, dry forage, and fresh forage. Therefore, for high forage and protein output with more balanced nutritional value, the barley–berseem clover intercrop at seeds should be employed in Mediterranean short-season growing settings as an alternative to berseem clover solo crop.

Recommendations

One of the main objectives of research and extension systems is the sustainable optimization of economic yields of fodder crops like barley and berseem clover. In the Libyation desert lands, which are known for their relatively low population density, small farm sizes, and low agricultural profitability, intercropping both companions may be economically and environmentally advantageous. In this study, the mixed culture as a whole demonstrated superior total productivity as measured by total biomass and protein yields as well as total LERs of the two crops, despite the lower barley yield caused by the legume partner's presence in the same region. Research and development stakeholders in the desert regions should pay more attention to the intercrop components' complementary utilization of nutrient and water sources as well as the cereal/legume mixed cropping's reduced requirement for external inputs. Future research is also required to evaluate the amount of N captured from different intercropping systems, especially those under stress.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

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