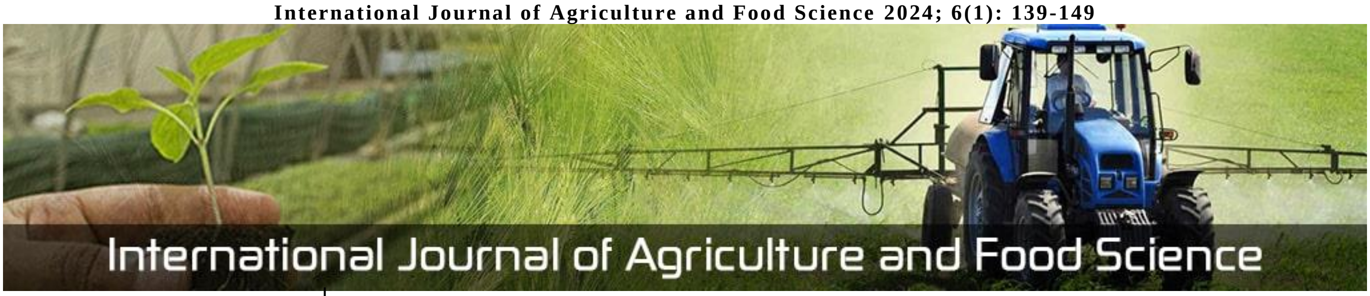

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Effect of different urea coating formulation, method and number of fertilizer partitions on some chemical characteristics of pepper plants

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Abstract

A field experiment was conducted during the 2023 growing season. The experiment aimed to investigate the impact of four treatments of coated urea fertilizer. The experiments aim to assess the efficiency of the coating in providing nitrogen during the crop growth period while reducing production costs. The experiment involved three factors: Factor 1: Coating Material Type (F): four coating materials were selected, and uncoated urea including: F1: Uncoated urea (control), F2: Finely ground tree bark + Arabic gum + water, F3: Finely ground tree bark + paraffin wax, F4: Residual oil + sulfur + soybean oil, F5: Residual oil + finely ground compost + soybean oil. Factor 2: Fertilizer Application Method (M): M1: Broadcasting Method: M2: Banding Method and Factor 3: Nitrogen Fertilizer Splitting (P): P1: Two Splits and P2: Three Splits. Coating treatment F2 exhibited significantly higher compared to the other coated treatments. All coated treatments Were significantly superior over the uncoated urea treatment in terms of Nitrogen and Phosphorus concentration in plant leaves. However, all coated treatments were superior over the uncoated urea treatment in these parameters. While F3 coating treatment superior over the other coated treatments in terms of Potassium concentration in plant leaves, and all coated treatments superior over the uncoated urea treatment. F2 coating treatment superior over the other coated treatments in terms of total soluble solids and vitamin C concentration in pepper fruits, and all coated treatments superior over the uncoated urea treatment in terms of total soluble solids and vitamin C concentration in pepper plants. Regarding application method, the banding method (M2) Were superior over the broadcasting method (M1) across all treatments. Regarding nitrogen fertilizer splitting, splitting into three applications (P2) generally Were superior over splitting into two applications (P1) in most plant traits (total soluble solids and vitamin C concentration in pepper plants). Splitting into two applications (P1) was superior only in terms of (NPK) concentration in plant leaves.

Keywords: Coated urea, fertilizer partitioning, methods of fertilizer application, sweet pepper

Introduction

With the world's rapidly growing population, the agricultural sector must utilize larger quantities of fertilizers to enhance food supplies, consequently escalating food production costs and global food demands. Simultaneously, arable land is dwindling due to soil degradation stemming from various factors. To meet the rising demand for food, the agricultural sector is compelled to employ vast amounts of fertilizers, which have thus far exhibited low fertilizer use efficiency and undesirable environmental impacts. Therefore, developing systems to augment production and mitigate environmental concerns is paramount (Chien *et al.*, 2009) [15]. Nitrogen is one of the most widely used nutrients in fertilization programs because plants generally require it in higher quantities compared to other nutrients. Nitrogen plays a crucial role in the synthesis of chlorophyll molecules, the formation of proteins, enzymes, and cell membranes, cell division and elongation, and the generation of new cells. Additionally, it enhances plant tolerance to extreme environmental conditions. Urea fertilizer is the most common nitrogen source for crops worldwide, owing to its high nitrogen content (46%) and low production costs. However, the hydrolysis of the amide molecule in urea fertilizer by the urease enzyme secreted by soil microorganisms can lead to significant nitrogen losses through nitrate leaching, ammonia volatilization, or other biological processes, thereby reducing nitrogen use efficiency in the soil (Parfitt *et al.*, 2006) [34].

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Due to the widespread use of urea fertilizer and the need to improve its utilization efficiency, various strategies have been developed to minimize nitrogen losses and enhance plant nitrogen uptake. other causes of loss include hot weather conditions and poor fertilizer management. These strategies include diversifying application methods, selecting the appropriate application timing, applying in split doses, and employing slow-release fertilizers.

Strategies for Minimizing Nitrogen Losses

1. Employ slow-release nitrogen fertilizers: Examples include sulfur-coated urea and controlled-release urea products.
2. Utilize nitrification inhibitors: Examples include nitrapyrin (Nitrobacter inhibitor) and dicyandiamide (DCD, commercially known as N-Serve).
3. Implement split nitrogen applications: This strategy ensures that the nitrogen supply matches the plant's demand, minimizing nutrient losses.

Nitrogen Fertilizer Application Methods

Environmental pollution has become a significant concern due to mismanagement, particularly in fertilizer application practices. Excessive fertilization leads to increased soil salinity, and over-application of nitrogen fertilizers has resulted in nitrate contamination of groundwater. Additionally, organic residues left behind after harvest contribute to environmental pollution, and water and soil pollution sources also pose health risks (Sönmez *et al*., 2002) [43]. Moreover, farmers often apply excessive amounts of nitrogen fertilizer at high doses without economic justification. Therefore, there is a need for application methods that minimize nitrogen volatilization losses. These methods include: Broadcast method, Banding method, Pop-up or starter method, side dressing method.

Alternative Methods for Coating Urea

Numerous researchers have conducted studies focused primarily on employing coating techniques using organic materials such as starch, fibrin, natural rubber, polyethylene, polyvinyl chloride, and ethyl cellulose, as well as inorganic materials like silicon and phosphate salts. Each of the aforementioned materials presents distinct advantages and drawbacks associated with its utilization. For instance, phosphate gypsum exists in a moist salt state, hindering its application in fertilizer equipment. Moreover, its drying process renders its use economically unviable, and it also crumbles during irrigation.

Recently, a team from Zewail City of Science and Technology in Egypt presented a polymer blend at a forum organized by the Egyptian Academy of Scientific Research. This blend comprises pectin, which can be extracted from citrus peels, cellulose derived from agricultural residues, and marine snails. The mixture, including these three components, was tested in a laboratory setting and demonstrated effectiveness in achieving slow-release urea. As demonstrated by Khairul *et al*. (2014) [28] in a study involving four materials: gypsum, cement, sulfur, and zeolite, these materials were mixed and employed as coating agents to identify the most effective and cost-efficient coating. The primary motivations for selecting these materials were to enhance fruit quality, prevent plant diseases, provide plant nutrients, increase soil fertility, and improve water retention. The study revealed that coating urea with equal proportions of gypsum and sulfur exhibited high resistance to degradation and a reduced dissolution rate. However, its effectiveness was further enhanced by applying molten paraffin wax to the hot urea surface. The efficiency of coated urea was optimized by employing a 26% gypsum-sulfur blend (20% total coating), 3% paraffin wax, and sieving the coating materials prior to application. Consequently, the aim of this study was to investigate different urea coating materials to minimize nitrogen losses and enhance nutrient availability in the soil, and evaluate the effects of coated urea formulations with the proposed materials on certain growth parameters of pepper plants (plant height, number of leaves, number of branches, leaf chlorophyll content, leaf area) and to mitigate the negative environmental impact of nitrogen losses.

Materials and Methods

A field experiment was conducted in a calcareous soil with physical and chemical properties as outlined in Table 1 to investigate the influence of coated urea, application method, and number of fertilizer applications on In some chemical properties of pepper crops

Experimental Factors: The study encompassed three factors:

Factor 1: coating Material Type (Represented by Symbol F)

Four formulations were selected with a fixed proportion of 4.5% coating material weight in addition to uncoated urea:

1. uncoated urea (F1)
2. Finely ground tree bark + Arabic gum + water (F2)
3. Finely ground tree bark + paraffin wax (F3)
4. Residual oil + sulfur + soybean oil (F4)
5. Residual oil + finely ground compost + soybean oil (F5)

Factor 2: Application Method (Represented by Symbol M)

1. Broadcast method (M1)
2. Banding method (M2)

Factor 3: Split Application of Nitrogen Fertilizer (Represented by Symbol P)

The recommended nitrogen fertilizer dose of 120 kg N/ha (Ministry of Agriculture, 2011) was split and applied as follows:

1. 1/2 of the recommended amount at planting + 1/2 one month after planting (P1)
2. 1/3 of the recommended amount at planting + 1/3 one month after planting + 1/3 70 days after planting (P2).

The experimental field was prepared by plowing twice perpendicularly using a moldboard plow. Subsequently, leveling and smoothing operations were conducted using disc harrows. The field was then divided into three blocks (RCBD design) with a 1-meter spacing between each block. Each block was further divided into 20 plots (experimental units) with an area of 4 m² per unit and dimensions of 2 m x 2 m. A 1-meter spacing was maintained between each plot. This resulted in a total of 60 experimental units. Sweet pepper seedlings of the cultivar 'Flavio F1' were transplanted on April 19, 2023, in rows spaced 75 cm apart, with a plant spacing of 25 cm within each row. Each plot had three rows, and each row had six plants. The experiment was irrigated using a drip irrigation system according to the plants' water requirements. Organic fertilizers were applied to each plot by broadcasting and mixing them with the soil using a hoe and then a hand cultivator. Weeding was done manually, while insect control was achieved using the insecticide Acetamiprid (Powder) at a rate of 1 g/L to combat chewing insects, whiteflies, and aphids. The insecticide was applied uniformly to all treatments whenever necessary. Spraying was carried out in the early morning until the plants were fully wetted. Field management and irrigation continued until August 20, 2023. Urea fertilizer was applied in split doses according to the splitting factor. Triple superphosphate (P_2O_5 (P 46%)) was applied as a phosphorus source at a rate of 160 kg P ha^{-1}, and potassium sulfate (K_2O (K 41%)) was applied as a potassium source at a rate of 120 kg K ha^{-1} in a single dose after planting. Five plants were randomly selected from each experimental unit, and their means were used to calculate the following experimental parameters: NPK Analysis in Leaves: Two months after planting in the field: Leaves were collected and air-dried. After grinding the samples, the following analyses were performed on the digested material: Nitrogen: Quantified using the micro-Kjeldahl method as described in Page *et al.* (1982) [46]. Phosphorus (%): Quantified using ammonium molybdate and ascorbic acid with a spectrophotometer at 840 nm wavelength following the Olsen method (Page *et al.* 1982) [46]. Potassium (%): Quantified using ammonium acetate solution and then a flame photometer as described in Page *et al.* (1982) [46]. Total soluble solids (TSS) percentage in fruits was measured using a digital refractometer and expressed as Brix%.

An electric blender was used to obtain plant juice, and 91 ml of fresh juice was taken using a pipette and placed in a 911 ml volumetric flask. The juice was then diluted with distilled water to the mark, and 91 ml of the solution was taken using a pipette and 2 drops of starch indicator were added. The solution was titrated with iodine solution slowly until a blue color appeared. These steps were repeated four times for each sample (Al-Fijm and Abdul Aziz, 1993) [4]. Vitamin C was estimated by oxidizing ascorbic acid (vitamin C) with an oxidizing agent, iodine. Iodine is relatively insoluble in water, but this can be improved by complexing iodine with iodide to form triiodide.

$$I_2 + I^- \rightleftharpoons 3I^-$$

As long as vitamin C is present in the solution, triiodide is rapidly converted to iodide ions.

However, once all of the vitamin C has been oxidized, iodide and triiodide will be present and will react with starch to turn the solution blue.

This is the endpoint of the titration, at which point the number of millimoles of iodine is equal to the number of millimoles of ascorbic acid.

$$mM\ iodine \times V\ iodine = mM\ AH\ in\ juice \times V\ juice$$

$mM\ iodine$: Iodine concentration (mmol/L)

$V\ iodine$: Volume of iodine solution (L)

- $mM\ AH\ in\ juice$: Millimoles of Ascorbic Acid (vitamin C) in juice (mmol/L)
- $V\ juice$: Volume of juice (L)

The following relationship is used to convert vitamin concentration from units of mole/L to mg/100ml, taking into account the dilution factor.

$$(mg/100\ ml) = (mole/L) \times AM \times 100$$

where AM is the molecular weight of ascorbic acid (Quan, 2011) [14].

Table 1: Physical and Chemical Properties of the Experimental Soil

Property	Unit of Measurement	Value
Sand	g/kg soil	70
Silt		490
Clay		440
Texture		Clay loam
pH		7.59
Electrical conductivity	dS m^{-1}	0.49
Organic matter	g kg $soil^{-1}$	21.6
Calcium carbonate	g kg $soil^{-1}$	107
Total nitrogen	g kg $soil^{-1}$	1.07
Available phosphorus	mg kg $soil^{-1}$	5.95
Available potassium	mg kg $soil^{-1}$	19
Sodium	mmol L^{-1}	0.31
Potassium		0.12
Calcium		0.39
Magnesium		0.9
Chloride		0.49
Carbonates		0.00
Bicarbonates		3.11

Results and Discussion

Chemical Properties of Pepper Leaves

Nitrogen, Phosphorus, and Potassium Concentrations

1. Percentage of Nitrogen in Leaves

Table (2) shows the effect of study factors on the percentage of nitrogen in leaves. Coating treatments had a significant effect on the percentage of nitrogen in plant leaves between treatments (F2, F3, F5, F4). The average coating values were (1.78, 1.70, 1.70, 1.53)%, respectively, and all coated treatments were significantly superior to the uncoated urea treatment, which gave the lowest nitrogen content value (1.38%). Treatment F2 was superior to the other treatments because the materials used to coat urea granules differ in their solubility, which in turn results in a difference in the amount of nitrogen released. This leads to an increase in available nitrogen in the soil in the coated urea fertilizer treatment during growth periods due to the slow decomposition of coated urea fertilizer and its provision of nitrogen to meet the plant's needs, which increased its absorption and transport by the roots into the plant, which in turn increased its concentration in plant tissues. This result is supporting the General Sugar Manufacturing Company (2018) that illustrated the coated treatment caused enhancement of nitrogen content in the leaves of sugarcane. This may be because nitrogen is present in the fertilizer and in the root zone and identified as highly available in the ammonium and nitrates throughout the application period leading to increased uptake by the plant hence increased concentration in the leaves. These results are similar to the findings made by the Castellano *et al.* (2011) [14]. These results are also consistent with those of Yassin (2023) [45], who found that the addition of nitrogen fertilizer led to a significant increase in nitrogen concentration in yellow corn leaves. The leaves were analyzed in the early stages of plant life, as this is considered the best period for measuring element concentration in plant leaves, as element concentration in leaves decreases with plant age. Several researchers (Hochmuth *et al.*, 1989) [25] have observed a decrease in nitrogen concentration in tomato leaves with plant age, which is attributed to increased vegetative growth rates with plant age, leading to a dilution of the element in the leaves, as well as increased nitrogen movement from leaves to fruits during their formation.

As is evident from the same table, the method of applying nitrogen fertilizer has a significant effect on the nitrogen concentration in the leaves. Adding nitrogen by the banding method recorded the highest value, reaching (1.70)%, and superior over the broadcasting method, which recorded a value of (1.54)%. The reason for the higher nitrogen concentration in the leaves with the banding method may be due to the fact that adding the fertilizer in this way at a depth of 10 cm helped to keep the nitrogen in the soil and reduce its loss through volatilization, thus allowing the plant to benefit from the largest possible amount. Li *et al*. (2020) [29] confirmed that applying nitrogen fertilizer by the banding method increased nitrogen efficiency compared to the broadcasting method, which led to increased nutrient uptake from the soil, especially nitrogen. A strong root system was observed, as evidenced by the longer root length and larger root volume of the rice crop, which was the reason for the increased nitrogen uptake. Islam *et al*. (2023) [38] concluded that applying nitrogen fertilizer by banding reduces nitrogen loss from the soil in the form of ammonia by increasing the contact between fertilizer granules and soil clay particles, which increases nitrogen uptake and utilization efficiency by providing more nitrogen in the root zone, which ensures a long-term supply of nitrogen and its retention in the form of non-exchangeable ammonium in the reduction zone throughout the rice growing season, which increases the nitrogen content in the plant leaves compared to the broadcasting method.

Table (2) shows the superiority of adding nitrogen in two splits, where it recorded a value of (1.72)% over adding it in three splits, which recorded a value of (1.52)%. Yassin (2023) [45] concluded that splitting nitrogen fertilizer led to a significant increase in nitrogen concentration in the leaves, as splitting nitrogen fertilizer resulted in a significant increase in absorbed nitrogen in the leaves. The reason for this might be that at this stage of development of the plants the splitting treatment allowed for more effective delivery of the nitrogen to the plants, and therefore, an increase in the amount of nitrogen applied over time, would correspond to the growth stage of the plant, leading to an increase in the nitrogen content of the leaves. Al-Baraki and Al-Ajmi (2020) [3] corroborated the implication of the splitting of nitrogen fertilizer to an increased amount of nitrogen absorbed and most other growth traits, yield, and its components. These findings agree with Abo-Zeid *et al*. (2017) [1] where splitting of nitrogen fertilizer was significant difference in terms of nitrogen content when right amount of nitrogen is given during plant growth stage because the plant requires nitrogen at constant, and nitrogen has positive effect on the root growth thus enhancing the nitrogen uptake from the soil in adequate quantity and hence increasing its content in plant tissues. The two-splits treatment was superior due to the fact that plant leaf samples were taken for element analysis shortly after the addition of the third batch, so the plants did not have the opportunity to benefit from the third batch, and the same was true for the elements phosphorus and potassium.

The triple interaction among the study factors (application method, number of doses, and coating material) showed clear significant differences between the treatments. Treatment (M2P1F2) recorded the highest mean, reaching (2.02)%, which was superior to all treatments, while treatment (M1P1F1) gave the lowest mean, reaching (1.36%).

Table 2: Effect of coated urea Combination, Number of Doses, and Application Method on Concentrations of Nitrogen in Leaves in Pepper Plants (%)

Application method M	**Number of Doses P**	**Coating material**					**Application method x Number of Doses P×M**
		F1	**F2**	**F3**	**F4**	**F5**	
M1	P1	1.36	1.79	1.76	1.59	1.67	1.63
		ij	b	bc	d-f	cd	B
	P2	1.24	1.66	1.4	1.4	1.5	1.44
		j	cd	hi	hi	e-g	C
M2	P1	1.49	2.02	1.86	1.66	1.99	1.8
		f-h	a	b	cd	a	A
	P2	1.43	1.63	1.76	1.5	1.66	1.6
		g-i	de	bc	f-h	cd	B
							Application method M
M × F	M1	zz1.3	1.73	1.58	1.5	1.58	1.54
		e	b	c	d	c	B
	M2	1.46	1.82	1.81	1.56	1.83	1.7
		d	ab	ab	c	a	A
							Number of Doses P
P xF	P1	1.43	1.91	1.81	1.61	1.83	1.72
		ed	a	b	c	b	A
	P2	1.34	1.65	1.58	1.45	1.58	1.52
		e	c	c	d	c	B
Average coating		1.38	1.78	1.7	1.53	1.7	
		D	A	B	C	B	
M1: Broadcast M2: Banding		P1: Two Splits P2: Three Splits		F1: un coated urea F2: Finely ground tree bark + Arabic gum + water F3: Finely ground tree bark + paraffin wax F4: Residual oil + sulfur + soybean oil F5: Residual oil + finely ground compost + soybean oil			
No Significant Differences Detected Among Means with Similar Letters Based on Duncan's Test							

2. Percentage of phosphorus in Leaves

Table (3) shows the effect of study factors on the phosphorus percentage in pepper leaves. Coated treatments did not show a significant effect on the phosphorus percentage in the leaves of the plant between the treatments (F2, F5, F4, F3). The average coated percentage was (0.17, 0.17, 0.16, 0.16)%, respectively. However, it was significantly higher than the average coated percentage for the uncoated urea treatment, which gave the lowest value for phosphorus percentage of (0.14)%. These results are consistent with those who found that coated urea slows the release of urea and reduces the amount released for a longer period during the growing season. This reflected positively on improving the plant's root system and its ability to reach phosphorus absorption sites, which increased its efficiency in absorbing elements in the soil solution, including phosphorus. This result is also consistent with Awwad and Mashhut (1987) [10], who showed that increasing the level of available nitrogen in the soil led to an increase in the phosphorus content of the leaves. In a study conducted on tomato plants, coated urea increased phosphorus absorption in the leaves by 30% compared to uncoated urea. This superiority of the coated urea fertilizer may be attributed to increased nitrogen processing and increased vegetative and root growth, which encouraged the absorption of the largest amount of phosphorus, as well as the action of hydrogen ions released from the nitrification process. Mengel and Kirkby (1982) [33]. The role of nitrogen in increasing the absorbed phosphorus may be through preventing the ammonium ions released from ammonia fertilizers from competing with the phosphate ions for absorption sites in the roots, reducing the degree of soil interaction due to the nitrification process, and increasing the solubility of non-ready phosphorus compounds, as well as increasing vegetative and root growth, which encouraged greater absorption. The amount of phosphorus is consistent with the results of Al-Hilli (2007) [6]. Table (3) shows that the banding application method was superior to the broadcasting method, with values of (0.17 and 0.15)%, respectively. Nitrogen affects phosphorus availability in the soil by influencing the activity of soil microorganisms: These microorganisms convert organic phosphorus into inorganic phosphorus, which is more readily available for plant uptake. Affecting the dissolution and mobility of inorganic phosphorus: Nitrogen can help to dissolve and mobilize inorganic phosphorus, making it more accessible to plant roots. Hence, increasing the nitrogen use efficiency by using banded application of nitrogenous fertilizers could also increase phosphorus availability and its absorption by plants. These findings are in line with those of other empirical investigations, including the studies conducted by Raun (1998) [36], Huijsmans (2003) [26], and Al-Hamdani (2008) [5].

The subscript 0 represents the base level, or in other words, no treatment at all; the subscript 1 represents splitting fertilizer into three doses as the treatment; the subscript 2 represents splitting fertilizer into two doses as the treatment; The value 0. 17% was preferred to the value of 0. 15% because it was closer to the base level, meaning that splitting fertilizer into two doses proved to be more effective than splitting The two-dose splitting method might have been superior to the one-dose splitting method because the samples of the leaves to be analyzed for element analysis (NPK) were collected before the third dose of fertilizers was applied. This means that the plants have already accumulated most of the phosphorus from the first two doses of the fertilizers. The third fertilizer dose might not have influenced much on the phosphorus uptake because at this stage the plants were able to uptake phosphorus to their maximum capacity. Nitrogen fertiliser can also be split applied in the field to increase the availability of phosphorus in the plant nutrient cycle by reducing nutrient leaching and nutrient volatilisation. It can also have a negative effect on the rate of nitrification as well, thus increasing the likelihood of nutrients being released in to the soil and the tissues of the plants. This synchrony of nutrients correlates with the study by Shilpha *et al.* (2017) [41] who demonstrated that split application of coated urea enhanced phosphorus uptake in maize plants. While a study conducted by Feleafel *et al.* (2005) [19] on eggplant plants showed that splitting the amount of applied nitrogen into five or six doses during the growing season did not significantly affect the nutrient and phosphorus content of eggplant leaves, in both seasons (2001, 2002) in which the study was conducted. The triple interaction between the three study factors (application method, number of doses, and coating materials) showed clear significant differences between the treatments. Treatment (M2P1F2) recorded the highest average of (0.20%) and outperformed all other treatments, while treatment (M1P1F1) gave the lowest average of (0.14%).

3. Percentage of potassium in Leaves

Table (4) shows the effect of study factors on the percentage of potassium in the leaves. There was a significant effect between the average of coated urea and uncoated urea. However, there were no significant differences between all the combinations. There was a significant difference between the treatments (F4, F2, F3), which recorded (2.36, 2.33, 2.30%), respectively. Except for treatment (F5), which had a value of (2.28) and did not show a significant difference from uncoated urea (F1), which had a value of (2.22%). This may be attributed to the addition of potassium fertilizer to the soil and also the presence of potassium in the soil before planting at a good level according to the proposed limits (Liu *et al*., 2007) [31]. In addition, proper nitrogen supply to the plant leads to increased growth and consequently to a large absorption of potassium from the soil. This increase may be attributed to the ability of coated materials to provide nitrogen and its superiority and increased concentration in the plant, which leads to an increase in potassium in the plant due to the existence of a positive correlation between them (Gill and Meelo, 1982) [22]. The superiority in the potassium percentage in the leaves may be due to the effect of the two elements nitrogen and phosphorus in encouraging root growth and increasing the absorption of as much potassium as possible, which raised its concentration within the plant tissues. The positive effect of nitrogen in increasing the absorbed potassium started from the soil by increasing its readiness, in addition to the role of nitrogen in encouraging potassium absorption in the plant, as indicated by many researchers (Al-Naimi, 1999) [7].

Table 3: Effect of coated urea Combination, Number of Doses, and Application Method on Concentrations of Percentage of phosphorus in Leaves in Pepper Plants (%)

Application method M	**Number of Doses P**	**Coating material**					**Application method x Number of Doses M x P**
		F1	**F2**	**F3**	**F4**	**F5**	
M1	P1	0.14	0.17	0.16	0.14	0.17	0.16
		cd	A-d	b-d	cd	a-d	bc
	P2	0.14	0.14	0.15	0.14	0.15	0.14
		d	cd	b-d	d	b-d	c
M2	P1	0.15	0.2	0.19	0.18	0.18	0.18
		b-d	a	ab	a-d	a-c	a
	P2	0.14	0.18	0.16	0.17	0.17	0.16
		cd	a-d	a-d	a-d	a-d	ab
							Application method M
M × F	M1	0.14	0.16	0.15	0.14	0.16	0.15
		d	b-d	b-d	c-d	a-d	B
	M2	0.15	0.19	0.18	0.17	0.18	0.17
		b-d	a	ab	a-c	ab	A
							Number of Doses P
P xF	P1	0.15	0.18	0.17	0.16	0.18	0.17
		bc	a	ab	a-c	ab	A
	P2	0.14	0.16	0.15	0.15	0.16	0.15
		c	a-c	bc	bc	a-c	B
Average coating		0.14	0.17	0.16	0.16	0.17	
		B	A	AB	AB	A	
M1: Broadcast :M2: Banding		P1: Two Splits P2: Three Splits		F1: un coated urea F2: Finely ground tree bark + Arabic gum + water F3: Finely ground tree bark + paraffin wax F4: Residual oil + sulfur + soybean oil F5: Residual oil + finely ground compost + soybean oil			
No Significant Differences Detected Among Means with Similar Letters Based on Duncan's Test							

Table (4) also shows the significant superiority of the banding application method, which recorded a value of (2.35%) over the broadcasting method, which recorded (2.25%). The superiority of this method may be attributed to the fact that the fertilizer applied in this way was concentrated in small quantities on the sides of the plant, which led to increased root growth due to the presence of effective and direct contact areas between the roots and the fertilizer on both sides. It also increased the readiness of nitrogen, which led to an increase in dry matter yield, and consequently, an increase in leaf area, growth indicators, and plant height, which led to an increase in lateral root extension and consequently increased potassium readiness and uptake by the plant. These results are consistent with those of Barar and Benbi (1992) [11], who found that banding application of phosphate fertilizer to maize plants led to increased root system development (increased root system size) and consequently increased nutrient uptake. These results are also consistent with those of John *et al*. (2005) [27], who found that banding application of fertilizer led to optimal plant utilization of fertilizer, as the roots absorbed from both sides by increasing the contact areas between the root and the fertilizer, which leads to an increase in the root system and thus increases the uptake of nutrients from both sides. This is in agreement with the findings of Al-Mujammai (2013) [2]. It can be concluded from the same table that the two-dose application method was superior, recording the highest value of (2.37%), while the three-dose application method recorded the lowest value of (2.23%). Leaf samples for element analysis (NPK) were taken seven days before the third fertilizer dose was applied. Splitting nitrogen fertilizer and providing nitrogen at the right time for plant growth encourages root growth and increases the absorption of as much potassium as possible, which leads to an increase in its concentration within plant tissues (Abo-Zeid *et al*., 2017) [1]. These results are consistent with those of Mengel and Kirkby (1982) [33], who found that the three-dose splitting treatment was superior to the other treatments and achieved the highest average potassium percentage in plant leaves. The triple interaction between the three study factors (application method, number of doses, and coating materials) showed clear significant differences between the treatments. Treatment (M2P1F3) recorded the highest average of (2.56%), superior over all other treatments, while treatment (M1P2F1) gave the lowest average of (1.96%).

Table 4: Effect of coated urea Combination, Number of Doses, and Application Method on Concentrations of potassium in Leaves in Pepper Plants (%)

Application method M	**Number of Doses P**	**Coating material**					**Application method x Number of Doses**
		F1	**F2**	**F3**	**F4**	**F5**	**M x P**
M1	P1	2.3	2.35	2.36	2.35	2.28	2.33
		b-d	b-d	b-d	b-d	cd	b
	P2	1.96	2.24	2.2	2.23	2.24	2.17
		e	cd	d	cd	cd	c
M2	P1	2.42	2.46	2.56	2.34	2.29	2.41
		a-c	ab	a	b-d	b-c	a
	P2	2.19	2.27	2.33	2.28	2.33	2.28
		d	cd	b-d	cd	b-d	b
							Application method x M
M × F	M1	2.13	2.3	2.28	2.29	2.26	2.25
		c	b	b	b	b	B
	M2	2.3	2.37	2.45	2.32	2.31	2.35
		b	ab	a	ab	b	A
							Number of Doses P
P xF	P1	2.36	2.41	2.46	2.34	2.28	2.37
		ab	a	a	ab	b	A
	P2	2.08	2.26	2.26	2.26	2.28	2.23
		c	b	b	b	b	B
Average Coating		2.22	2.33	2.36	2.3	2.28 AB	
		B	A	A	A		
M1: Broadcast M2: Banding		P1: Two Splits P2: Three Splits		F1: un coated urea F2: Finely ground tree bark + Arabic gum + water F3: Finely ground tree bark + paraffin wax F4: Residual oil + sulfur + soybean oil F5: Residual oil + finely ground compost + soybean oil			
No Significant Differences Detected Among Means with Similar Letters Based on Duncan's Test							

Some Chemical Properties of Fruits

1. Total Soluble Solids (%)

Table (5) shows the effect of study factors on the percentage of total soluble solids in pepper fruits. Treatments (F4, F2) did not show significant differences in the total soluble solids trait, with average coating values of (7.01, 7.02%), respectively. They were significantly superior to treatments (F5, F3), which recorded values of (6.68, 6.79%), respectively. Treatment (F1) of uncoated urea gave the lowest average of (6.09%). The superiority of F2 may be attributed to the fact that the treatment coated with Arabic gum and tree bark caused the coating to adhere well. Tree bark, as mentioned earlier, contains cellulose and cork materials that are not easily soluble in water. These materials affect the slow release of nitrogen and its presence at the times needed by the plant, which was the reason for the increase in the percentage of total soluble solids. The increase in total soluble solids may be due to the role of nitrogen and its entry into the composition of amino acids, which are the building blocks of proteins. Nitrogen also enters with magnesium into the chlorophyll molecule and into the structure of enzymes, some vitamins, and some growth regulators (Haile *et al*., 2012) [24]. Table (5) shows the superiority of the banding fertilizer application method, which recorded a value of (7.15%), over the broadcasting method, which recorded (6.29%). However, it is worth to point out, that the level of total soluble solids, as influenced by the banding application of nitrogen fertilizer can be quite variable and many factors, to achieve the best optimized results. Such factors include soil testing to assess the availability of nitrogen, correct application of nitrogen fertilizers depending on what the plant may require, plant growth observation, and making changes to the fertilization program as and when required. By managing nitrogen as such, these results can be compared to those obtained by Biesiada *et al*. (2009) [12] in an experiment on squash plants, where they also verified the efficiency of the method of banding applications of nitrogen fertilizer in increasing the percentage of TSS, carotenoids and sugars in fruits after harvest. These results are also in consonance with earlier work by Arvayo-Ortiz *et al*. (1994) [9] in a study involving zucchini plants.

From table (5) it was observed that the fertilizer splitting method of three doses produced higher yield of (7. 05%) as compared to that of two doses which yielded (6. 39%). The effects of nitrogen concentration are as follows: high concentration of nitrogen lowers the total soluble solids and low concentration of nitrogen raises the percentage total soluble solids. Therefore, it is preferable to add fertilizer in three doses to provide nitrogen at different stages of plant growth instead of losing a large amount of it when added in one dose. This is attributed to the fact that the nitrogen fertilizer applied by the banding method made the fertilizer available in a good way, i.e., it gives the ammonium ion a greater chance to be adsorbed on the surface of soil particles, which reduces its exposure to the loss process. In addition, placing the fertilizer under the soil surface reduces the effect of environmental factors on the fertilizer, including reducing the effect of direct air currents when the fertilizer is spread on the soil surface. The percentage of nitrogen lost through volatilization reached more than 50% of the nitrogen added to the soil surface. These results are consistent with those of Sánchez-Bel *et al*. (2010) [39]. Dhillon *et al*. (2009) [16] confirmed the significant effect of total fruit juice solids content on nitrogen fertilization, where the highest total solids content was recorded with the nitrogen fertilization treatment, but on condition that it is divided into doses, as adding it in one dose led to a decrease in the total solids content of the juice. Ghoneim (2005) [21], in a study on the addition of nitrogen fertilization in several doses, showed that splitting nitrogen fertilization into three doses was the best, as it led to a significant increase in the percentage of total soluble solids in the fruits of the pepper crop. Table (5) shows the triple interaction between the three study factors (application method, number of doses, and coating materials) with clear significant differences between the treatments, as treatment (M2P2F2) recorded the highest average of (7.85%), which outperformed all treatments, while treatment (M1P1F1) gave the lowest average of (5.18%).

Table 5: Effect of coated urea Combination, Number of Doses, and Application Method on Total Soluble Solids (%)in Pepper Fruits

Application method M	Number of Doses P	Coating material					Application method x Number of Doses M x P
		F1	F2	F3	F4	F5	
M1	P1	5.18	6.22	6.12	6.05	5.85	5.88
		j	h	hi	hi	i	d
	P2	6.02	6.72	6.66	7.32	6.76	6.69
		hi	g	g	cd	fg	c
M2	P1	6.32	7.29	6.98	7.09	6.84	6.9
		h	cd	ef	de	e-g	b
	P2	6.86	7.85	7.42	7.59	7.29	7.4
		e-g	a	bc	ab	cd	a
							Application method M
M × F	M1	5.6	6.47	6.39	6.69	6.3	6.29
		g	ef	ef	d	f	B
	M2	6.59	7.57	7.2	7.34	7.07	7.15
		de	a	bc	b	c	A
							Number of Doses P
P xF	P1	5.75	6.75	6.55	6.57	6.35	6.39
		f	c	cd	cd	e	B
	P2	6.44	7.29	7.04	7.45	7.02	7.05
		de	a	b	a	b	A
Coating average		6.09	7.02	6.79	7.01	6.68	
		C	A	B	A	B	
M1: Broadcast :M2: Banding			P1: Two Splits P2: Three Splits		F1: un coated urea F2: Finely ground tree bark + Arabic gum + water F3: Finely ground tree bark + paraffin wax F4: Residual oil + sulfur + soybean oil F5: Residual oil + finely ground compost + soybean oil		
No Significant Differences Detected Among Means with Similar Letters Based on Duncan's Test							

Vitamin C Concentration (mg 100 g^{-1} Fruit) in Pepper Fruits

Table (6) shows the effect of study factors on vitamin C concentration in pepper fruits. Coating treatments had a clear significant effect on vitamin C in fruits, as coating treatments (F3, F5, F4, F2) recorded average coating values of (37, 38.49, 40.30, 51.52) mg 100 g^{-1} fruit, respectively, and were significantly superior to the uncoated urea treatment, which gave the lowest average of (25.65) mg 100 g^{-1} fruit. This means that treatment F2 was 101% higher than treatment F1, which is the uncoated urea treatment. The superiority of F2 over the other treatments is attributed to the fact that the materials in the treatment coated with tree bark and gum arabic were able to provide the appropriate amounts of nitrogen in a ready-to-absorb form at the time the plant needed it. Li *et al.* (2017) [30] confirmed that the use of slow-release fertilizers (coated fertilizers) leads to an increase in vitamin C concentration. There are several possible explanations for this effect. First, the nitrogen in urea can help improve plant growth, which can lead to increased vitamin C production. Second, nitrogen can help regulate soil pH levels, which can affect vitamin C production. Third, By reducing oxidative stress, nitrogen can protect vitamin C from degradation and promote its accumulation in fruits. In general, studies indicate that adding coated urea to the soil can have a positive effect on the levels of vitamin C in fruits and vegetables because nitrogen is provided in large quantities when adding uncoated urea negatively affects the concentration of vitamin C, but the slow release of nitrogen positively affects the level of vitamin C in vegetables and fruits, so that it is available at all stages of plant growth (Dong *et al*. 2016) [18]. Further research is needed to fully elucidate the molecular and physiological processes underlying the positive effects of coated urea on vitamin C biosynthesis Shoji (2005) [42] and Tachibana (2007) [44]. As also shown in Table (6), the banding fertilizer application method was superior to the broadcasting method, as the banding method recorded a value of (42.66) mg 100 g^{-1} fruit, while the broadcasting method recorded (34.52) mg 100 g^{-1} fruit. Nitrogen is important for plants because it enters into the formation of chlorophyll and increases the efficiency of photosynthesis. It is also involved in protein metabolism and helps in the synthesis of vitamins. Therefore, good management of nitrogen fertilization leads to an improvement in the quality of fruits in terms of their components, especially vitamin C (Parisi *et al.*, 2022) [35]. Gordon and Whitney (2000) [23] stated that fertilizer placement is one of the factors affecting plant growth and yield. Therefore, placing the fertilizer in the appropriate place, so that it is close to the root, facilitates the absorption of nutrients by the plant, thus helping the plant to manufacture important components, including vitamins.

Anghinon and Barber (1980) [8] demonstrated that the banding application method of superphosphate fertilizer superior over the broadcasting method in increasing maize yield. These findings align with those of Biesiada (2009) [12], who showed that applying nitrogen fertilizer in band around the plant ensures satisfactory nutritional value for squash fruits with the highest vitamin C content. Table (6) also shows the main effect of the number of urea application doses, as the three-dose fertilizer application method, which recorded a value of (44.33) mg 100 g^{-1} fruit, outperformed the two-dose method, which recorded (32.85) mg 100 g^{-1}. These results are generally consistent with those of Dod *et al*. (1983) [17], who showed that the highest vitamin C content in chili pepper fruits was obtained by applying nitrogen in four equal doses; at planting and 30, 51, and 72 days later. Frontela and Morejon (1988) [20] reported that the highest vitamin C content in pepper fruits was obtained by applying nitrogen in three doses: 25% of the nitrogen at planting, followed by 25% after 30 days, and 50% after 60 days. Table (6) shows triple interaction between the three study factors (application method, number of doses, and coating materials) with clear significant differences between the treatments, as treatment (M2P2F2) recorded the highest average of (64) mg 100 g^{-1} fruit, which outperformed all treatments, while treatment (M1P1F1) gave the lowest average of (18.36) mg 100 g^{-1} fruit.

Table 6: Effect of coated urea Combination, Number of Doses, and Application Method on Vitamin C Concentration (mg 100 g^{-1} Fruit) in Pepper Fruits

Application method M	**Number of Doses P**	**Coating material**					**Application method x Number of Doses M x P**
		F1	**F2**	**F3**	**F4**	**F5**	
M1	P1	18.36	24.35	29.61	25.15	36.19	26.73
		n	m	kl	m	gh	d
	P2	28.5	58.49	34.23	50.29	40.03	42.31
		l	b	hi	d	f	b
M2	P1	25.2	59.24	40.81	32.25	37.39	38.98
		m	b	f	ij	g	c
	P2	30.55	64	43.34	53.52	40.34	46.35
		jk	a	e	c	f	a
							Application method M
M × F	M1	23.43	41.42	31.92	37.72	38.11	34.52
		g	c	e	d	d	B
	M2	27.87	61.62	42.07	42.89	38.86	42.66
		f	a	bc	b	d	A
							Number of Doses P
P xF	P1	21.78	41.8	35.21	28.7	36.79	32.85
		h	c	f	g	e	B
	P2	29.52	61.25	38.79	51.91	40.19	44.33
		g	a	d	b	d	
Average coating		25.65	51.52	37.00	40.30	38.49	
		E	A	D	B	C	A
M1: Broadcast M2: Banding		P1: Two Splits P2: Three Splits			F1: un coated urea F2: Finely ground tree bark + Arabic gum + water F3: Finely ground tree bark + paraffin wax F4: Residual oil + sulfur + soybean oil F5: Residual oil + finely ground compost + soybean oil		
No Significant Differences Detected Among Means with Similar Letters Based on Duncan's Test							

Conclusion

1. Coating urea fertilizer with tree bark plus gum arabic and tree bark plus paraffin wax effectively reduced losses and provided a controlled release of nitrogen throughout plant growth stages. This resulted in superior nitrogen, potassium, and phosphorus concentrations in plant leaves, as well as higher soluble solids and vitamin C content in pepper fruits.
2. Splitting urea fertilizer into three doses, applied 1/3 at planting, 3/1 one month after planting, and 3/1 two months after planting, significantly superior other treatments in terms of soluble solids and vitamin C concentration in pepper fruits.
3. Splitting urea fertilizer into two doses led to improved nitrogen, phosphorus, and potassium concentrations in plant leaves, depending on the period from which plant leaves samples were taken for elemental analysis.
4. The banding fertilizer application method consistently superior over the broadcasting method in all studied parameters.

References

1. Abo-Zeid ST, Abd El-Latif AL, El Shafey S. Effect of sources and rates of nitrogen fertilizers on forage yield and nitrate accumulation for Sudan grass. Egyptian Journal of Soil Science. 2017;57(1):23-30.
2. Al-Mujammai KHH. The effect of tillage systems and level and methods of adding phosphate fertilizer on the growth and yield of wheat (*Triticum aestivum* L.) in gypseous soil [Master's Thesis]. Tikrit: University of Tikrit, College of Agriculture; c2013.
3. Al-Baraki RHA. The use of coated urea soil amendment technology and its effect on growth, yield, and yield components of wheat crop [Ph.D. Thesis]. Al-Muthanna: Al-Muthanna University, College of Agriculture; c2020.
4. Al-Fijm A. Vitamins: Their Vital Importance and Medical Uses. Dar Al-Saalah for Printing and Publishing; c1993.
5. Al-Hamdani RIA. Effect of sulfur on ammonia volatilization from urea fertilizer and sheep manure in

calcareous soils [Ph.D. Thesis]. Mosul: University of Mosul, College of Agriculture and Forestry; c2005.

6. Al-Hilli MMT. Efficiency of urea and sulfur-coated urea in potassium release, phosphorus availability, growth, and wheat yield (*Triticum aestivum* L.) [Ph.D. Thesis]. Baghdad: University of Baghdad, College of Agriculture; c2007.
7. Al-Naimi SN. Fertilizers and soil fertility. 2nd ed. Mosul: University of Mosul Press; c1999.
8. Anghinoni I, Barber SA. Phosphorus application rate and distribution in the soil and phosphorus uptake by corn. Soil Science Society of America Journal. 1980;44(5):1041-1044.
9. Arvayo-Ortiz RM, Garza-Ortega S, Yahia FM. Postharvest response of winter squash to hot-water treatment, temperature and length of storage. HortTechnology. 1994;4(3):253-255.
10. Awwad KM. Fertilization and soil fertility. Basra: Ministry of Higher Education and Scientific Research, University of Basra; c1987.
11. Barar SA, Benbi JH. Using a mechanistic model to evaluate the effect of soil phosphorus uptake. Plant and Soil Journal. 1992;14:18-55.
12. Biesiada A, Nawirska A, Kucharska A, Sokol LA. Effect of nitrogen fertilization methods on yield and chemical composition of pumpkin (*Cucurbita maxima*) fruits before and after storage. Vegetable Crops Research Bulletin. 2009;70(1):203-211.
13. Candolfi MC, Koblet W. Yield fruit quality, bud fertility, and starch yield of the wood as a function of leaf removal in Vitis vinifera; c1990.
14. Castellanos TM, Cabello MJ, Cartagena MC, Tarquis AM, Ribas F. Growth dynamics and yield of melon as influenced by nitrogen fertilizer. *Scientia Agricola*. 2011;68(2):157-163.
15. Chien SH, Prochnow LI, Cantarella H. Recent developments of fertilizer production and use to improve nutrient efficiency and minimize environmental impacts. In: Donald LS, editor. Advances in Agronomy. London: Academic Press; c2009. p. 267-322.
16. Dhillon WS, Gill PPS, Singha NP. Effect of nitrogen, phosphorus and potassium fertilization on growth, yield and quality of pomegranate ‘Kandhari’. Acta Horticulturae; c2009. p. 890.
17. Dod VN, Joshi AT, Kale PB, Kulwal LV. Effect of different levels of nitrogen in split doses on yield and quality of red ripe chilly (*Capsicum annuum* L). Proceedings of National Seminar on the Production Technology of Tomato and Chillies; c1983. p. 152-153.
18. Dong YJ, He MR, Wang ZL, Chen WF, Hou J, Qiu XK, *et al*. Effects of new coated release fertilizer on the growth of maize. Journal of Soil Science and Plant Nutrition. 2016;16(3):637-649.
19. Feleafel MN. Response of growth, yield and its quality of eggplant to varying nitrogen fertilizer rates and their application systems. Journal of Agriculture and Environmental Sciences. 2005;4(1):122-136.
20. Frontela RA, Morejon JMM. Effect of split nitrogen applications on sown and transplanted pepper (cv. Medalla de oro). Centro Agricola. 1988;15(1):51-60.
21. Ghoneim IM. Effect of nitrogen fertilization and its application systems on vegetative growth, fruit yield and quality of sweet pepper. Journal of Agriculture and Environmental Sciences, Alexandria University, Egypt. 2005;4(2):58-77.
22. Gill Flanigen HS, Meel OP. Studies on the substitution of inorganic fertilizer with organic manure and their effect on soil fertility in rice-wheat rotation. Fertilizer Research. 1982;3:303-314.
23. Gordon WB, Whitney D. Nutrient management in reduced tillage systems. In: Schlegel AJ, editor. Great Plains Soil Fertility Conference Proceedings; c2000. p. 302-307.
24. Haile D, Nigussie D, Ayana A. Nitrogen use efficiency of bread wheat: Effects of nitrogen rate and time of application. Journal of Soil Science and Plant Nutrition. 2012;12(3):389-409.
25. Hochmuth GJ, Hanlon E, Gilreath P, Shuler K. Field evaluations of nitrogen fertilization programs for subsurface irrigated tomato. Proceedings of the Florida State Horticultural Society. 1989;102(12):351-354.
26. Huijsmans JFM. Manure application and ammonia volatilization [Ph.D. Thesis]. Wageningen: Wageningen University; c2003.
27. John AS, Brown JR, Kitchen NR. Soil Management Practices for Sustainable Agriculture; c2005.
28. Khairul RM, Farahnaz EB, Robiah Y. Comparative performance of different urea coating materials for slow release. Journal of Elsevier. 2014;17(12):165-172.
29. Li SD, Feng B, Han W, Li WJ, Li ZX, Wang ZS, *et al*. Effect of optimized nitrogen application on summer maize yield and water-nitrogen utilization. Shandong Agricultural Sciences. 2020;52(8):57-63.
30. Li Y, Zhang M, Zheng J, Pan L, Kong P, Lei Z. Design and experiment of prototype soil pretreatment device for ISE-based soil nitrate-nitrogen detection. Transactions of the Chinese Society of Agricultural Engineering. 2017;33(1):120-125.
31. Liu GC, Li YC, Alva AK. Moisture quotients for ammonia volatilization from four soils in potato production regions. Water, Air, and Soil Pollution. 2007;183(1-4):115-127.
32. Kaplan M, Sönmez S, Tokmak S. Antalya-Kumluca yöresi kuyu sularının nitrat içerikleri. Turkish Journal of Agriculture and Forestry. 1999;23(2):309-313.
33. Mengel K, Kirkby EA. Principles of Plant Nutrition. 2nd ed. Bern: International Potash Institute; c1982.
34. Parfitt RL, Schipper LA, Baisder WT, Elliott AH. Nitrogen inputs and outputs for New Zealand in 2001 at national and regional scales. Biogeochemistry. 2006;80(1):71-88.
35. Parisi M, Burato A, Pentangelo A, Ronga D. Towards the optimal mineral nitrogen fertilization for improving peeled tomato quality grown in Southern Italy. Horticulturae. 2022;8(8):697.
36. Raun L. Surface banding superior to broadcasting on reduced tiller. Fluid Journal. 1998;7:10-13.
37. Stecker JA, Brown JR, Kitchen NR. Residual phosphorus distribution and sorption in starter fertilizer bands applied in no-till culture. Soil Science Society of America Journal. 2001;65(4):1173-1183.
38. Mofijul Islam SM, Gaihre YK, Islam MR, Islam A, Singh U, Sander BO. Effects of integrated plant nutrition systems with fertilizer deep placement on rice yields and nitrogen use efficiency under different irrigation regimes. Heliyon. 2023;9(12).

39. Sánchez-Bel P, Flores FB, Madrid MC, Tébar EM, Cabello MJ, Castellanos MT, *et al*. Effects of nitrogen fertilization on fruit quality during storage of Spanish Piel de Sapo melon. Horticulturae; c2010. p. 87-91. Available from: http://hdl.handle.net/10400.1/3022.
40. Selim EM, Elsirafy ZM, Taha AA. Effect of irrigation methods and nitrogen application on the utilization of nitrogen by sugar beet grown under arid conditions. Australian Journal of Basic and Applied Sciences. 2010;4(7):2114-2124.
41. Shilpha SM, Soumya TM, Girijesh GK, Dhananjaya BC. Effect of different natural oil coated urea fertilizers on productivity and nutrient uptake of maize. International Journal of Pure and Applied Bioscience. 2017;5(2):807-812.
42. Shoji S. Innovative use of controlled availability fertilizers with high performance for intensive agriculture and environmental conservation. Science China Life Sciences. 2005;48:912-920.
43. Sönmez İ, Sönmez S, Kaplan M. The Contents of the Nutritional Elements of the Municipal Waste Compost and Comparison with Some Organic Manures. Selcuk Journal of Agriculture and Food Sciences. 2002 Jun 6;16(29):31-38.
44. Tachibana M. Chissoasahi Fertilizer Co. Ltd: Personal report; c2007-08.
45. Yassin MM. Optimal management of nitrogen fertilization for maize (*Zea mays* L.) in gypseous soil [Master's Thesis]. Tikrit: University of Tikrit, College of Agriculture; c2023.
46. Page D, de Martinville B, Barker D, Wyman A, White R, Francke U. Single-copy sequence hybridizes to polymorphic and homologous loci on human X and Y chromosomes. Proceedings of the National Academy of Sciences. 1982;79(17):5352-5356.