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Production of Indigenous Microorganism organic fertilizer and its impact on growth and yield component of Chickpea (*Cicer areitinum* L.)

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ABSTRACT

The aim of this research to improve the productivity of a local variety of chickpea by enriching the soil produced indigenous microorganism (IMO) and reducing the rate of nitrogen fertilizer. The experimental design used in this study was randomized complete block design with three replications. In this research, the soil was enriched with indigenous microorganism with different rates.The treatment combinations were soil with three different rates of IMO (Soil + 0, 2 and 4Tbsp of IMO) .The N fertilizer used in this study was installed in three different rates (0, 30 and 60 ppm NFR) in form of Urea in water) each rate of NFR was measured according to the weight of the soil in the pot. Morphological characters and yield component were determined in this research. The morphological characters included the height of plant, number of branches, days to 50% flowering (days), days to physiological maturity (days) and yield components were: pods number /plant, seed number/plant, seeds weight/plant (g), hundred seed weight (g) and grain yield (kg/ha). The result illustrated that the main effect of IMO gave maximum plant height, number of branches, number of pods/plant, number of seeds/plant, weight of seeds/plant, hundred seeds weight and grain yield. The combination of IMO and NFR under treatment of (Soil + 4Tbsp IMO) with application of 30 ppm NFR also gave highest value of each of morphological characters and yield components. The result of this study demonstrates that enriching soil with 4Tbsp optimize the rate of N fertilizer to 30 ppm.

Keywords: Chickpea, Indigenous microorganism, Nitrogen inorganic fertilizer

1. INTRODUCTION

Chickpea (Cicer arietinum L.) is known as one of the essential food economically among legume crop production. It is cultivated on approximately 14.56 Mio. hectares, yielding 14.78 Mio. tons in excess of 55 nations of the world (Roorkiwal et al., 2020). It is also produced in a wide area of in semi-arid regions as globally third largest yielded legume crop. Chickpea is cultivated in more than 50 countries and higher than 90 % of chickpea yields produced in Asia(Chen & Sharma, 2007). The nutritional content of chickpea is very essential because it contain a great amount of protein (approx. 19.3–25.4%), and have a great role in human intakes especially in the developing countries. The countries that cultivate chickpea in a wide ranges are India, Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico, and Iraq (Janmohammadi, Abdoli, Sabaghnia, Esmailpour, & Aghaei, 2018). Chickpea in not only used a human food source, it also widely applied as a source of fodder for animal and green manure for agricultural production as it have essential role in crop rotations in most regions of the world by improving the fertility of the soil (Namvar, Sharifi, & Khandan, 2011). Due to the essentiality of chickpea as a source of food for human diet and animal, the yield quality of chickpea is also essential which improved by cultivating the crop in a soil improved by organic agricultural system which is a systems that shown to be able to produce food with greater yield and quality.

The production of crop under the organic system of production will be enhanced by optimizing the nutrient needs of the crop. Organic systems of production relies on how the organic content of the system is managed to improve the fertility of the soil (Naik, Patel, & Patel, 2014). Furthermore, nowadays agricultural productions that only based on chemicals are not sustainable due to many problems that occur such as the erosion occurrence that cause loss of soil productivity and plant nutrient losses as well as the pollution that occur in the ground water and due to fertilizers and pesticide products (Joshi, Gediya, Patel, Birari, & Gupta, 2016). However, the inorganic or chemical fertilizer benefits the plant by improving its growth but also chemical fertilizer have some hazards such as leaching, high energy consumption for their production, risk of the toxic chemicals, stimulating the vegetative growth and depletion of soil water storage (Janmohammadi et al., 2018).

Therefore, it is important to reduce the usability of chemical fertilizer and increasing the productivity of chickpea under locally made bio fertilizer such as indigenous microorganism (IMO). Bio-fertilizers can reduce the required amount of chemical fertilizers and affect the environment adversely in terms of easing the environmental contamination and worsening of nature (Seleiman & Abdelaal, 2018). These microorganisms can be collected and cultured easily and have an essential role in improving the soil for the plants growth. The Indigenous Microorganisms or IMO s, are small colonies of life that are found and can be produced from the immediate vicinity of the growing location supplies readily available nutrients directly to the soil-rhizosphere system. It is essential to know that the best way to enhance growth, yield and quality of crop by application of beneficial microorganisms that, in turn, can improve the growth, yield and quality of crops (M. Soma & D. Sai, 2013). IMO is known as a source of all kinds of nutrient by enhancing the fertility of the soil and adding organic matter to the soil. Plants that inoculated with IMO have a great growth and nutrient content such as phosphorus and also IMO prevent microorganism pathogen and disease to attack the plant. Several plants nutrients and substances that promote the growth of plant such as chelated and trace elements, aminoacid and carbohydrates are found in IMO suspension.

These nutrient, substance and elements have a great role in improving the soil microbial activity consequently enhancing the relationship between air and water of the soil which improve the fertility of the soil and reduce soil erosion and compaction(Sumathi, Janardhan, Srilakhmi, Gopal, & Narasimha, 2012). All of the great functions of IMO as an organism that increase the nutrient quality of soil returns back to the availability of bacterial, fungi and cynobacteria. These microorganisms are known to transport several promotions to the plant such as nutrition, resistance to disease, tolerance and adapt to different climatic changes. The cultivation of local variety of chickpea in this region is low due to its less yield component as investigated by many researchers compared to other variety that used such as Ghab1, Filip1 and Filip 2 (Ahmed, Mohammad, Abdulla, & Meerza, 2018). Therefore, this study was conducted to increase the productivity of local variety of chickpea in the region by locally producing of indigenous microorganism which is done for the very first time in this region and also optimizing the use of inorganic nitrogen fertilizer rate.

2. MATERIALS AND METHODS

This experiment was conducted in the experimental farm of Bakrajo Technical Institute in Sulaimani which is located in Kurdistan region of Iraq**.**The genotype of chickpea (*Cicer areitinum* L.) seed was local spring. The seed sowing was done on 21st February 2019. The germination of the seeds reached its 100% on 13 March 2019. The harvesting of the plant took place on 21st July 2019 and duration from sowing to harvesting took 151 days. In this experiment 54 pots were filled with local soil and the size of the pots was (5 L with with a diameter of 260 mm and height of 340 mm). The soil texture in the investigation area was clay soil to silty loam with chemical characteristic that is shown in Table (1). The soil was treated with two rates of indigenous microorganism (IMO) and for control treatment, only soil was used in the pots. The treatment combinations were soil amendment (SA) with three different suspensions of which were (Soil + 0, 2 and 4 Tbsp indigenous microorganism (IMO)).The Nitrogen fertilizer (NF) used in this research study was installed in three different rates (0, 30 and 60 ppm NF) which was in form of Urea in water) each rate of NF was measured according to the weight of the soil in the pot.

The experiment was arranged in randomized complete block design (Twoway- ANOVA-RCBD) with 3 replications. The treatments mean was compared by using Duncan's Multiple Range Test and the F values were significant at ($P \leq 0.05$). IMO suspensions (2 and 4 Tbsp) were sprayed on the soil surface of the pot. Distilled water without IMO was applied as control. The NF were applied in 2 equal doses which were 50% applied at sowing and the remaining 50% at vegetative growth period. The investigation parameters (morphological characters and yield components) of this study were determined on 108 chickpea plants. The plants didn't need manual irrigation because rainfall was sufficient to cover the water needs of the crop during growth periods and the average rainfall during plant growth period was 5mm per 24 hours in the field area. The morphological characteristics included plant height, branch number, days to 50% flowering (days), days to physiological maturity (days) and yield components were: pods number /plant, seed number/plant,

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seeds weight/plant (g), hundred seed weight (g) and grain yield (kg/ha). The statistical analysis and analysis of variance was determined by using XLSTAT 2016.

Preparation of Indigenous microorganism

The cultivation of indigenous microorganism returns back to Korean natural farming (Cho & Koyama, 1997). The IMO preparation was done by preparing an empty in a wooden container (fig.1 A) and placing 1 kg of cooked rice (organic) (fig.1 B) and covering the mouth of the container by clean sheets of paper and plastic to prevent entering water and small insects from getting in the container it was wrapped with rubber band (fig.1 C). The container was then buried 5cm deep in the soil under a big tree and covered with dry thick leaves for 7 days (fig.1 D). After two days whitish moldy filaments which was the fungi mycelium grown on the rice surface (fig.1 E). Then the entire content of the wooden container was mixed with 1kg of brown sugar in a plastic container, firmly covered with a clean piece of soft, white paper and kept in a dark and cool place. The mixture was fermented for seven days until a muddy mixture appeared (fig.1 F). The fermented IMO was applied to the soil in two concentrations which were 2Tbsp and 4Tbsp and mixed with 1 L of distilled water to make a suspension then left to decompose.

3. RESULTS AND DISCUSSION

Morphological Characters

The results of analysis of variance (ANOVA) of soil enrichment with different rates of indigenous microorganism (IMO), Nitrogen fertilizer rates (NFR) and their interaction effects on some morphological character of local variety of chickpea (*Cicer areitinum* L.) are shown in (Table 2). The main effect of IMO was highly significant for plant height and significant for number of branches, days to 50% flowering and days to physiological maturity. The main effect of Nitrogen fertilizer rates (NFR) was highly significant for the plant height and significant for number of branches while the same effect was not significant for the days to 50% flowering and days to physiological maturity. The interaction effects of IMO and NFR was highly significant for plant height and significant for number of branches but non-significant for days to 50% flowering and days to physiological maturity. As it is shown in (Table 3) the maximum plant height, number of branches, days to 50% flowering and days to physiological maturity was observed under treatment when soil enriched with 4 Tbsp of IMO (Soil + 4Tbsp.IMO) which were (39.9 cm, 13.3, 93.6 days and 140 days) respectively, compared to control treatment with only soil which were (29.6 cm, 10.6, 76.8 days and 119.7 days) respectively.

This attributed to the potentiality of available microorganism in IMO which improve releasing nutrients from the soil which cause the elongation and multiplication of the plant cell. This result concur a result of a study which was done by (S. Soma & G. Sai, 2013), in which the highest plant of several types of crop plant was determined when IMO applied to the crops. In addition, the results of this study also I line with a result of a research study done by (Islam, Islam, Akter, Rahman, & Nandwani, 2017) in which the growth of Tomato plant enhanced with application of organic fertilizer. According to the result of the effect of different NFR (Table 4) the maximum plant height was observed under 60 ppm NFR which was (38.4cm). Similarly in a result of a study it was also revealed that with increasing the rate of N fertilizer the height of sunflower increased (Oyinlola, 2015). This observation illustrates that that N fertilizer application promoted easy absorption of the N by the plant which could consequently cause growth in the plant. While, the highest number of branches, days to 50% flowering and days to physiological maturity was recorded under 30 ppm of NFR which were (13.2, 86.6 days and 133 days) respectively in comparison to the control treatment with (0 ppm NFR) which were (28.1cm, 9.9, 81.2 days and 128.2 days) respectively. The rapid enhancement of the number of branch by increasing the N rate might returns back to the ability of N fertilizer in promoting vegetative growth of the plant. This results are in line with a result of a study which was done by Öztürk (2010) in which it have been revealed that the branch number of rapeseed increased with increasing N rate. This result is inline with a result of a study done by Saleem, Haqqani, Javed, Ali, and Fateh (2006) which illustrated that the maturity delayed with enhancing the rate of nitrogen fertilizer.

The interaction between (IMO) and (NFR) is shown in (Table 5). The highest plant was observed under enriching the soil with 4 Tbsp. of IMO (Soil + 4Tbsp.IMO) and application of 30 ppm NFR which was (48.5 cm).The shortest plant was observed in control (Soil + 0 Tbsp. IMO) with 0ppm NFR which was (26.2 cm). As it’s shown in (Table 5) the interaction effect of (Soil + 4 Tbsp. IMO) and application of 30 ppm NFR gave maximum number of branches which was (17.3 branch/plant) while, the lowest branch number was observed in control (Soil + 0Tbsp. IMO) with 0ppm NFR which was (9.7 branch/plant). The earliest initiation of 50% flowering was observed under control treatment with 0ppm NFR which was (71 days).The plant that 50% of its flowering initiation took longest period of (101.3 days) was grown under (Soil + 4 Tbsp. IMO) treatment with 30ppm NFR. The delay in the flowering might be due to the availability of rhizosphere microbial communities in which modulate the timing of flowering. There are several hormones in the IMO which enhance and prolonged N bioavailability by nitrification which cause delayed flowering by converting tryptophan to the phytohormone indole acetic acid (IAA), thus downregulating genes that trigger flowering, and stimulating further plant growth (Lu et al., 2018).

The plant that needed longer period of time to reach its physiological maturity was also grown under (Soil + 4Tbsp. IMO) with 30ppm NFR which was (50 days). The plants that reached its physiological maturity in a shortest period of time (118.3 days) grown under control treatment with 0ppm NFR. It is clear that application of IMO with a rate of 4Tbsp optimized the rate of N fertilizer to 30 ppm which indicates that with application of IMO the rate of chemical N fertilizer will be reduced. The essential role of microorganism is enhancement of the quality of the soil by which consequently accelerate the growth of the plant. In addition microorganism plays an important role in decomposing organic matter in the soil which in returns increase (Desire, Fosah, & Desire, 2018). Similar results were also revealed on tomato plant which demonstrated that with application of organic fertilizer the rate of chemical fertilizer reduced (Ye et al., 2020). For the relationship between 50% flowering and days to physiological maturity it is obvious that there is a direct relationship each parameter which illustrates that the later the plant flower the longer is the period of maturity.

Yield Component

The results of analysis of variance (ANOVA) of soil enrichment with different rates of indigenous microorganism (IMO), Nitrogen fertilizer rates (NFR) and their interaction effects on the yield components of local variety of chickpea (*Cicer areitinum* L.) are shown in (Table 6). The main effect of IMO was significant for pod No./plant, seed No./pod , seed weight/plant (g), hundred seed weight (g) and non-significant for grain Yield (kg/ha) . The main effect of NFR was only significant for the seed No./pod and seed weight per plant, while it was not significant for the rest of yield components. The interaction effects IMO and NFR was significant for seed No. /pod and non-significant for other yield components (pod No./plant, seed weight/plant (g), hundred seed weight (g) and grain Yield (kg/ha)). As it is shown in (Table 7) the maximum pod No./plant, seed No./pod , seed weight/plant (g), hundred seed weight (g) and grain Yield (kg/ha) was observed in treatment of (Soil + 4Tbsp.IMO) which were (34.4, 1.2, 42.9(g), 43.8(g) and 714.4(kg/ha)) respectively, compared to control treatment which were (28.8, 1.00, 33.8(g), 35.7(g) and 591.3(kg/ha)) respectively. This result concur the result of a study in which with application of IMO the yield component of rice increased (Siti zaharah sakimin, 2017).

According to the result of the effect of NFR (Table 8) the maximum pod No./plant, seed No./pod , seed weight/plant (g), hundred seed weight (g) and grain Yield (kg/ha) was recorded under 30 ppm of NFR which were (33.9, 1.1, 42 (g), 42.9(g) and 698.8(kg/ha)) respectively in comparison to the control (0 ppm NFR) which were (28.5, 1.00, 33.4(g), 35.3(g) and 585.1 (kg/ha))s) respectively. The interaction between (IMO) and (NFR) is illustrated in (Table 9). The increase in morphological characteristic and yield could be due to the improvement of the yield components (number of pods per plant, seed weight per plant and 100 seed weight) consequently (Ebaid & El-Refaee, 2007).

As it's shown in table (9) the maximum pod number per plant was observed under (Soil + 4Tbsp.IMO) and application of 30 ppm NFR which was (43). The minimum number of pods per plant was observed in control treatment with 0ppm NFR which was (28). The maximum seed number per pod was observed in treatment of (Soil + 4Tbsp.IMO) with application of 30 ppm NFR which was (1.3) compared to the control which was (1). The maximum seed weight per plant (54.3 g), hundred seed weight (53.3 g) and grain yield (843.7 kg/ha) were determined from plants that grow under (Soil + 4Tbsp.IMO) treatment with application of 30 ppm NFR. The minimum seed weight per plant (30.0 g), hundred seed weight (32.2 g) and grain yield (530.5 kg/ha) were determined from plants that grown under control treatment with 0ppm NFR. It is obvious that in this study the highest yield was under (Soil + 4Tbsp.IMO) with application of 30ppm N and this is because of the ability of chickpea to gain an good amount of (4–85%) of its nitrogen requirement through symbiotic N2 fixation (Togay, Togay, Cimrin, & Turan, 2008). One of the clear result of this research was that the IMO has significant impact on the growth and production of chickpea. However, Chickpea is a legume that derives greater nitrogen requirement by its biological N_2 fixation, through Rhizobium inoculants that increase the nitrogen concentration of the fields and thus fertility of the soil (Hayat, Ali, Siddique, & Chatha, 2008). The flowering period can directly affect the grain yield. In a research study (Yusuf Ali, Johansen, Krishnamurthy, & Hamid, 2005) reported that number of days taken to flowering directly as well as significantly related with the grain yield. early Flowering chickpea produced in higher yields at different location and stresses (Turner et al., 2006). When greater rate of N fertilizer applied less yield component observed. This may be due to the application of IMO which is a beneficial microorganisms make nutrient and hormones that can be absorbed by the plant and with excessive application of N it can burn to the roots system of the plant and cause death of the seedling or it will undergo slow growth in later stage.

4. CONCLUSIONS AND SUGGESTION

Based on the results of this study the interaction of indigenous microorganism and nitrogen fertilizer significantly enhanced the plant height number of branches and seed number. While the morphological characters and yield component of local variety of chickpea can be improved by enriching the soil with 4Tbsp of IMO and optimizing the rate of nitrogen fertilizerin to 30ppm. From the results of this study it is clear that IMO could contribute in reducing the used amount of N fertilizer in which the optimum N rate for the highest morphological characteristic and yield component was 30 ppm N rate.

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Table 1: Chemical Characteristic of Soil

Parameter	Amount
pH	7.4
Electrical conductivity(EC) mmhos/cm)	1.7
N (%)	0.24
P (mgkg^{-1})	3.1
Potassium (K) (mgkg^{-1})	234.1
Calcium(Ca) (mgkg^{-1})	4775.8
Mg (mgkg^{-1})	219.0
Na (mgkg^{-1})	45.9
Fe (mgkg^{-1})	8.2
Zn (mgkg^{-1})	1.0
Cu (mgkg^{-1})	1.5
Mn (mgkg^{-1})	32.3
O.M (%)	1.8

Source: (Mjeed & Ali, 2017)

Table 2: Analysis of variance (ANOVA) morphological character of chickpea (Cicer areitinum L.) as influenced by Indigenous microorganism (IMO) and nitrogen fertilizer (NF) and their interaction (IMO*NF)

S.O.V.	**MS**				
	DF	**Plant height**	**No. of branches/plant**	**Days to 50% flowering**	**Days to Physiological Maturity**
Block	2	1.33^{ns}	4.48^{ns}	422.10*	284.08^{ns}
IMO	2	239.97**	18.93*	639.36*	952.1*
NFR	2	313.26**	25.59*	88.05^{ns}	55.82^{ns}
IMO*NFR	4	57.11**	10.65*	105.41^{ns}	173.70^{ns}
Error	16	2.3	31.04	113.4	93.5

*, ** and ns represent significant at $P \leq 0.05$, $P \leq 0.01$ and non-significant, respectively. S.O.V.: Source of Variance, DF: Degree of Freedom and MS: Mean Square

Table 3: Morphological character of chickpea (Cicer areitinum L.) as influenced by Soil Indigenous Microorganism (IMO)

Treatments with IMO	**Plant Height (cm)**	**No. of branches/plant**	**Days to 50% flowering**	**Days to Physiological Maturity**
Soil + 0 Tbsp IMO (control)	29.6 c	10.6 b	76.8 b	119.7 b
Soil + 2Tbsp IMO	35.1 b	11.2 b	84.0 ab	133.0 a

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Soil + 4Tbsp IMO	39.9 a	13.3 a	93.6 a	140.0 a

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test. Tbsp: table spoon.

Table 4: Morphological character of chickpea (Cicer areitinum L.) as influenced by Nitrogen fertilizer Rate(NFR)

Nitrogen Fertilizer Rates (NF) (ppm)	Plant Height (cm)	No. of branches/plant	Days to 50% flowering	Days to Physiological Maturity
0 (ppm)	28.1 b	9.9 b	81.2 a	128.2 a
30 (ppm)	38.2 a	13.2 a	86.6 a	133.0 a
60 (ppm)	38.4 a	12.0 a	86.5 a	131.5 a

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test.

Table 5: Morphological character of chickpea (*Cicer areitinum* L.) as influenced by combination of Indigenous microorganism (IMO) and Nitrogen Fertilizer (NF)

Treatments with IMO	Plant Height (cm)			No. of branches/plant			Days to 50% flowering			Days to Physiological Maturity		
	Nitrogen Fertilizer Rates (NFR) (ppm)											
	0	30	60	0	30	60	0	30	60	0	30	60
Soil + 0 Tbsp IMO (control)	26.2 f	30.5 de	32.2 d	9.7 c	10.7 bc	11.3 bc	71.0 b	76.0 b	83.3 ab	113.3 c	118.3 bc	127.6 bc
Soil + 2Tbsp IMO	28.5 ef	35.5 c	41.2 b	10.0 bc	11.7 bc	12.0 bc	81.2 ab	82.5 ab	88.1 ab	134.7 ab	130.8 bc	133.6 ab
Soil + 4Tbsp IMO	29.5 de	48.5 a	41.8 b	10.0 bc	17.3 a	12.7 b	91.3 ab	101.3 a	88.1 ab	136.6 ab	150.0 a	133.4 ab

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test. Tbsp: table spoon.

Table 6: Analysis of variance (ANOVA) Yield component of chickpea (Cicer areitinum L.) as influenced by Indigenous microorganism (IMO) and nitrogen fertilizer (NF) and their interaction (IMO*NF)

S.O.V.	MS					
	DF	Pod No./plant	Seed No./pod	Seed weight/plant (g)	Hundred seed weight (g)	Grain Yield (kg/ha)
Block	2	121.93*	0.007ns	325.01*	304.28*	94570.96*
IMO	2	83.6*	0.051*	195.59*	153.55*	34651.42ns
NFR	2	65.81ns	0.024*	165.14*	130.52ns	30167.16ns
IMO*NFR	4	53.70ns	0.020*	90.33ns	61.49ns	11169.5ns
Error	16	22.59	0.0062	39.35	41.81	12183.3

*, ** and ns represent significant at $P \leq 0.05$, $P \leq 0.01$ and non-significant, respectively. S.O.V.: Source of Variance, DF: Degree of Freedom and MS: Mean Square.

Table 7: Yield Components of chickpea (Cicer areitinum L.) as influenced by Indigenous microorganism (IMO)

Treatments with IMO	Pod No./plant	Seed No./pod	Seed weight/plant (g)	Hundred seed weight (g)	Grain Yield (kg/ha)
Soil + 0 Tbsp IMO (control)	28.8 b	1.0 b	33.8 b	35.7 b	591.3 b
Soil + 2Tbsp IMO	29.7 b	1.0 b	36.5 b	38.4 ab	639.1 ab
Soil + 4Tbsp IMO	34.4 a	1.2 a	42.9 a	43.8 a	714.4 a

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test. Tbsp: table spoon.

Table 8: Yield components of chickpea (Cicer areitinum L.) as influenced by Nitrogen fertilizer Rate (NFR)

Nitrogen Fertilizer Rates (NF) (ppm)	Pod No./plant	Seed No./pod	Seed weight/plant (g)	Hundred seed weight (g)	Grain Yield (kg/ha)
0 (ppm)	28.5 b	1 b	33.4 b	35.3 b	585.1 b
30 (ppm)	33.9 a	1.1 a	42 a	42.9 a	698.8 a
60 (ppm)	30.5 ab	1.1 a	37.8 ab	39.7 ab	660.8 ab

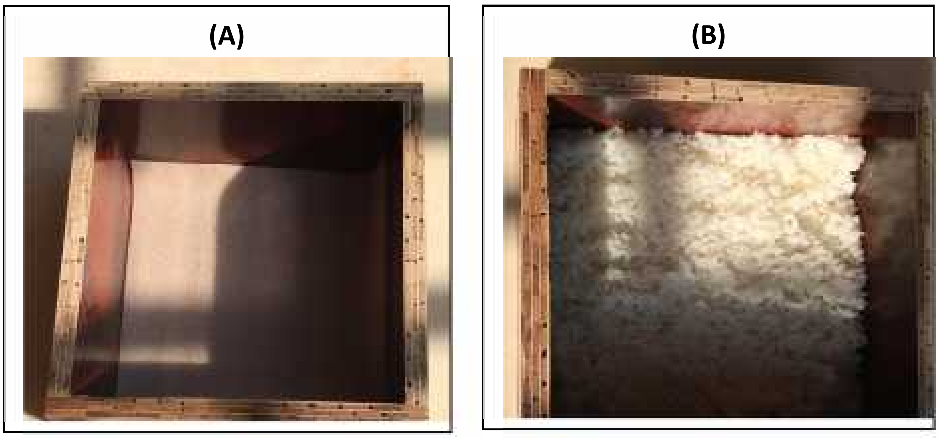
Remarks: *Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test.

Table 9: Yield component of chickpea (Cicer areitinum L.) as influenced by combination of Indigenous microorganism (IMO) and nitrogen fertilizer Rate (NFR).

Treatments with IMO	Pod No./plant			Seed No./pod			Seed weight/plant (g)			Hundred seed weight (g)			Grain Yield (kg/ha)		
	Nitrogen Fertilizer Rates (NFR) (ppm)														
	0	30	60	0	30	60	0	30	60	0	30	60	0	30	60
Soil + 0 Tbsp IMO (control)	28.0b	28.7b	29.7b	1.0c	1.0c	1.0 c	30.3b	34.7b	36.3b	32.2b	36.6b	38.3b	530.5b	607.8b	635.7ab
Soil + 2Tbsp IMO	28.3b	30.0b	30.7b	1.0c	1.0c	1.1bc	34.2b	36.9b	38.5b	36.1b	38.8b	40.4b	598.4b	645.0ab	673.8ab
Soil + 4Tbsp IMO	29.3b	43.0a	31.0b	1.0c	1.3a	1.2ab	35.8b	54.3a	38.5b	37.7b	53.3a	40.4b	626.4b	843.7a	673.0ab

Remarks: *Mean values within a column followed by the same letters are not significantly different at $p < 0.05$ according to Duncan's Multiple Range Test. Tbsp: table spoon.

Figure 1: Indigenous Microorganism production



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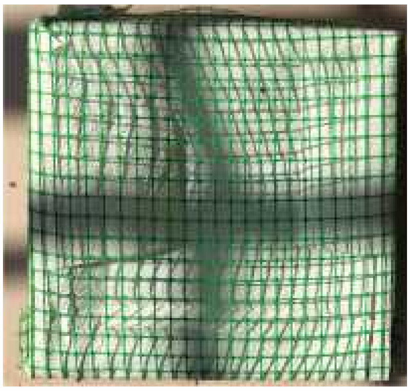

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