RESEARCH ARTICLE Agricultural Science Digest, Volume 46 Issue 3: 440-445 (June 2026)

Response of Mungbean Yield to Some Sustainable Farming Techniques

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10.18805/ag.DF-775

ABSTRACT

Background: The study was conducted in the field of the College of Agriculture and Forestry at the University of Mosul during the summer agricultural season of 2024.

Methods: Investigate the effects of three agricultural factors: Factor 1: Two local mung bean varieties, the green and black ones; Factor 2: Three planting dates: June 1, June 15 and June 30 and Factor 3: Spraying at a concentration of 2 ppm with different types of foliar fertilizers: (wood vinegar, balanced nano fertilizer, amino acids and spraying with water only). Plants were sprayed at three different stages (at branching, at the beginning of flowering and during pods formation). The study was implemented according to the randomized complete block design (RCBD) with three replications according to the split-plot system. After recording the data.

Result: The results were as follows: The local green variety was superior in all studied traits. The 1/6 planting date was significantly superior in plant height, leaf area and pod length, while the 15/6 planting date was significantly superior in harvest index only, while the 30/6 planting date was significantly superior in the number of branches per plant, number of pods, biological yield and seed yield. Foliar fertilizer spray treatments recorded a significant superiority compared to water spraying, especially when spraying with wood vinegar and some traits were significantly affected by the use of balanced nano-compound and amino acids, especially seed yield.

Key words: Leaf materials, Mung bean varieties, Sustainable agriculture.

INTRODUCTION

One of the biggest challenges facing modern agriculture is producing enough food to feed the world's population of 8 billion without depleting natural resources (Becagli *et al*., 2022). Crop productivity has relied on the use of fertilizers to keep pace with population expansion, but due to their intensive use, natural resources are rapidly degrading and soil and water are being used in unsustainable ways. Alternative approaches are needed to increase crop productivity without endangering the environment, farm animals, or human health in light of these pressing environmental concerns (Zhu *et al.,* 2021).

Mung bean (*Vigna radiata* L.) is one of the solutions to this problem, as it is a legume crop and is characterized by a short growing season (90-120 days) and its tolerance to drought conditions in all stages of its growth except the flowering stage. Its seeds are used in human and animal nutrition because of their protein and carbohydrate content, in addition to its use as green fodder for animals, as well as its use as green fertilizer to improve soil properties, especially because it contains iron, calcium, potassium, magnesium and zinc. All of this qualifies it to be part of sustainable development (Smiglak-Krajewska *et al*., 2021). It is widely cultivated in the central and southern governorates of Iraq, while its cultivation is still limited in northern Iraq due to many reasons, including the lack of modern research in these areas, especially regarding the planting date. This is more necessary when climate change occurs, as we are experiencing now (Ali *et al*., 2025).

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How to cite this article: Jawad, Y.Q. and Ali, M.A. (2026). Response of Mungbean Yield to Some Sustainable Farming Techniques. *Agricultural Science Digest*. **46(3):** 440-445. doi: 10.18805/ag.DF-775.

Submitted: 16-07-2025 **Accepted:** 14-09-2025 **Online:** 01-10-2025

The planting date is of great importance in crop cultivation, as it varies according to the locations where the crop is grown (Van Loon *et al*., 2018). In general, planting dates are a complex issue in legume crops due to the fact that varieties belong to multiple maturity groups and are greatly affected by the environment. It is necessary to determine the appropriate date for planting varieties with environmental adaptation. The reason for choosing these dates to plant this crop is after the harvest of wheat and barley (Ali *et al*., 2020). Ali *et al*. (2024) showed that when planting mung beans at different dates, a significant superiority of some dates was observed at the expense of others in most traits. Research by (Ali *et al.,* 2024b) showed that late maturing genotypes produce tall plants with many branches, while early maturing genotypes produce few branches. It was also found that plant height decreases with delayed planting date. Khatik *et al*. (2022); Eshanee *et al*. (2023); Arya *et al*. (2024); Rai *et al*. (2024) found that when planting mung beans at three dates (25/4, 5/5, 15/5) in Pakistan, planting date 25/4 caused a significant increase in plant height, pod length, number of pods per plant, seed yield per unit area and biological yield compared to other dates. Despite the importance of this crop, its productivity rate is still low compared to global production due to the lack of interest of specialists in variety development programs and the reliance of Iraqi farmers on growing the only variety (green) that is locally traded and suitable for the conditions of the region. Ali (2021) indicated in his study in which he used many varieties that there were significant differences between the traits and for three periods of growth (Ali *et al.,* 2024c) also agreed with him through their study (Ali *et al.,* 2023b) noted in his experiment that included two varieties, where he recorded significant differences between the varieties in most of the studied traits.

The excessive use of chemical fertilizers in agricultural production has led to an increased need for new products that improve the quantity and quality of legume crops in a more sustainable manner. One such approach is the use of alternatives to or reduction of chemical fertilizers. Wood vinegar (pyrogensic acid), balanced nano-complex fertilizer and amino acids have emerged and have been successfully applied in agricultural production due to their ability to improve the growth and productivity of legume crops. In addition to neglecting the foliar nutrition factor and not differentiating between its modern products, especially with the presence of materials that have proven their efficiency in a distinguished manner, such as wood vinegar, nano fertilizers and amino acids, which are among the important materials in improving the performance of varieties, increasing their productivity and improving their quality, especially the above materials, as they play a role in building hormones and plant protein, an important role in the process of photosynthesis, chelating nutrients and regulating the acidity of the cell. Recently, wood vinegar (pyroligneus acid) has been used as an organic agricultural product in Italy (Italian Ministerial Decree 6793, 2018). It is a by-product obtained from the condensation of gases produced during the pyrolysis of woody biomass and consists of 200 or more water-soluble compounds, including phenols, tannins, esters and acetic acids (Mathew *et al*., 2015). Get in touch (Ali *et al.,* 2021) concluded that the use of some materials led to an improvement in most of the studied crop traits. Abdulqader *et al.* (2021) showed that plant yields differed significantly due to the addition of some stimulating substances compared to the control treatment, achieving an increase of 27.13%. Ali *et al.* (2023a) conducted a study on the effect of some germination and growth stimulants and found a significant effect on crop traits when adding stimulants compared to the control treatment. Mota *et al*. (2021); Ali *et al*. (2025) concluded that spraying nano-fertilizer at a concentration of (45 mg L^{-1}) on mung bean plants caused a significant increase in the number of plant branches, biological yield and harvest index. This study aims to determine the best date for planting mung beans without affecting the cultivation of strategic crops (wheat and barley), to identify the best local varieties that have not been thoroughly tested and to test some modern natural materials to complement chemical fertilization to produce a crop with natural advantages and to create a distinct quantitative and qualitative balance to gradually move towards sustainable agriculture.

MATERIALS AND METHODS

The field experiment was conducted in the fields of the College of Agriculture and Forestry at the University of Mosul in 2024. The soil specifications are shown in Table 1. It included three factors: Two varieties of local green (V1) and black (V2) mung bean crops; three planting dates (June 1, June 15 and June 30) and the third factor: spraying with three types of foliar fertilizers: wood vinegar, balanced nano-NPK fertilizer and amino acid fertilizer. All materials were sprayed at a concentration of 2 ppm, in addition to water spraying (control treatment). The spraying was applied to the plants at three stages (at branching, at the beginning of flowering and at the time of pods formation).

According to the experimental factors, a randomized complete block design was used as a factorial experiment with a split-plot system, where the varieties were placed in the main plots, the planting dates were placed in split-plots once and the fertilization treatments were placed in split-plots twice. 24 experimental units were available for each replicate, with dimensions of 2*2 m and an area of 4 m^2, where 10 plants were planted in each row with a distance of 20 cm between holes and 40 cm between lines, so there will be 5 rows. 0.5 m was left between experimental units and 1 m between replicates.

The following traits were studied: Plant height (cm), number of branches per plant, leaf area per plant (cm^2 per plant), pod length (cm), number of pods per plant, number of seeds per pod, weight of 1000 seeds (g), seed yield (g $plant^{-1}$), biological yield (g $plant^{-1}$) and harvest index (%). After recording the data, they were statistically analyzed

Table 1: Some of the physical and chemical properties of the soil of the experimental field before planting.

Attributes and units of measurement	Appreciation
Degree of interaction PH	7.1
Electrical conduction EC (D cm^{-1})	1.80
Field capacity %	19.98
Ready-made nutrient content	
Nitrogen content (PPM)	40
Phosphorus content (PPM)	159
Potassium content (PPM)	90
Volume distribution of soil particles	
Sand %	25.05
Salt %	37.00
Clay %	37.95
Soil texture	Clay mixture

*The analysis was conducted in the Central Laboratory, College of Agriculture and Forestry, University of Mosul.

Table 2: The effect of study factors on the productivity of two types of mung bean.

Treatments	Plant height	Number of branches	Leaf area	Pod length	Number of pods	Number of seeds	Weight of 1000 seeds	Biological yield	Seed yield	Harvest index
Varieties										
V1	84.14a	4.62a	259.52a	7.21a	108.30a	11.78a	34.05a	116.85a	42.06a	36.13a
V2	83.29b	4.51b	250.69b	6.90b	99.82b	11.30b	33.45a	107.01b	37.23a	34.84a
Data sowing										
1/6	84.58 a	4.50b	265.58a	7.21a	103.08b	11.23b	33.87a	110.39b	38.38b	34.82b
15/6	84.23b	4.53b	254.88b	7.02b	101.35b	11.72a	33.53a	106.69c	38.96b	36.63a
30/6	82.34c	4.67a	244.85c	6.93c	107.75a	11.68a	33.85a	118.72a	41.60a	35.01b
Types of foliar fertilizer										
Wood vinegar	83.98a	4.86a	261.04a	7.36a	108.70a	11.47a	35.59a	116.20a	41.39a	35.66a
Balanced nanocomposite	84.60a	4.71b	256.00ab	7.188b	105.91b	11.63a	33.98c	111.65b	40.60a	36.54a
Amino acids	84.09a	4.59c	251.02b	7.27ab	106.48ab	11.60a	34.67b	112.62ab	41.42a	36.88a
comparative treatment	82.21b	4.09d	252.36b	6.411c	95.14c	11.47a	30.77d	107.26c	35.19b	32.8b
Interaction										
V1 × 1/6	84.725a	4.500b	272.217a	7.283a	106.642b	11.550a	34.316 a	114.550b	40.927	35.874ab
V1 × 15/6	84.445ab	4.716a	255.708bc	7.191ab	102.208c	11.916a	33.433 b	104.875d	39.565bc	37.795a
V1 × 30/6	83.275c	4.658a	250.642c	7.158b	116.050a	11.883a	34.425 a	131.150a	45.715a	34.729b
V2 × 1/6	84.45ab	4.50b	258.95b	7.14b	99.53c	10.91b	33.42 b	106.23cd	35.85d	33.77b
V2 × 15/6	84.02b	4.35c	254.05bc	6.86c	100.49c	11.52a	33.64 ab	108.51c	38.36c	35.47ab
V2 × 30/6	81.41d	4.68a	239.07d	6.71d	99.45c	11.48ab	33.29 b	106.29cd	37.50cd	35.29b
V1 × Wood vinegar	84.03b	5.022a	266.72a	67.66a	116.46a	11.91a	36.24 a	126.15a	46.28a	36.92a
V1 × Balanced nanocomposite	85.16a	4.77b	256.34bc	7.36b	109.44b	11.88a	33.64 d	113.91bc	42.38b	37.56a
V1 × Amino acids	85.38a	4.60c	259.83ab	7.26b	111.18b	11.66ab	35.24 b	118.14b	43.97ab	37.36a
V1 × comparative treatment	82.00c	4.10d	255.18bc	6.544d	96.10d	11.66ab	31.10 e	109.222cd	35.637d	32.671c
V2 × Wood vinegar	83.93b	4.71cd	255.36bc	7.06c	100.94c	11.03b	34.94 bc	106.24d	36.51cd	34.40bc
V2 × Balanced nanocomposite	84.03b	4.65C	255.65bc	7.011c	102.37c	11.37ab	34.32 cd	109.38cd	38.82c	35.51ab
V2 × Amino acids	82.80c	4.58C	242.22d	7.27b	101.78b	11.53ab	034.10 cd	1107.10d	38.86c	36.40ab
V2 × Comparative treatment	82.422c	4.088D	249.544c	6.277e	94.189e	11.288ab	30.444 e	105.311d	34.746d	33.058c
1/6 × Wood vinegar	84.900a	4.850b	269.383a	7.650a	110.983a	10.900c	35.750ab	115.400bc	40.092abc	34.662cd
1/6 × Balanced nanocomposite	85.70a	4.56cd	267.15ab	7.41b	103.98b	11.3bc	34.73 bc	104.18e	39.69bc	38.10ab
1/6 × Amino acids	84.81a	4.48d	258.65bcd	7.31bc	102.45b	11.26bc	34.21 cd	113.01cd	38.40cd	34.04cd
1/6 × Comparative treatment	82.93b	4.10e	267.16ab	6.46e	94.93c	11.43bc	30.78 e	108.96cde	35.36d	32.48d
15/6 × Wood vinegar	84.65a	4.86b	262.25abc	7.26Bc	102.10b	11.65abc	36.23 a	106.76de	40.44abc	37.89b
15/6 × Balanced nanocomposite	84.75a	4.53cd	253.38cde	7.28bc	102.41b	11.56abc	33.61 d	106.80de	38.32cd	36.05bc
15/6 × Amino acids	84.70a	4.61cd	256.71cde	7.250bc	105.31b	12.30a	33.86 cd	104.13e	42.33ab	40.69a
15/6 × Comparative treatment	82.84b	4.11e	247.18ef	6.31e	95.56c	11.36bc	30.43 e	109.08cde	34.75d	31.88d

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30/6 × Wood vinegar	82.40b	4.88b	251.50def	7.18c	113.03a	11.86ab	34.80bc	126.43a	43.65a	34.43cd
30/6 × Balanced nanocomposite	83.35b	5.05a	247.46ef	6.86d	111.33a	12.00ab	33.60d	123.96a	43.79a	35.46bc
30/6 × Amino acids	82.766b	4.68c	237.71g	7.250bc	111.70a	11.23bc	35.93a	120.73ab	43.53a	35.92bc
30/6 × comparative treatment	80.86c	4.06e	242.75fg	6.45e	94.93c	11.63abc	31.10e	103.75e	35.45d	34.22cd
V1 × 1/6 × Wood vinegar	84.23a-g	4.90cde	283.93a	7.80a	119.76a	11.20cd	37.16a	125.13cd	45.22bcd	36.15bÜf
V1 × 1/6 × Balanced nanocomposite	86.20a	4.60i-f	277.43ab	7.733ab	104.40bc	11.66a-d	34.16def	102.53gh	40.04i-d	39.01abc
V1 × 1/6 × Amino acids	85.70a b	4.40ijk	262.86cde	7.16de	105.33bc	11.40bcd	34.83e-b	117.10de	40.85gd	35.08g-c
V1 × 1/6 × comparative treatment	82.76i-e	4.10lm	264.63e-b	6.43jk	97.06g-d	11.93abc	31.10g	113.43ef	37.59je	33.24g-d
V1 × 15/6 × Wood vinegar	84. 6f-a	5.46a	260.33f-c	7.73ab	104.93bc	11.80a-d	36.30ab	106.00fgh	42.03def	39.68ab
V1 × 15/6 × Balanced nanocomposite	84.93a-d	4.76d-g	237.60jk	7.40cd	105.63bc	11.86abc	32.96f	101.00h	39.95i-d	39.56ab
V1 × 15/6 × Amino acids	85.60ab	4.53hi	269.73bc	7.10e	103.56bcd	12.46ab	33.66def	105.00fgh	41.75def	39.76ab
V1 × 15/6 × comparative treatment	82.68i-f	4.10lm	255.16h-c	6.53hij	94.70fg	11.53bcd	30.80g	107.50h-e	34.53ij	32.16fg
V1 × 30/6 × Wood vinegar	83.30h-c	4.70h-e	255.90g-c	7.46bc	124.70a	12.73a	35.26bcd	147.33a	51.58a	34.94g-c
V1 × 30/6 × Balanced nanocomposite	84.36f-a	4.96bcd	254.00i-e	6.96ef	118.30a	12.13abc	33.80def	138.20b	47.16abc	34.11g-d
V1 × 30/6 × Amino acids	84.86d-a	4.86cde	246.90j-f	7.53abc	124.66a	11.13cd	37.23a	132.33bc	49.33ab	37.25bcd
V1 × 30/6 × comparative treatment	80.56J	4.10l m	245.76j-f	6.66j-g	96.53efg	11.53bcd	31.40g	106.73h-e	34.78ij	32.60efg
V2 × 1/6 × Wood vinegar	85.56ab	4.80def	254.83h-c	7.50bc	102.20e-b	10.60d	34.33def	105.66fgh	34.96hlj	33.17g-d
V2 × 1/6 × Balanced nanocomposi	85.20abc	4.53hi	256.86g-c	7.10e	103.56cd	11.00cd	35.30bcd	105.83fgh	39.35i-e	37.19bcd
V2 × 1/6 × Amino acids	83.93g-b	4.56hlj	254.43h-d	7.46bc	99.56g-c	11.13cd	33.60ef	108.93h-e	35.95j-g	33.00g-d
V2 × 1/6 × comparative treatment	83.10h-d	4.10m	269.70bc	6.50ij	92.80g	10.93cd	30.46g	104.50gh	33.13j	31.71g
V2 × 15/6 × Wood vinegar	84.75e-a	4.26kl	264.16e-b	6.80fgh	99.26g-c	11.50bcd	36.16abc	107.53h-e	38.86i-e	36.10b-f
V2 × 15/6 × Balanced nanocompo	84.56f-a	4.30klj	269.16bcd	7.16de	99.20g-c	11.26bcd	34.26def	112.60efg	36.70j-f	32.55efg
V2 × 15/6 × Amino acids	83.80b-g	4.70e-h	243.70j-g	7.40cd	107.06b	12.13abc	34.06def	103.26fgh	42.92cde	41.61a
V2 × 15/6 × comparative treatment	83.00i-d	4.13lm	239.20jk	6.10l	96.43efg	11.20cd	30.06g	110.66h-e	34.97hij	31.61g
V2 ×× 30/6 × Wood vinegar	81.50ghi	5.06bc	247.10j-f	6.90efg	101.36f-b	11.00cd	34.33def	105.53fgh	35.73j-g	33.92dg
V2 × 30/6 × Balanced nanocomposite	82.33j-g	5.13b	240.93k-h	6.76i-f	104.36bc	11.86abc	33.40e f	109.73h-e	40.42h-d	36.81e-b
V2 × 30/6 × Amino acids	80.66J	4.50hij	228.53k	6.96de	98.73g-c	11.33bcd	34.63cde	109.13h-e	37.73j-e	34.60d-g
V2 ×30/6 × comparative treatment	81.16g i	4.03m	239.73ijk	6.233kl	93.33g	11.73a-d	30.80g	100.76h	36.12j-g	35.84b-g

according to the design used and Duncan's multiple range test was used to compare the means.

Results and Discussion

The results in (Table 2) show significant differences between the varieties, as the green variety was significantly superior to the black variety in the averages of most of the studied traits. The results were as follows: plant height (84.148 and 83.298 cm), number of branches (4.625 and 4.511 branches. plant^{-1}), leaf area (259.522 and 250.697 cm^2/plant^{-1}), pod length (7.211 and 6.908 cm), number of pods (108.300 and 99.825 pod/plant^{-1}), number of seeds (11.783 and 11.308 seeds.pod^{-1}), biological yield (116.858 and 107.014 g.plant^{-1}), seed yield (42.069 and 37.239 g.plant^{-1}) and harvest index. (36.132 and 34.846%) for the green and black varieties, respectively. This was similar to what was obtained by Ali *et al*. (2020); Ali *et al*. (2024c); Ali *et al*. (2024b); Ali *et al*. (2023b). This is due to the Iraqi farmer's reliance on cultivating the locally traded green variety, which is suitable for Iraqi conditions and has better specifications than the black variety. This is due to the difference in the genetic makeup of the two varieties and thus their variation in response to prevailing environmental conditions, especially when significant climatic and environmental changes occur. This is due to the varieties belonging to multiple maturity groups and being greatly affected by the environment. This necessitates determining the appropriate date for planting varieties with different environmental adaptations (Ali *et al.,* 2024a; Ali *et al*., 2025).

The results of (Table 2) indicate that planting dates had a significant effect on most of the studied traits. The first date achieved a significant superiority over the other dates, recording an average of 84.587 cm for the trait of plant height, 265.588 cm^2 for the trait of leaf area and 7.212 cm for pod length, compared to the second date, which recorded a significant superiority rate of 36.632% for the harvest index, while the third date was significantly superior in the traits of the number of branches (4.670 branches. plant^{-1}), the number of pods (107.750 pod.plant^{-1}), the biological yield (118.720 g.plant^{-1}) and the seed yield (41.609 g.plant^{-1}). The superiority of early planting dates over late planting dates in vegetative growth characteristics may be attributed to the longer vegetative growth period of the crop, which allows plants to utilize more light, thus increasing the efficiency of photosynthesis. This is positively reflected in the growth and development of plants, including encouraging the growth of green parts and increasing plant height, leaf area and pod length. The superiority of late planting dates in crop characteristics and components may be due to the availability of suitable environmental conditions such as appropriate temperature and lighting, which help the plant form a reproductive group that matches the requirements of seed production. Consequently, the carbohydrates stored in the meristematic parts will be transferred to the economic part once it is formed. These results are consistent with the findings of Van Loon *et al*. (2018); Ali *et al*. (2020); Ali *et al.* (2024a).

From the results of the nutritional materials added to the mung bean plants, it is noted that the addition of these materials led to an improvement in most of the studied characteristics compared to the control treatment, especially when adding wood vinegar, as we notice a significant superiority when adding this material with all the studied characteristics, followed by amino acids and balanced nano-complex fertilizer. Water spraying had the lowest values recorded in the treatment. This may be attributed to the role of these materials in increasing the transfer of carbohydrates to the active areas during the reproductive stage, which affected reducing competition for the products of metabolism, positively affecting most of the characteristics, as these materials contribute to increasing the photosynthesis process and thus preparing new growth sites with growth requirements, reducing their abortion. Materials that have proven their efficiency in a distinctive way, such as wood vinegar, nano-fertilizers and amino acids, are among the important materials in improving the performance of varieties, increasing their productivity and improving their quality, especially the above materials, as they play a role in building hormones and plant protein, an important role in the process of photosynthesis, chelating nutrients and controlling the acidity of the cell. Recently, wood vinegar (pyroligneus acid) has been used as an organic agricultural product in Italy (Italian Ministerial Decree 6793, 2018). It is a by-product obtained from the condensation of gases produced during the pyrolysis of woody biomass. It consists of 200 or more water-soluble compounds, including phenols, tannins, esters and acetic acids. This has been confirmed by studies by Mathew *et al*. (2015); Abdulqader *et al*. (2021); Ali *et al*. (2025). All interactions behaved as single agents in terms of superiority and distinction, whether for binary or triple interactions.

Conclusion

The local green variety was superior in all studied traits. The 1/6 planting date was significantly superior in plant height, leaf area and pod length, while the 15/6 planting date was significantly superior in harvest index only, while the 30/6 planting date was significantly superior in the number of branches per plant, number of pods, biological yield and seed yield. Foliar fertilizer spray treatments recorded a significant superiority compared to water spraying, especially when spraying with wood vinegar and some traits were significantly affected by the use of balanced nano-compound and amino acids, especially seed yield.

Acknowledgement

The authors are very grateful to the University of Mosul/ College of Agriculture and Forestry for its facilities, which improved the quality of this article.

Conflict of interest

The authors have no conflict of interest to declare.

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