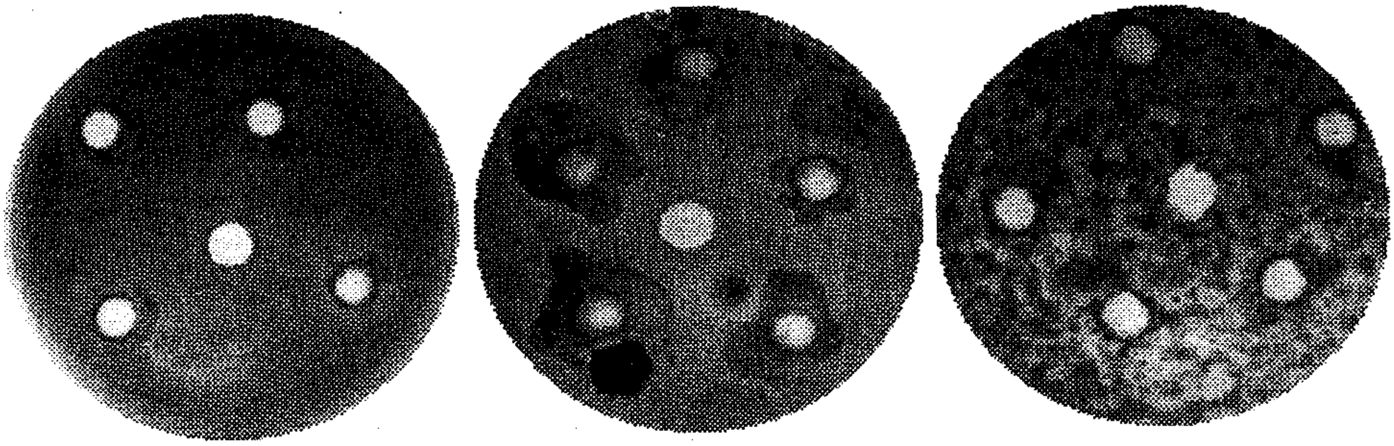
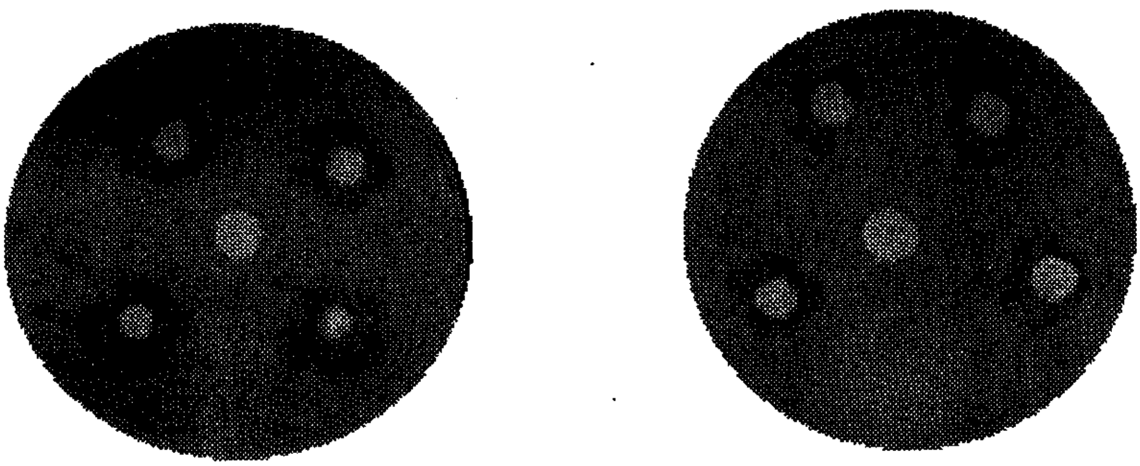
RESULTS AND DISCUSSION



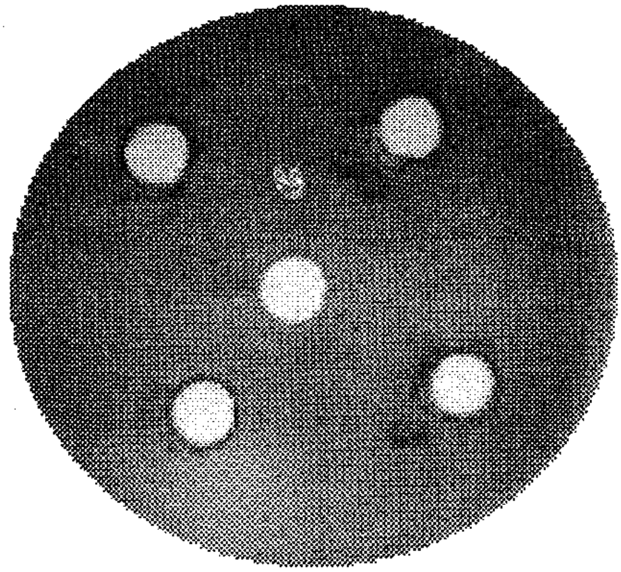
ARC 103 USDA 2101 USDA 2128

Fig.(1): Effect of clover seeds diffusate on the survival of *Rhizobium leguminosarum bv. trifolii*



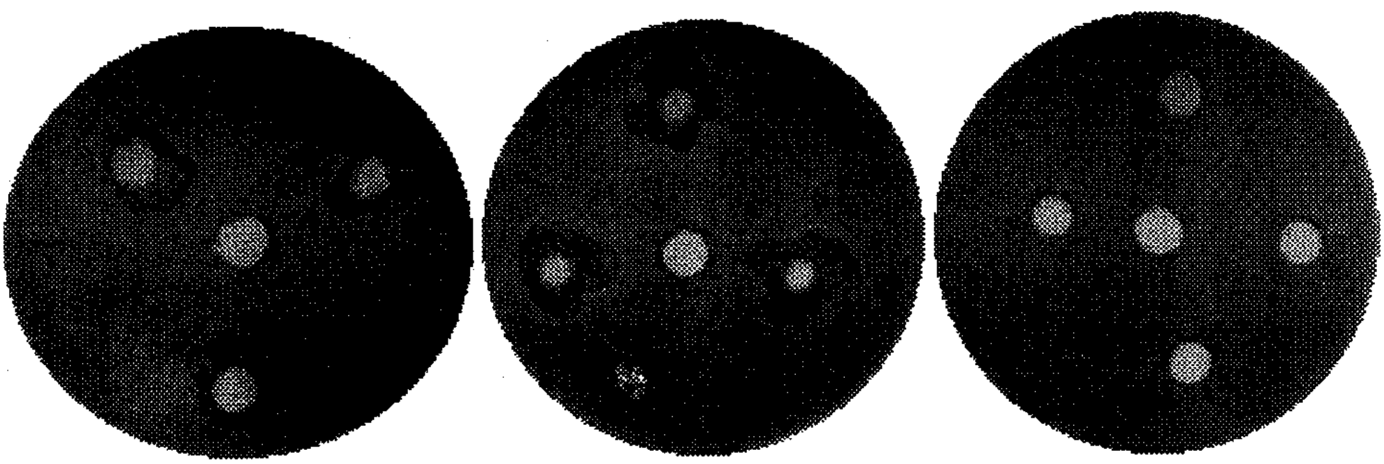
ICARDA 441 ARC 205

Fig. (2) : Effect of faba bean and lentil seeds diffusate on the survival of *Rhizobium leguminosarum* bv. *viceae.*



ARC 302

Fig (3): Effect of bean seeds diffusate on the survival of *Rhizobium leguminosarum* bv. *phaseoli*.



RCR 3407 **USDA 110** **ARC 501**

Fig (4): Effect of soybean seeds diffusate on the survival of *Bradyrhizobium japonicum*.

growth density than those of the other two strains with a diameter of about 1.2 - 1.4 cm.

It was clear that all tested strains for soybean are different in their sensitivity everywhere of the agar surface except for the zones close to the spots containing the pre-soaked seeds filtrate. However, seed diffusates are among the important factors that affect the rate of growth and survival of rhizobia.

The aforementioned results are in agreement with the findings of **Bowen (1961)** who declared that seed diffusates could have a depressive or stimulative effect on multiplication of rhizobia around seed germination in sandy soil. He also stated that seed coat diffusates from the legumes ***Centrosema pubescens*** and subterranean clover contain a water soluble, thermostable antibiotic inhibiting a wide range of rhizobia and other Gram-negative as well as Gram-positive organisms, while Lucerne seed diffusates showed little activity and the extent of inhibition varied with the microorganism. However, diffusates from subterranean clover were generally more active than from ***Centrosema pubescens.*** In harmony with **Bowen (1961),** the results showed that seed diffusates of ***Phaseolus vulgaris*** (Giza 6) had neither stimulative nor depressive effect on ***Rhizobium leguminosarum* bv. *phaseoli*** (ARC 302) growth hence the growth of rhizobia as shown by Fig. 3 was normal. On the other hand, the filtrate of pre-soaked seeds enhanced the growth of the rhizobial strains USDA 2101, USDA 2128 and ARC 103, which infect clover (***Trifolium alexandrinum***) variety Sakha 4. However, the superiority of growth enhancement was for the strain 2101. These results are in parallel with those obtained by **Abd El-Nasser *et al.,* (1986)** who found that the strains of ***Rhizobium phaseoli*** varied in their sensitivity to seed diffusates. These findings of **Abd El-Nasser *et al.,* (1986)** confirmed the results of this work on bean (Fig 3). The same trend shown by soybean seed and its respective ***Bradyrhizobium japonicum*** strains of USDA 110, RCR 3407 and ARC 501 (Fig.4) had proved by **Ali and Loynachan (1990)** who indicated that the response of the strains to seed diffusates had differed from each other. Generally, all results in Figures 1 & 2 and 4 corresponding to clover, faba bean and lentil and soybean are in accordance with those of ***kato et al., (1997)*** who revealed that seed diffusates of common beans have a substantial potential to promote rhizobia proliferation. They also added that seed diffusates achieved a remarkable increase in the number of bacterial cells in all combinations of plant cultivars and rhizobial strains. However, they owed this trend to that seed exudates contained large amounts of sugars, amino acids, nitrogen, phosphorus, potassium and magnesium, which enhanced the rhizobia multiplication.

4.1.2. PART .II.

Survival of rhizobia on stored pre-inoculated seeds of faba bean and soybean pelleted with different carrier-based inocula and different adhesive agents

Determining the number of cells capable of forming colonies performs viable rhizobial cells counts. According to **Vincent (1970),** the most widely used method is the poured-plate count technique using the yeast extract mannitol agar medium. Seeds of both faba bean and soybean were pre-inoculated and exposed for counting the viable rhizobial cells at different shelf-time storage periods, initially, and after 7, 15, 30, 45, 60, 75, 90, 105 and 120 days. Seed inoculations were done using different carrier-based inocula (fine-peat, vermiculite, talc powder and calcium carbonate) in alternation with different sticker solutions as adhesive agents (gum arabic, molasses, mineral oil and water as control).

4.1.2.1. Viable rhizobial cells count on pelleted faba bean seeds

Data in Table (4) illustrated by Figures (5 and 6) show the number of viable count of rhizobial cells/seed at different storage periods for the pre-inoculated seeds as affected by different carrier-based inocula and different adhesive agents.

4.1.2.1.a. Fine-peat

It was obvious in Fig. (5) that fine peat-based inoculant recorded the highest viable count of rhizobial cells at zero-time (shelf-time storage) with all adhesive agents (gum arabic, molasses, mineral oil and water). The corresponding rhizobial numbers were 9.1×10^5, 6.1×10^5, 4.1×10^5 and 3.2×10^5 cells/seed.

The lowest viable rhizobial number (6 cells/seed) was achieved after 120 days shelf-time storage for fine peat in combination with mineral oil as an adhesive agent.

Table (4): Viable number of rhizobial cells/seed of faba bean (x 10^2) inoculated with different carrier-based inocula (*R. leguminosarum* bv. *viceae* strains 441) and adhesive agents as affected by different shelf-time storage days).

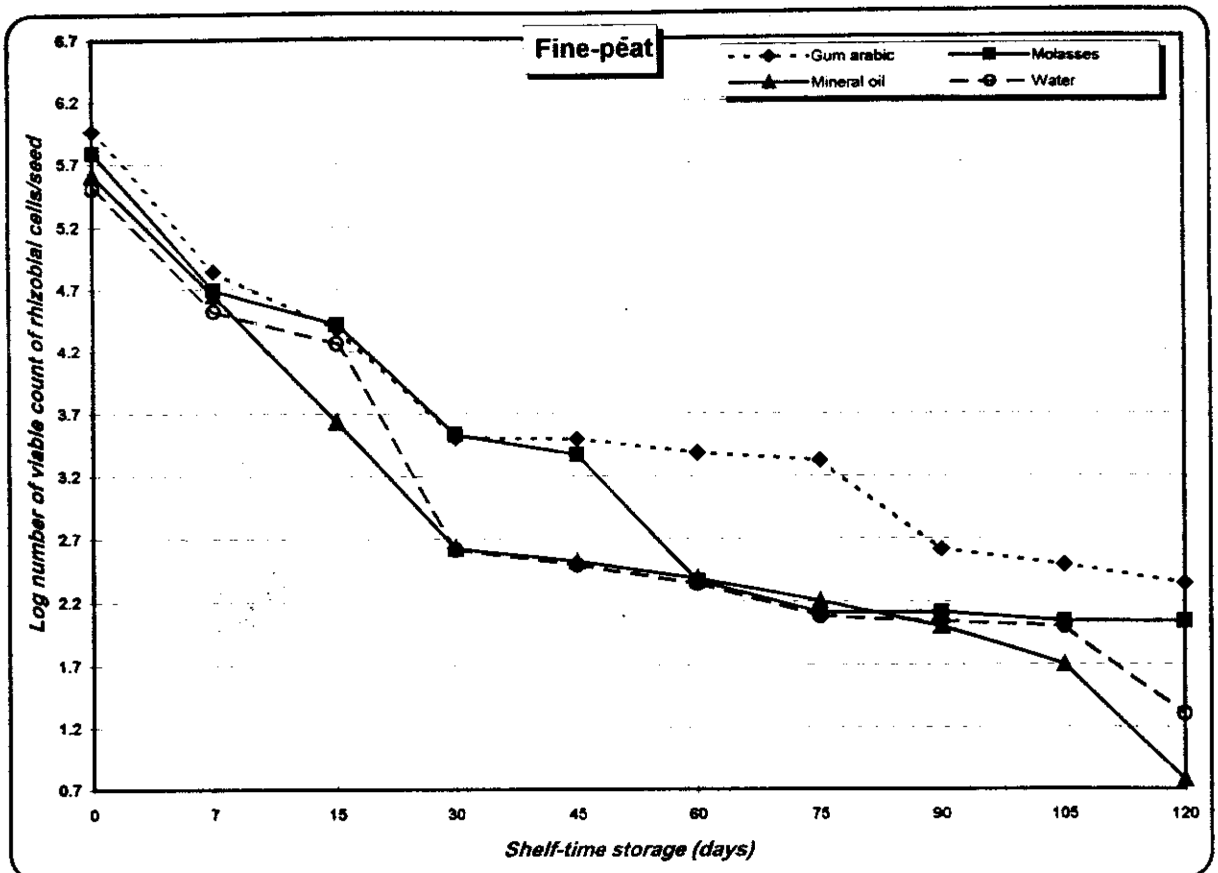
Shelf-time / reatment	Shelf-time storage (days)									
	Initial	7	15	30	45	60	75	90	105	120
					FINE PEAT					
Gum arabic	*9100*	*700*	*240*	*32*	*31*	*24*	*2 1*	*4.1*	*3.1*	*2.2*
Molasses	*6100*	*490*	*260*	*34*	*23.2*	*2.3*	*1.3*	*1.1*	*1.3*	*1.1*
Mineral oil	*4100*	*450*	*43*	*4.2*	*3.3*	*2.4*	*1.6*	*1.0*	*0.5*	*0.06*
Water	*3200*	*330*	*183*	*4.1*	*3.1*	*2.2*	*1.2*	*1.1*	*1.0*	*0.20*
					VERMICULITE					
Gum arabic	*7100*	*760*	*150*	*4.1*	*3.4*	*3.2*	*2.3*	*2.2*	*2.2*	*1.1*
Molasses	*8300*	*860*	*53*	*3.7*	*3.3*	*3.2*	*3.1*	*2.4*	*2.3*	*1.8*
Mineral oil	*3200*	*97*	*4.4*	*3.6*	*3.1*	*2.5*	*2.4*	*2.2*	*2.1*	*2.0*
Water	*4300*	*420*	*34*	*3.1*	*2.5*	*2.3*	*2.2*	*2.2*	*1.5*	*0.7*
					TALC POWDER					
Gum arabic	*5100*	*390*	*61*	*4.2*	*4.1*	*3.2*	*3.2*	*2.3*	*2.2*	*2.0*
Molasses	*4300*	*420*	*34*	*3.1*	*2.5*	*2.3*	*2.2*	*2.2*	*1.5*	*0.7*
Mineral oil	*2500*	*49*	*24*	*3.4*	*3.4*	*2.4*	*2.2*	*2.1*	*1.0*	*0.9*
Water	*2500*	*340*	*27*	*3.4*	*3.1*	*2.6*	*2.4*	*2.3*	*2.1*	*0.0*
					CALCIUM CARBONATE					
Gum arabic	*7200*	*320*	*33*	*4.1*	*3.2*	*3.2*	*2.2*	*2.1*	*2.1*	*2.1*
Molasses	*6200*	*340*	*37*	*6.1*	*4.0*	*2.7*	*2.3*	*2.2*	*1.4*	*2.2*
Mineral oil	*3100*	*23*	*25*	*4.1*	*3.1*	*2.2*	*2.1*	*0.13*	*0.12*	*0.11*
Water	*3100*	*33*	*29*	*4.4*	*4.2*	*3.0*	*2.4*	*0.21*	*0.20*	*0.10*

Increasing the storage period more than initial shelf-time storage period for all adhesive agents with fine peat-based inoculant had showed different aspects towards the number of the viable count of cells/seed at all periods. However, the decline time was differed from adhesive agent to another. The sharp decline in the viable cells was noticed for gum arabic after 90 days shelf-time storage period (4.1×10^2 cells/seed) hence it was 2.4×10^3 cells/seed at 60 days shelf-time storage. While the sharp deterioration in the number of viable count of rhizobial cells/seed was exhibited at 60 days shelf-time storage (2.3×10^2 cells/seed) for molasses, 30 days shelf-time storage period (4.2×10^2 cells/seed) for mineral oil and 30 days shelf-time storage (4.1×10^2 cells/seed) for water. Moreover, it is important to notice that the sequence of decline of the viable rhizobial cells number was accomplished first at 30 days shelf-time storage period for mineral oil and water, second at 60 days shelf-time storage for molasses and then at 90 days after planting (DAP) for gum arabic.

However, sowing the stored pelleted seeds using fine peat-based inoculant with different adhesives agents of gum arabic, molasses, mineral oil and water had confirmed the results of nodulation (Tables 7 and 12) at 45 and 90 (DAP) .

At 45 (DAP), data in Table (7) showed that the number of nodules/plant had affected by gum arabic (7.33) up to 60 days shelf-time storage, with molasses had affected up to 45 days shelf-time storage (7 nodules/plant) and decreased thereafter up to 5.0 nodules/plant at 60 days shelf-time storage period. On the other hand, mineral oil with fine peat was able to form a reasonable number of nodules/plant (8.67) up to 30 days shelf-time storage, while water gave the lowest number of 2.33 nodules/plant. However, this low number of nodules/plant recorded by using water as adhesive was in adverse with the total count of viable rhizobial cells/seed (1.8×10^4) at the same shelf-time storage period (Table 4).

The same trend was noticed after 90 (DAP) as shown in Table (12).



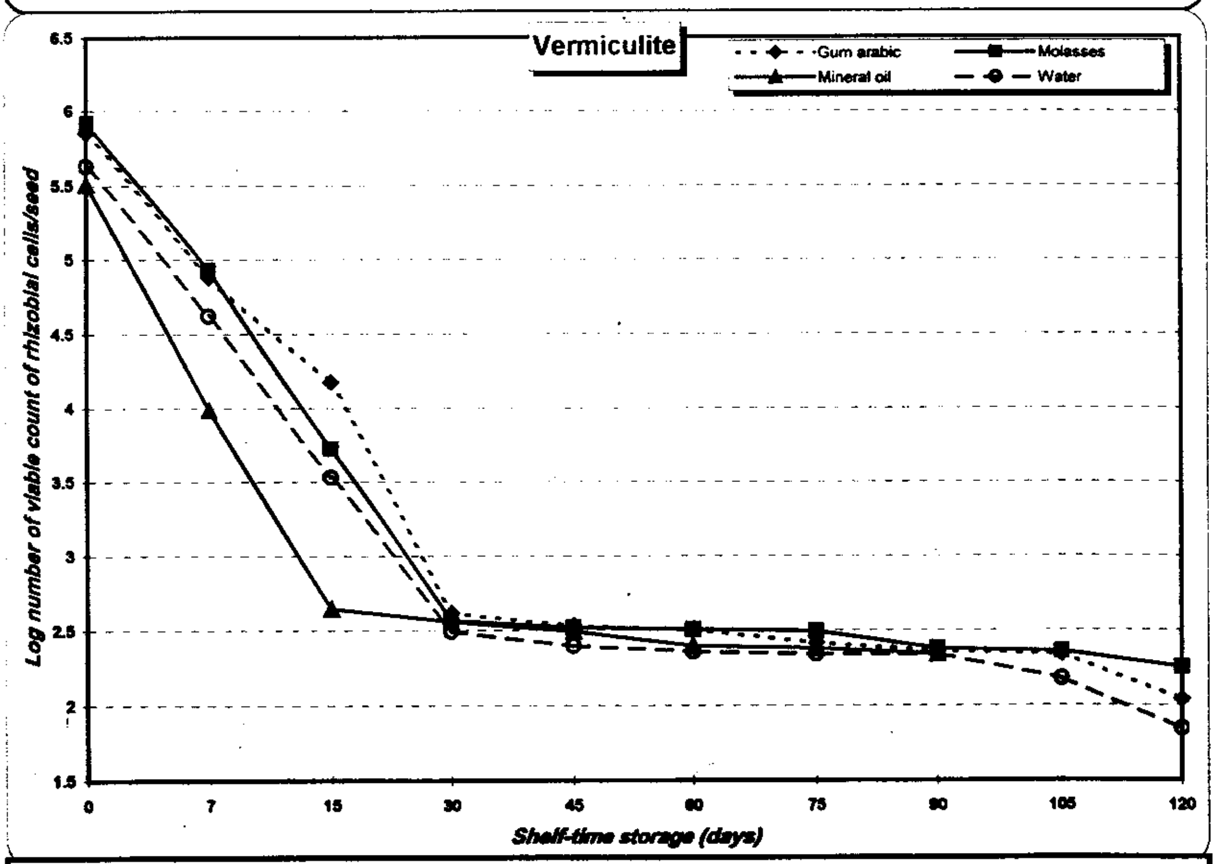


Fig.(5): Log No. of viable count of rhizobial cells/seed of faba bean inoculated with fine peat and vermiculite as carrier-based inocula (*R. leguminosarum* bv. *viceae* strain 441) and different adhesive agents as affected by shelf-time storage (days).

4.1.2.1.b. Vermiculite

The application of vermiculite-based inoculant in combination with the tested adhesive agents (Fig. 5) had changed than those of fine peat as carrier agent. The number of cells/seed ranged from 8.3 x 10^5 to 70 cells/seed corresponded to molasses at zero day shelf-time storage period and water at 120 days shelf-time storage period.

At zero day shelf-time storage period of inoculation all adhesive agents had achieved superior values of 7.1 x 10^5, 8.3 x 10^5, 3.2 x 10^5 and 4.3 x 10^5 cells/seed for vermiculite with gum arabic, molasses, mineral oil and water, respectively.

Up to 15 days shelf-time storage period, still the viable number of rhizobial cells/seed is acceptable for all the tested adhesive-agents except for mineral oil, which the viable number started to decrease to unacceptable number of 4.4 x 10^2 cells/seed. Meanwhile, the severe decline in the number of rhizobial viable cells had dramatically achieved after 30 days shelf-time storage for the other adhesive agents. The corresponding number of rhizobial cells/seed was 4.1 x 10^2, 3.7 x 10^2, 3.6 x 10^2 and 3.1 x 10^2 for gum arabic, molasses, mineral oil and water, respectively. This tendency continued to be clearer with shelf-time storage of 30 days and up to 120 days shelf-time storage.

On the other hand, when the stored pelleted faba bean seeds had been planted, the nodules formation showed different numbers/plant at the two sampling periods of 45 and 90 DAP (Tables 7 and 12).

At 45 days sampling, the use of vermiculite in alternation with the adhesive agents tested (Table 7), molasses gave the highest number (10 nodules/plant) at initial storage period followed by 9, 7 and 4 nodules/plant for 30, 45 and 60 days shelf-time storage period, respectively. While gum arabic recorded 10, 10, 8 and 6 nodules/plant initially and for 30, 45 and 60 days shelf-time storage, respectively. However, both mineral oil and water gave the least numbers of nodules/plant.

Generally, the numbers of nodules/plant achieved by the combination of vermiculite with any of gum arabic, molasses, mineral oil and water were in accordance with those numbers of viable cells/seed. Moreover, the same results were detected at 90 DAP.

4.1.2.1.c. <u>Talc powder:</u>

Talc powder when mixed with the adhesive agents at zero day shelf-time storage Fig. (6) gave the highest values of viable rhizobial cells/seed which were 5.1 x 10^5 (gum arabic), 4.3 x 10^5 (molasses) and 2.5 x 10^5 for both of mineral oil and water. However, these numbers decreased with increasing the storage periods.

At 15 days shelf-time storage, the viable count continued to decrease with all adhesive agents tested but still reasonable to achieve nodulation. The corresponding numbers of cells/seed obtained were 6.1 x 10^3, 3.4 x 10^3, 2.4 x 10^3, and 2.7 x 10^3 for gum arabic, molasses, mineral oil and water, respectively.

At 30 days shelf-time storage, sudden decrease in viable cell numbers/seed was noticed. These numbers were 4.2 x 10^2, 3.1 x 10^2, 3.4 x 10^2 and 3.4 x 10^2 rhizobial cells/seed for gum arabic, molasses, mineral oil and water, respectively. However, it was clear that pre-inoculated seeds using such adhesive sticker agents of gum arabic, molasses, mineral oil and water and stored for 30 days and up to 120 days shelf-time storage, the viable count of rhizobial cells/seed were not able to cause nodulation, the mean number of nodules/plant ranged from 5 to 6 nodules/plant at 45 and 90 DAP, respectively (Tables 7 & 12). This trend was true when those stored pelleted seeds were sown to test nodulation after 45 and 90 DAP, (Tables 7 &12). The number of nodules/plant showed a reverse proportional with the shelf-time storage. At 45 days sampling, increasing the shelf-time storage more than 30 days decreased the number of nodules/plant (Table 7) with gum arabic from 8 nodules/plant after 30 days shelf-time storage to 5 nodules/plant after 60 days. However, using molasses as adhesive agent the

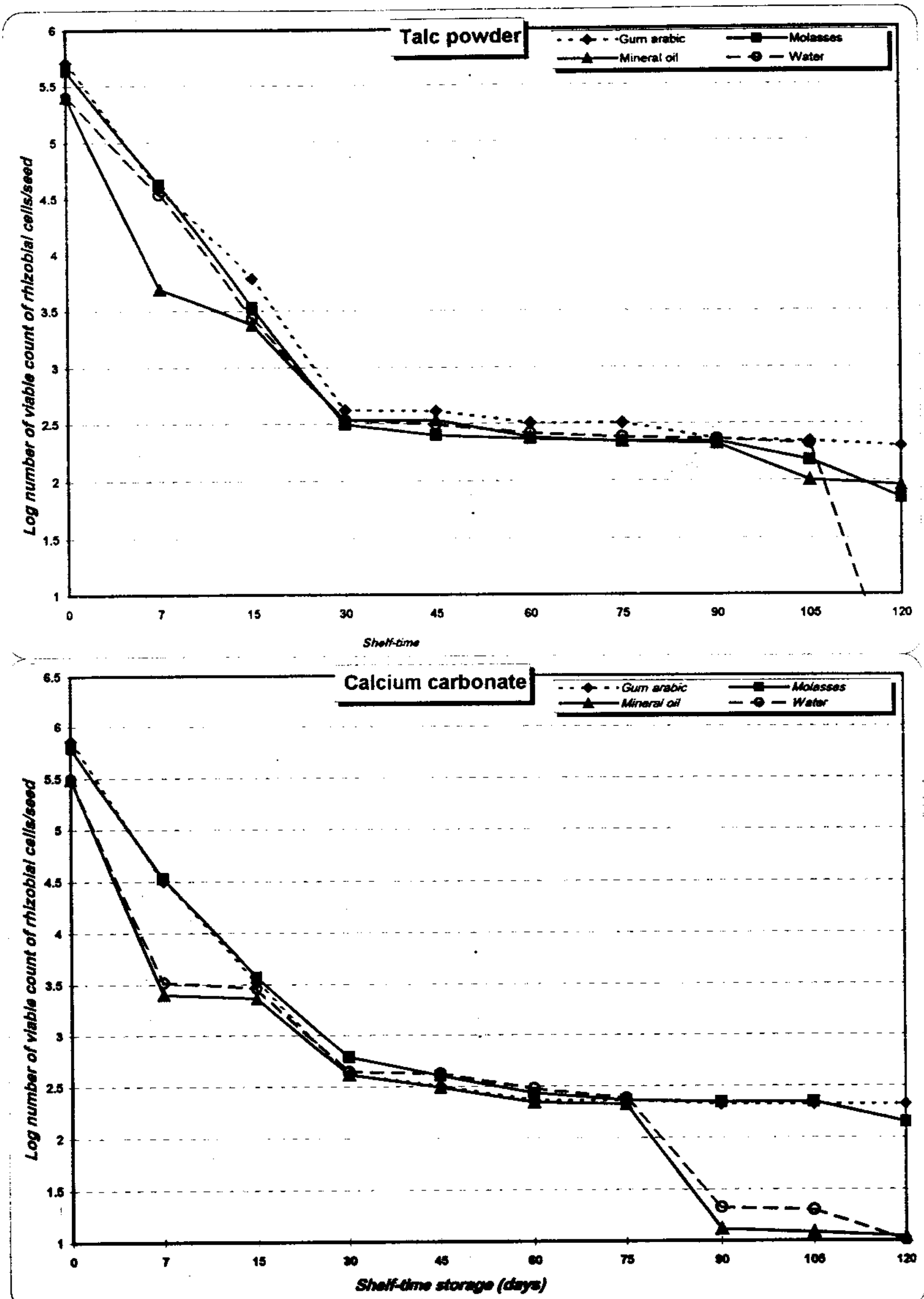


Fig.(6): Log number of viable count of rhizobial cells/seed of faba bean inoculated with talc powder and calcium carbonate as carrier-based inocula (*R. leguminosarum* bv. *viceae* strain 441) and different adhesive agents as affected by shelf-time storage (days).

number of nodules/plant recorded from 8 to 4.0 respective to 30 and 60 days shelf-time storage, with mineral oil from 3 nodules/plant (30 days shelf-time storage) to 2 nodules/plant (60 days shelf-time storage period) and finally with water as adhesive agent from 2.0 to 1.67 nodules/plant at 30 and 60 days shelf-time storage, respectively.This behavior was also recorded at 90 DAP (Table 12).

4.1.2.1.d. Calcium carbonate:

The effect of calcium carbonate as carrier-based inoculant in combination with gum arabic, molasses, mineral oil and water as adhesive agents on the viable number of rhizobial cells/seed is shown in Table (4) and illustrated by Fig.6.

It was clear that all adhesive agents with calcium carbonate gave the best values at zero day shelf-time storage. The numbers of rhizobial cells/seed at this time were 7.2×10^5, 6.2×10^5,3.1×10^5, and 3.1×10^5 for gum arabic, molasses, mineral oil and water, respectively.

The same as happened with talc powder, after 15 days shelf-time storage period the number of cells/seed began to decrease to be 3.3×10^3, 3.7×10^3, 2.5×10^3 and 2.9×10^3 cells/seed corresponded to gum arabic, molasses, mineral oil and water, respectively. However, along with those decreases, those viable cells/seed were still capable to cause nodulation.

By increasing shelf-time storage period up to 30 days, sharp decline in the number of rhizobial viable cells appeared strongly since those numbers became not capable to cause nodulation. The corresponding values were 4.1×10^2, 6.1×10^2, 4.1×10^2 and 4.4×10^2 cells/seed for gum arabic, molasses, mineral oil and water, respectively. Increasing storage period more than 30 days and up to 120 days for all adhesive agents tested had a negative effect on the number of the viable rhizobial cells/seed, that they are less enough to form nodules.

In relation to nodulation, those viable number of rhizobial cells/seed had showed nearly active nodulation when the stored pelleted faba bean seeds had planted at 45 and 90 DAP (Tables 7 and 12). Gum arabic and molasses as sticker agents when mixed with calcium carbonate-based inoculant showed different responses towards nodulation. Gum arabic gave highest value of 7 nodules/plant (initially) and then started to decrease at 30 and up to 60 days shelf-time storage while molasses gave lower numbers of nodules/plant than those of gum arabic and were 7, 6, 4 and 3 nodules/plant initially and for 30, 45 and 60 days shelf-time storage, respectively.

For mineral oil and water as adhesive agents the trend was different that the number of nodules/plant had decreased and were in parallel to the number of viable rhizobial cells/seed (Table, 4). Also, similar results recorded at 45 DAP had been detected for nodulation at 90 DAP (Table 12).

4.1.2.2. Viable rhizobial cells count on pelleted soybean seeds:

Data in Table (5) illustrated by Figures (7 and 8) show the number of viable rhizobial cells/seed of the pelleted soybean seeds as affected by the types of rhizobial based-inoculant, adhesive agents and different shelf-time storage periods (0 -120 days).

4.1.2.2.a. Fine peat:

Data in Table (5) illustrated by Fig. (7) indicate the effect of storage periods on the number of viable rhizobial cells/seed when pre-inoculated with fine peat-based inoculant using different adhesive agents such as gum arabic, molasses, mineral oil and water.

Data revealed that the highest viable rhizobial cell count/soybean seed was at zero day shelf-time storage period with all adhesive agents tested. The corresponding numbers were 6.7 x 10^4, 6.5 x 10^4, 3.6 x 10^4 and 4.1 x 10^4 cells/seed for gum arabic, molasses, mineral oil and water, respectively.

At 15 day shelf-time storage period, the viable rhizobial cells/seed decreased but these numbers were still exponentially able to cause nodulation with all adhesive agents tested such as gum arabic (2.3 x 10^4), molasses (2.2 x 10^4) and water (1.3 x 10^4) except for mineral oil which recorded also acceptable viable

Table (5): Viable number of rhizobial cells/seed of soybean (x 10^2) inoculated with different carrier-based inocula (*Bradyrhizobium japonicum* strains 3407) and adhesive agents as affected by different shelf-time storage (days).

Shelf-time / reatment	Shelf-time storage (days)									
	Initial	7	15	30	45	60	75	90	105	120
FINE PEAT										
Gum arabic	*667*	*490*	*233*	*250*	*119*	*116*	*111*	*56*	*39*	*17*
Molasses	*646*	*410*	*224*	*161*	*128*	*33*	*33*	*29*	*24*	*13*
Mineral oil	*355*	*164*	*81*	*33*	*28*	*27*	*2.0*	*1.5*	*1.1*	*1.0*
Water	*412*	*231*	*130*	*18*	*7.8*	*2.6*	*2.1*	*0.61*	*0.21*	*0.0.*
VERMICULITE										
Gum arabic	*690*	*200*	*161*	*191*	*167*	*143*	*90*	*78*	*57*	*27*
Molasses	*780*	*270*	*101*	*60*	*72*	*61*	*60*	*48*	*26*	*11*
Mineral oil	*380*	*230*	*49*	*49*	*37*	*33*	*21*	*5.2*	*2.1*	*0.30*
Water	*335*	*220*	*90*	*78*	*21*	*4.2*	*1.5*	*0.67*	*0.31*	*0.11*
TALC POWDER										
Gum arabic	*415*	*214*	*217*	*166*	*126*	*39*	*33*	*26*	*1.4*	*0.31*
Molasses	*462*	*370*	*265*	*141*	*137*	*63*	*51*	*23*	*2.2*	*1.0*
Mineral oil	*413*	*214*	*121*	*70*	*67*	*62*	*3.2*	*2.5*	*2.08*	*0.21*
Water	*421*	*222*	*123*	*24*	*21*	*3.2*	*1.2*	*0.50*	*0.39*	*0.22*
CALCIUM CARBONATE										
Gum arabic	*760*	*251*	*209*	*198*	*70*	*65*	*31*	*5.0*	*4.5*	*0.11*
Molasses	*439*	*271*	*181*	*108*	*42*	*31*	*17*	*1.6*	*1.0*	*0.19*
Mineral oil	*367*	*272*	*133*	*29*	*26*	*21*	*2.1*	*1.0*	*0.70*	*0.35*
Water	*217*	*139*	*102*	*12*	*9.6*	*4.5*	*4.2*	*0.28*	*0.14*	*0.02*

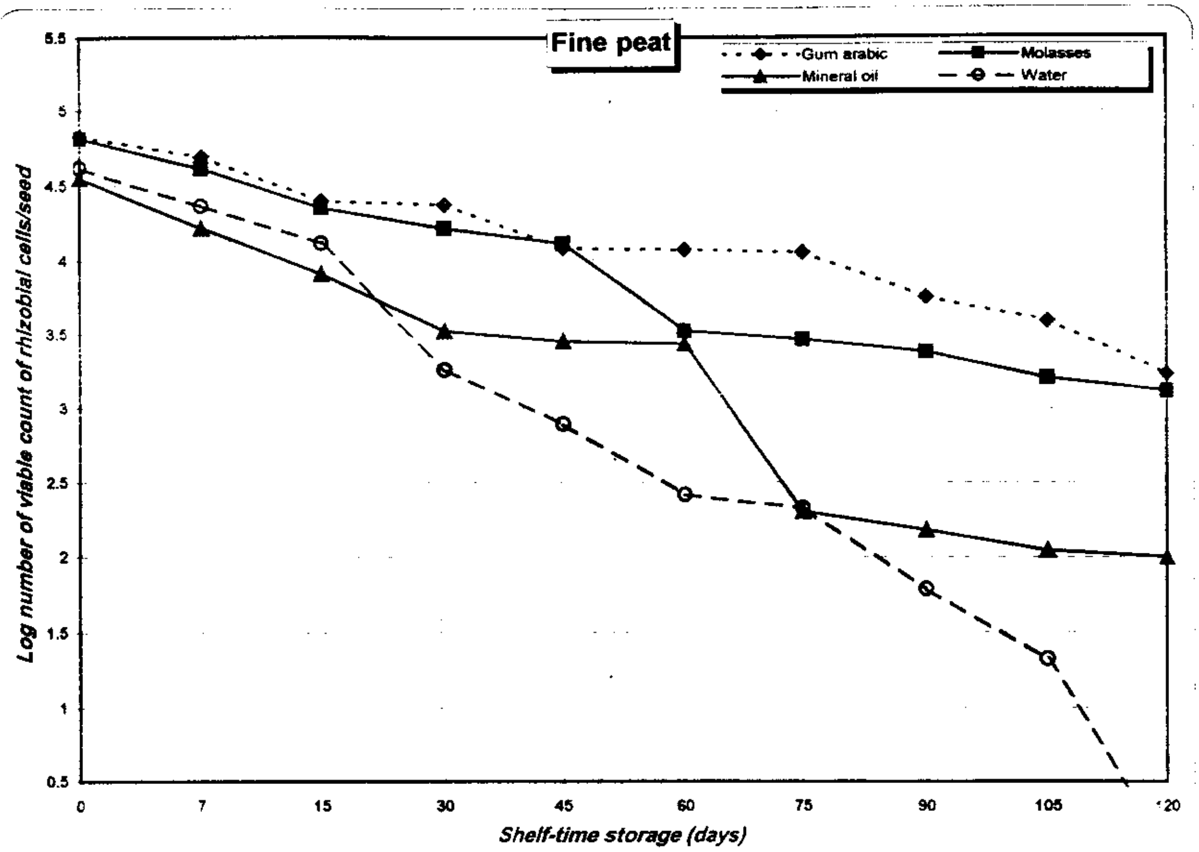
count (8.1×10^3) which was less than the numbers of other adhesive agents. This situation noticed at 15 days shelf-time storage, was continued with increasing the storage periods up to 30 and 45 days (shelf-time storage) with all adhesive agents used except for water which recorded 7.8×10^2 cells/seed at 45 days shelf-time storage. This number is not sufficient enough to form well nodulated plants.

At 60 days shelf-time storage, gum arabic gave the highest viable rhizobia cells/seed of 1.2×10^4 followed by 3.3×10^3 for molasses and 2.7×10^3 for mineral oil. However, application of water as a sticker agent the number of rhizobial count on seeds recorded 2.6×10^2 cells/seed and still in deterioration that is not possible to be infective for nodules formation.

Increasing shelf-time storage more than 60 days and up to 120 days both gum arabic and molasses had continued to carry enough number of viable rhizobial cells/seed which could be able to form nodules. The corresponding viable counts at 120 days shelf-time storage period were 1.7×10^3 cells/seed and 1.3×10^3 cells/seed for gum arabic and molasses, respectively.

At 75 days shelf-time storage, the viable rhizobial cells/seed achieved by using mineral oil as adhesive agent was 2.0×10^2 representing the point of decline after which the number decreased to be 1.5×10^2, 1.1×10^2 and 1.0×10^2 cells/seed corresponding to 90, 105 and 120 days shelf-time storage. However, application of water as sticker agent at 120 days, the viable rhizobial cells on seed was not detected.

However, the number of nodules/plant formed at 45 and 90 DAP of the stored pelleted soybean seeds (Tables 17 and 22) were in accordance to the viable rhizobial cell count/seed. At 45 DAP sampling when fine peat was used as carrier-based inoculum in combination with adhesive agents of gum arabic or molasses recorded the highest numbers of nodules/plant from zero to 30 days shelf-time storage, respectively (Table 17). While mineral oil and water gave less numbers of nodules/plant at the same periods.



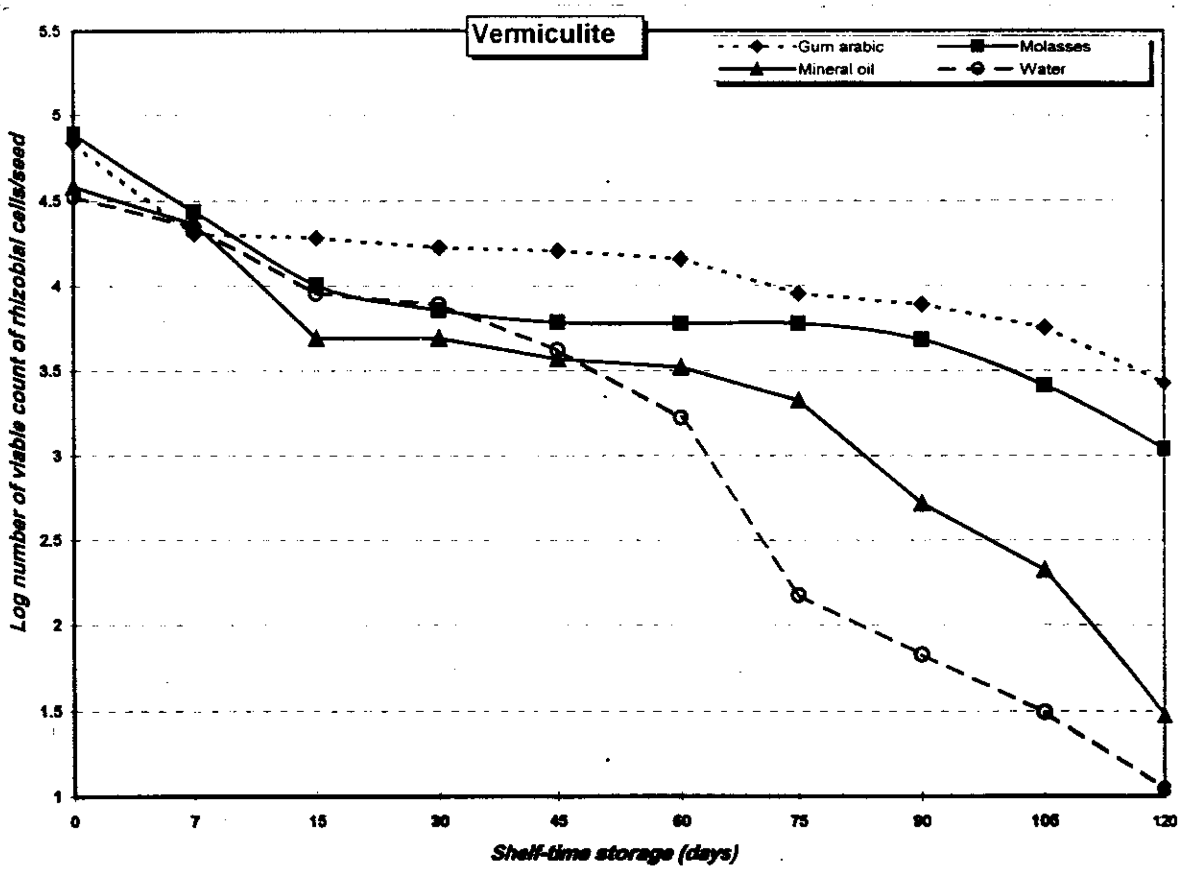


Fig.(7): Log No. of viable count of rhizobial cells/seed of soybean inoculated with fine peat and vermiculite as carrier-based inocula (*Bradyrhizobium japonicum* strain 3407) and different adhesive agents as affected by shelf-time storage (days).

Results in Table (5) showed the same trend recorded at 45 DAP for nodulation to 90 DAP.

4.1.2.2.b. Vermiculite:

The same trend noticed by fine peat with gum arabic and molasses had been achieved with vermiculite (Fig.7). The highest viable count of cells/seed of 6.9×10^4 and 7.8×10^4 were given by gum arabic and molasses at zero day shelf-time storage period, respectively. While consequently both of them recorded the lowest viable number of cells/seed of 2.7×10^3 and 1.1×10^3 at 120 days shelf-time storage.

Mineral oil as an adhesive agent gave reasonable viable rhizobial cells/seed up to 75 days shelf-time storage of 2.1×10^3. However, the highest number was achieved by combination of mineral oil with vermiculite (3.8×10^4 cells/seed) at zero day shelf-time storage period. On the other hand, storing pelleted seeds for more than 75 days shelf-time storage caused dramatic decline in the rhizobial viable cells which started from 90 days shelf-time storage (5.2×10^2 cells/seed) to reach the least number of 30 cells/seed at 120 days shelf-time storage.

Application of water as an adhesive agent with vermiculite based-inoculant to pellet soybean seeds under different storage periods gave the highest viable rhizobial count of 3.4×10^4 cells/seed at initial shelf-time storage. Then these numbers started to decrease after 7, 15, 30 and 45 days shelf-time storage with corresponding values of 2.2×10^4, 9.0×10^3, 7.8×10^3 and 2.1×10^3 cells/seed, respectively.

Increasing the shelf-time storage more than 45 days to reach 60 days decreased the viable number of rhizobial cells/seed to be 4.2×10^2 which was unsuitable to get well nodulated faba bean plants. However, this depression was more pronounced with water as an adhesive agent at 105 days shelf-time storage period with corresponding number of 31 cells/seed.

Data in Tables (17 and 22) confirmed that the storage of pelleted seed did not affect the number of nodules/plant either after 45 or 90 DAP with both of gum arabic and molasses up to 30 days shelf-time storage period after which the number of nodules/plant had declined. This was not in accordance with the number of viable rhizobial cells/seed (Table 5) which had given acceptable values up to 120 days shelf-time storage. For mineral oil as a sticker agent, the number of nodules/plant formed was in accordance with those of viable cells/seed up to 30 days shelf-time storage after which the number of nodules was declined up to 60 days storage.

4.1.2.2.c. <u>Talc powder:</u>

Talc powder-based inoculant and the adhesive agents (gum arabic, molasses, mineral oil and water), were used in alternation under storage time effect in soybean seeds pelleting. Data in Table (5) illustrated by Fig.(8) revealed that the highest viable rhizobial cells/seed were recorded at zero shelf-time storage by all adhesive agents. The corresponding values were 4.2×10^4, 4.6×10^4, 4.1×10^4 and 4.2×10^4 cells/seed for gum arabic, molasses, mineral oil and water, respectively.

Up to 15 days shelf-time storage period, all the numbers of viable cells/seed recorded by all adhesive agents tested were still high and exponentially had the same degree of 10^4. Increasing shelf-time more than 15 days showed different responses for the adhesive agents towards talc powder. However, both gum arabic and molasses continued to be effective in viable rhizobial numbers up to 90 days shelf-time storage with corresponding values of 2.6×10^3 and 2.3×10^3 cells/seed. Moreover, both gum arabic and molasses showed the symptoms of deterioration in the number of viable rhizobial count at 105 and 120 days shelf-time storage with respective values of 1.4×10^2 and 31 cells/seed (gum arabic) and 2.2×10^2 and 1.0×10^2 cells/seed (molasses). On the other hand, mineral oil

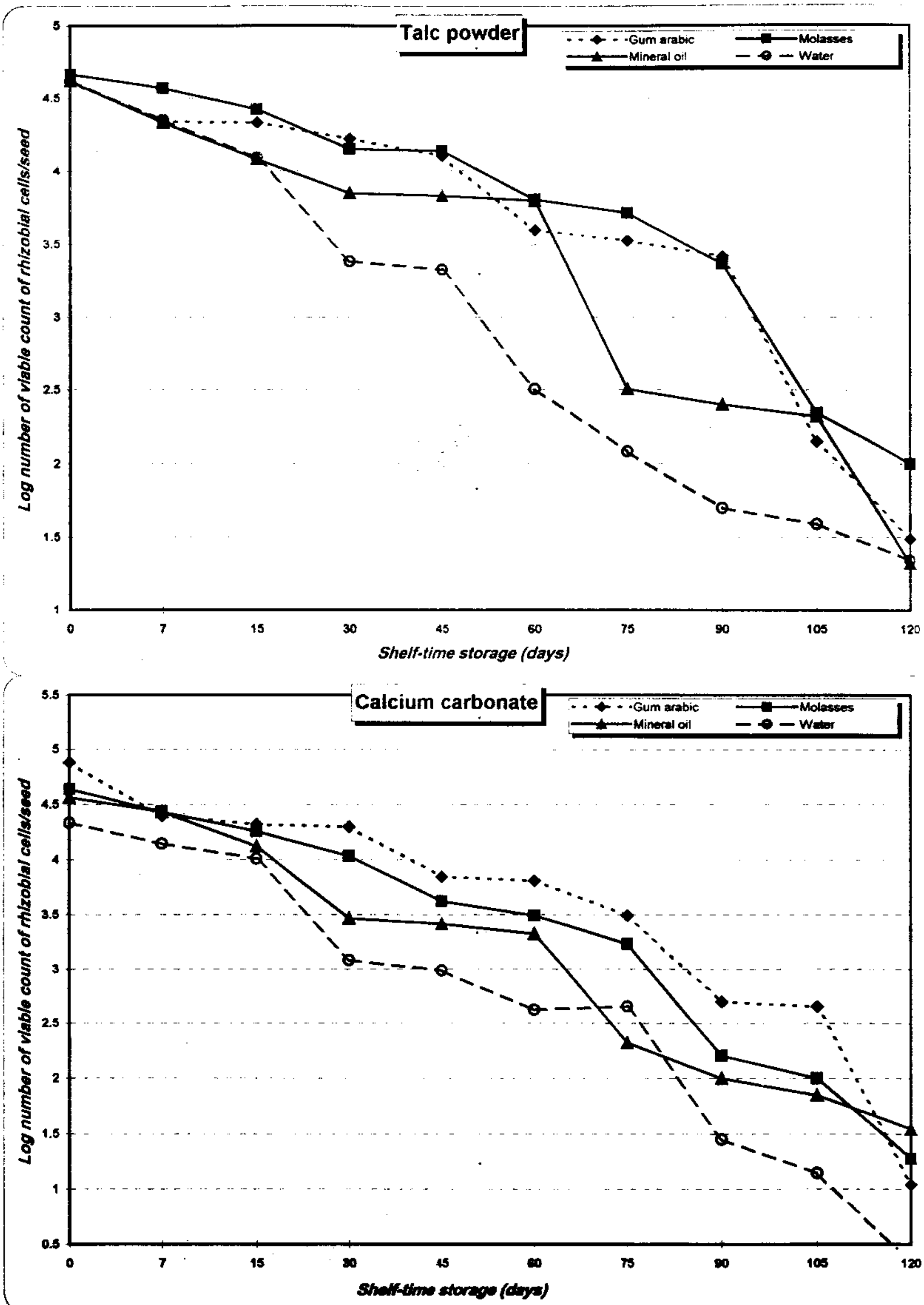


Fig.(8): Log No. of viable count of rhizobial cells/seed of soybean inoculated with talc powder and calcium carbonate as carrier-based inocula (*Bradyrhizobium japonicum* strain 3407) and different adhesive agents as affected by shelf-time storage (days).

results started to show its worse effect on the viable cell count at 75 days shelf-time storage with corresponding value of 3.2×10^2 cells/seed.

When shelf-time storage increased for more than 75 days to reach 90, 105 and 120 days shelf-time storage, the viable number cells had decreased obviously with respective numbers of 2.2×10^2, 2.1×10^2 and 21 cells/seed.

Water as an adhesive agent, showed the suitability to be used as an adhesive agent in combination with talc powder up to 45 days shelf-time storage period as it recorded 2.1×10^3 cells/seed after which this number started to decline at 60 days shelf-time storage (3.2×10^2 cells/seed). This tendency had continued up to 120 days shelf-time storage with corresponding value of (22 cells/seed).

The number of nodules/plant (Tables 17 and 22) showed different responses to shelf-time storage when talc powder had accompanied with any of gum arabic, molasses, mineral oil and water at 45 DAP (Table 17). While this character was nearly in steady trend with all adhesive agents tested at 90 DAP (Table 22). However, These results were not in agreement with the viable numbers of rhizobial cells/seed recorded at different shelf-time storage period (Table 5).

4.1.2.2.d. <u>Calcium carbonate:</u>

Data in Table (5) illustrated by Fig. (8) indicate the effect of different shelf-time storage on the viable rhizobial cells/pelleted soybean seeds using calcium carbonate as carrier-based inoculant in combination with different adhesive agents (gum arabic, molasses, mineral oil and water).

At initial shelf-time storage, all adhesive agents recorded the highest viable rhizobial cells/seed of 7.6×10^4, 4.4×10^4, 3.7×10^4 and 2.2×10^4 for gum arabic, molasses, mineral oil and water, respectively. On the other hand, all adhesive agents gave the lowest values after 120 days shelf-time storage period with corresponding values of 1.1×10, 1.9×10, 3.5×10 and 0.2×10 cells/seed for gum arabic, molasses, mineral oil and water, respectively. It is also important to state that the values of the viable rhizobial cells/seed up to 15 days shelf-time storage for all adhesive agents were high to reach 2.1 x 10^4, 1.8 x 10^4, 1.3 x 10^4 and 1.0 x 10^4 for gum arabic, molasses, mineral oil and water, respectively. Both gum arabic and molasses up to 30 days shelf-time storage gave also high numbers of viable rhizobial cells/seed with respective values of 2.0 x 10^4 and 1.1 x 10^4. However, mineral oil and water gave lower numbers of 2.9 x 10^3 and 1.2 x 10^3 cells/seed, respectively.

On the other hand, using both gum arabic and molasses as adhesive agents combined with $CaCO_3$ had successfully produced acceptable viable rhizobial cells/seed up to 75 days shelf-time storage period after which the viable rhizobial cell count started to decrease. The corresponding numbers for gum arabic and molasses at this period were 3.1 x 10^3 and 1.7 x 10^3, respectively. Consequently, for 90, 105 and 120 days shelf-time storage periods the number of the viable cells/seed had been nearly destroyed to be 5.0 x 10^2, 4.5 x 10^2, and 1.1 x 10 cells/seed for gum arabic and 1.6 x 10^2, 1.0 x 10^2 and 1.9 x 10 cells/seed for molasses, respectively.

However, mineral oil in combination with calcium carbonate carrier-based inoculant gave viable rhizobial number cells of 2.1 x 10^3 at 60 days shelf-time storage. Thereafter, at 75 days shelf-time storage, the viable cell numbers of rhizobia started to decrease sharply (2.1 x 10^2 cells/seed) and then the decreases were widened to reach 3.5 x 10 cells/seed at 120 days shelf-time storage.

In case of water as an adhesive agent, it had successfully produced viable rhizobial cells/seed up to 30 days shelf-time storage with relative number of 1.2 x 10^3. The viable cell number afterwards declined after 45 days storage (9.6 x 10^2 cells/seed) and then continued to decrease with increasing the shelf-time storage up to 120 days shelf-time storage period (0.2 x 10 cells/seed).

The number of nodules/plant Tables (17 and 22) showed different responses as calcium carbonate was used in soybean seed pelleting with any of gum arabic, molasses, mineral oil and water. At 45 DAP (Table 17) gum arabic recorded 11, 8, 7, 4 and 4 nodules/plant for the shelf-time storage of zero, 30, 45 and 60 days, respectively. Increasing shelf-time storage periods up to 60 days decreased the number of nodules/plant to 4 with the application of gum arabic as a sticker agent. This trend was in accordance with the viable rhizobial cells count/seed for the same treatment. However, the number of nodules/plant for the other adhesive agents were not in parallel to the viable rhizobial cells/seed achieved by the same treatments (Table 5). Moreover, the results in Table (22), showed that the number of nodules/plant at 90 DAP was in agreement with the viable rhizobial cells/seed (Table 5) at all shelf-time storage periods for any of the adhesive agents tested.

Legume root nodule bacteria genus ***(Rhizobium***) have become widely distributed as a result of the natural distribution of ***Leguminosae*** and, in more recent times, through leguminous crops. In spite of this, there are many soils devoid of the bacteria which efficiently nodulate and fix nitrogen in symbiosis with leguminous crops. In such cases it is necessary to introduce the bacteria by seed inoculation at the time of sowing. Various methods are used for the introduction of rhizobia to leguminous crops to ensure nodulation. Seed pelleting is used to provide the inoculant with additional protection for survival. In the present work for this purpose different adhesive agents (gum arabic, molasses, mineral oil and water) were mixed in alternation with different carrier-based inocula (fine peat, vermiculite, talc-powder and calcium carbonate) under different shelf-time storage periods at room temperature (0, 7, 15, 30, 45, 60, 75, 90, 105 and 120 days) to test the favorite combination for either adhesive agents or carrier-based inocula which achieve the reasonable viable rhizobial cell counts which remain on faba bean or soybean seeds and consequently capable to form well nodulated plants.

It was noticed that for both faba bean and soybean, the combination of gum arabic and fine peat gave the splendid count of viable rhizobial cells/seed which was able to withstand up to 75 days shelf-time storage period for faba bean (2.1x 10^3 cells/seed) and 120 days for soybean (1.7 x 10^3 cells/seed). However, molasses with fine peat gave positive results (2.3 x 10^3 cells/seed) at 45 days shelf-time storage period for faba bean while it was (1.3 x 10^3 cells seed) at 120 days shelf-time storage period for soybean . These results had ensured that with fine peat as a carrier-based inoculant molasses could be replaced gum arabic for seed pelleting process. Some authors had discussed the matter of seed pelleting.

In Australia, **Brockwell (1963)** tested gum arabic as an adhesive agent with different carrier-based inocula included milk powder, bentonite, delomite, peat and gypsite to pellet the buffel grass seed to minimize the loss of this light seed due to wind drift during aerial sowing. He revealed that peat cultures for incorporation in the pellet gave more than 1.0 x 10^9 rhizobial cells per gram of peat. He also added that at recommended rate of inoculant application gives an inoculation rate on, for example, ***Lucerne*** of approximately 2.0 x 10^4 rhizobial cells/seed while this number is much higher than the standard laid down by **Vincent (1954),** there are many situations so unfavorable that even 2.0 x 10^4 rhizobial cells/seed are far too few to ensure nodulation.

Burton and **Curley (1965)** showed that good effective nodulation was obtained by 2.0 x 10^5 rhizobial cells per soybean seed and 2.0 x 10^4 rhizobial cells/seed for alfalfa or clover. While **White (1967)** stated that contained larger proportion of nodulated plants, increased number of nodules and greater yields when rhizobia on the seed were increased from 4.0 x 10^3 to 4.0 x 10^6 /seed.

In contrast with the result of this work **Date (1970)** reported that in well documented evidence the number of ***Rhizobium*** on the seed of most temperate species, even with high quality inocula, decline with storage. However, these results of **Date** were in agreement with those achieved in faba bean seeds by the combination of fine peat with mineral oil and water, since storage of seeds with them led to decrease the number of viable rhizobial cells/seed. Also, this was true with the results obtained with the combination of any of vermiculite, talc powder or calcium carbonate with any of mineral oil and water. On the contrary, for soybean the results were different as the combination of fine peat and vermiculite as carrier-based inocula with gum arabic or molasses as adhesive agents up to 120 days shelf-time storage led to viable rhizobial cells/seed to be alive.

Moreover, **Thompson** ***et al,*** **(1975)** owed the death of rhizobia on inoculated seeds to the inhibitory nature of soluble substances or harmful methods and unfavorable temperatures during storage.

FAO (1984) reported that viable rhizobia may be expressed in terms of number per gram of inoculant or as number per seed. The latter is more meaningful because the quantity of inoculant per unit weight of seed varies with different inoculant manufactures. They also added that **Canadian** authorities have adopted the following standards for pre-inoculated seeds: small seeds (e.g. clover), 10^3/seed, intermediate seeds (e.g Sain foin), 10^4 /seed and large seeds (e.g. soybean), 10^5 /seed. While in France, farmers' practices are used in establishing standards. Inoculant must provide a minimum of 5.0×10^3 viable rhizobia/lucerne seed and 1.0×10^6 viable rhizobia per soybean seed. Finely they recommended that the inoculant should provide large numbers of viable rhizobia, at least 1×10^4 to 1×10^6.

Rennie and Elegba (1985) found that the adhesive agents used such as wallpaper glue, carboxymethyl cellulose and gum arabic binded > 800 mg inoculant to soybean seed which produce > 10^5 viable rhizobial cell/seed and gave > 100 nodules/plant.

On the other respect, **Farria** ***et al,*** **(1985)** found that survival of ***Rhizobium*** on the seed of ***Phaseolus vulgaris*** and ***Macroptilium*** was higher with gum arabic when mixed with peat to pellet seeds than other home made adhesives (wheat flour-starch from ***Manihot esculanta*** or ***Maranta arundinaccea***).

Hoben ***et al.,*** **(1991)** suggested that oil has a protective effect when used as sticker with a powdered peat inoculant and explained that an oil envelope may possibly form around rhizobial cells preventing moisture from escaping and this supported the viability of large numbers of viable rhizobial on ***Phaseolus vulgaris cv. Bountiful, Kabuli chichpea (Cicer arietinum), soybean (Glycine max*** **cv. Davis**) and peanut ***(Arachis hypogaea*** **cv. Burpea spanish**). Moreover, they added that more work is required to find suitable adhesive for other agriculturally important legumes.

However, **Jansen** ***et al.,*** **(1994)** stated the pre-inoculated pelleted seed stored for 56 days contained sufficient bacteria/seed for effective nodulation. Moreover, these results were not achieved using a liquid inoculum of ***Rhizobium.***

4.2. GREENHOUSE EXPREREMENTS

4.2.1. Effect of rhizobial seed pelleting method on faba bean and soybean plants under different shelf-time storage periods

4.2.1.1. Faba bean trial

4.2.1.1.1. Sampling at 45 days after planting (DAP).

Growth and nodulation of faba bean plants as affected by rhizobial seed pelleting inoculation method using different carrier-based inocula, different adhesive agents and different shelf-time storage periods were studied.

For faba bean experiment, seeds were previously pelleted and air dried under laboratory conditions for 72 hours, then stored for intervals of 30, 45, 60 days before sowing. Control treatment was inoculated and pelleted only at sowing time, (zero time). After sowing faba bean plants were uprooted after 45 and 90 days to determine the number and dry weight of nodules, dry weight of roots, dry weight of shoots and N-content.

4.2.1.1.1.1. Roots dry weight:

Data presented in Table (6) show the effect of inoculation with ***R. leguminosarum*** **bv.** ***viceae*** 441 using different adhesive and carrier materials on the dry weight of roots of faba bean after pelleting and under different storage periods of 30 ,45 and 60 days before sowing for the pelleted seeds. Results showed the following.

4.2.1.1.1.1.1. Effect of adhesive agents and carrier-based inocula:

At zero-time storage, as compared to the control treatment using water as adhesive, all the adhesive materials investigated significantly increased the roots dry weight at 5% level. Results in Table (6) also emphasized the superiority of the mineral oil as adhesive agent that gave the best results of roots dry weight (2.02 g/plant) against the other adhesive materials studied.

Table (6): Roots dry weight of faba bean plants (g/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	1.57	1.57	1.57	1.57	1.57
	Fine peat	2.39	2.56	2.76	2.56	2.57
	Vermiculite	2.22	2.41	2.55	2.49	2.42
	Talc powder	2.04	1.94	2.36	2.30	2.16
	$CaCO_3$	1.42	1.70	2.41	1.71	1.81
Mean		1.92	2.03	2.33	2.12	2.10
Molasses	*Unioc.*	1.57	1.57	1.57	1.57	1.57
	Fine peat	2.22	2.28	3.29	3.15	2.74
	Vermiculite	2.09	1.95	2.73	2.39	2.29
	Talc powder	1.77	1.74	2.17	2.10	1.94
	$CaCO_3$	1.80	1.32	1.37	2.16	1.66
Mean		1.89	1.77	2.22	2.28	2.04
Mineral oil	*Unioc.*	1.57	1.57	1.57	1.57	1.57
	Fine peat	2.48	2.68	2.73	2.95	2.71
	Vermiculite	2.14	2.01	2.82	2.82	2.45
	Talc powder	2.25	1.51	2.34	2.49	2.15
	$CaCO_3$	1.66	1.27	2.14	2.42	1.87
Mean		2.02	1.81	2.32	2.45	2.15
Water	*Unioc.*	1.57	1.57	1.57	1.57	1.57
	Fine peat	2.20	2.10	2.51	2.06	2.22
	Vermiculite	1.91	1.87	2.17	2.61	2.14
	Talc powder	1.65	1.51	1.78	2.29	1.81
	$CaCO_3$	1.35	1.35	1.52	1.81	1.51
Mean		1.74	1.68	1.91	2.07	1.85
Mean	*Unioc.*	1.57	1.57	1.57	1.57	1.57
	Fine peat	2.32	2.40	2.82	2.68	2.56
	Vermiculite	2.09	2.06	2.56	2.58	2.32
	Talc powder	1.93	1.68	2.16	2.30	2.02
	$CaCO_3$	1.56	1.41	1.86	1.02	1.71
Mean		1.89	1.82	2.20	2.23	2.04

	LSD 5 %				INTERACTION
Shelf-time storage					0.13
Adhesive	0.20	0.12	0.28	N.S.	0.11
Shelf-time x Adhesive					N.S.
Carrier	0.22	0.13	0.32	0.32	0.13
Shelf-time x Carrier					0.25
Adhesive x Carrier	N.S.	0.27	N.S.	N.S.	N.S.
Shelf-time x Adhesive x Carrier					N.S.

Concerning the application of different carrier materials tested such as fine peat, vermiculite, talc powder and calcium carbonate used as carrier-based inocula, significantly increased the root dry weight/plant compared to the uninoculated control except for calcium carbonate. However, the fine peat-based inoculant was superior and recorded root dry weight of 2.32 g/plant followed by vermiculite (2.09 g/plant) without significant difference between them.

After 30 days of shelf-time storage of pelleted seeds, gum arabic showed significant effect and recorded the highest root dry weight (2.03g/plant) compared with the other adhesive materials used.

All carrier-based inoculants tested significantly increased the roots dry weights. Also fine peat-based inoculum gave the highest dry weight (2.4 g/plant) which was significantly different from that of vermiculite (2.06 g/plant).

Storage of the pelleted seeds up to 45 days before sowing under room temperature exhibited different results concerning the root dry weight. Gum arabic as an adhesive agent gave 2.33 g/plant followed by mineral oil (2.32 g/plant) and molasses (2.22 g/plant) without significant difference from each other, however, all the adhesive agents tested were significantly different from that of water (1.91 g/plant) as adhesive control treatment.

However, using the carrier materials for inocula pre-inoculation positively affected the root dry weights. Again fine peat-based pelleted inoculant gave the highest dry weight of roots (2.82 g/plant) with significant difference from vermiculite (2.56 g/plant), and these two carriers were significantly different from uninoculated treatment (control), talc powder and calcium carbonate based inoculants.

Adhesives applied for seed pelleting stored for 60 days before sowing had no significant effect on the root dry weight values which were 2.45, 2.28, 2.12, and 2.07 g/plant for corresponding mineral oil, molasses, gum arabic and water (control treatment).

All carrier materials studied had significantly affected the dry weight of roots. Fine peat and vermiculite based inocula recorded the highest root dry weight of 2.68 and 2.58 g/plant, respectively with no significant difference between both of them. However, they were significantly different from talc powder and calcium carbonate and control uninoculated seeds.

4.2.1.1.1.1.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on root dry weight:

Data presented in Table (6) show the cumulative effect of all the factors tested (adhesives, carriers and shelf-time storage) and their interaction on the dry weight of roots.

Generally, the shelf-time storage had significantly affected the dry weight of roots. Sixty days shelf-time gave the highest value (2.23 g/plant) followed by 2.20 g/plant for 45 days shelf-time with no significant difference. However, they were statistically different from unstored and 30 days-stored pelleted seeds before sowing.

All the adhesive agents tested had significantly affected the root dry weight. Mineral oil (2.15 g/plant) and gum arabic (2.10 g/plant) achieved the highest root dry weight with no significant difference. On the other respect, these two adhesives were statistically different from molasses and water.

The highest root dry weight was noticed with fine peat-based inoculant (2.56 g/ plant) and this was different significantly from and higher than the vermiculite-based inoculant which gave 2.32 g/ plant. The other two carriers (talc power and $CaCO_3$) gave the lowest root dry weight of 2.02 and 1.71 g/ plant, respectively .It is worthy to state that the results given by talc powder and $CaCO_3$ were significantly different from those of peat and vermiculite.

The interaction effect of both shelf-time storage period and type of inoculant carrier material showed significant difference in the dry weight of roots (Table 6).

The highest dry weight (2.82 g/plant) was recorded after 45 days of storage with the use of fine peat as carrier-based inoculant.

In general, the abovementioned results, may suggest that pelleted faba bean seeds stored for 45 or 60 days before sowing, fine peat or vermiculite as carrier-based inocula gave the highest significant dry weight of roots.

4.2.1.1.1.2. Nodules number:

Data in Table 7 illustrated by Fig. 9 show the effect of pre-inoculation and seed pelleting on the number of nodules/plant of faba bean inoculated with ***R. leguminosarum*** using different adhesives and carriers stored initially and for different shelf-time of 30, 45 and 60 days before sowing (sampling 45 DAP).

4.2.1.1.1.2.1. Effect of adhesive agents and carrier-based inocula:

For adhesive and carrier materials (Table 7 and Fig. 9) the same trend was noticed from sowing (at zero-time storage) up to 60 days shelf-time storage. The favorite results of all storage periods were achieved by gum arabic and molasses as adhesive agents and by fine peat and vermiculite as carrier-based inoculants with no significant difference between them except for 45 days for adhesive and at 60 days for carrier. The number of nodules/plant achieved by using gum arabic or molasses significantly exceeded both of mineral oil and water. Also using fine peat and vermiculite as carrier-based inocula were statistically different from and higher than those of talc powder and $CaCO_3$.

Sowing of pelleted-seeds directly (without storage), gum arabic and molasses gave the highest number of nodules/plant of 7 and 7, respectively. However, increasing the storage shelf-time up to 30 days before sowing the corresponding values recorded were 7 and 7 nodules/plant. Whereas for carriers, fine peat at sowing (zero-time storage) recorded 9 nodules/plant and vermiculite gave 8 nodules/plant, at 30 days the corresponding values were 8 and 8 nodules/plant.

Table (7): Nodules number of faba bean plants (nodules/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	0	0	0	0	0
	Fine peat	11	11	9	7	10
	Vermiculite	10	10	8	6	9
	Talc powder	9	8	7	5	7
	$CaCO_3$	7	7	6	4	6
Mean		7	7	6	5	6
Molasses	*Unioc.*	0	0	0	0	0
	Fine peat	10	10	7	5	8
	Vermiculite	10	9	7	4	8
	Talc powder	8	8	6	4	7
	$CaCO_3$	7	6	4	3	3
Mean		7	7	5	3	5
Mineral oil	*Unioc.*	0	0	0	0	0
	Fine peat	10	9	6	5	8
	Vermiculite	7	7	5	4	6
	Talc powder	4	3	3	2	3
	$CaCO_3$	3	3	2	2	2
Mean		5	4	3	3	٤
Water	*Unioc.*	0	0	0	0	0
	Fine peat	3	2	2	2	3
	Vermiculite	5	3	3	3	4
	Talc powder	2	2	2	2	2
	$CaCO_3$	2	1	1	1	2
Mean		2	2	2	2	2
Mean	*Unioc.*	0	0	0	0	0
	Fine peat	9	8	6	5	7
	Vermiculite	8	8	6	4	6
	Talc powder	6	6	4	3	5
	$CaCO_3$	5	4	4	3	4
Mean		5	5	4	3	4

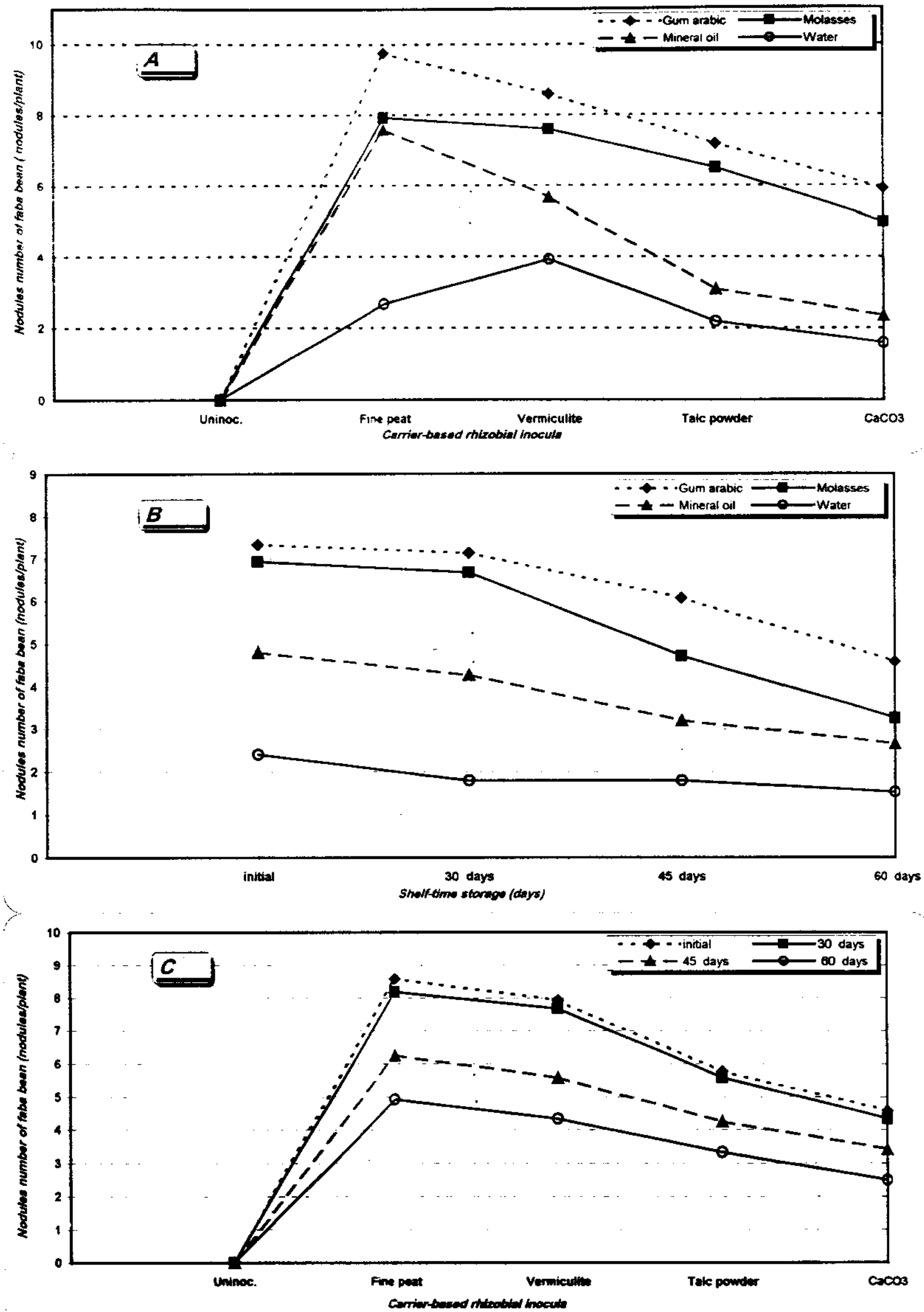


Fig.(9): Nodules number of faba bean plants (nodules/plant) as affected by inoculation with *R. leguminosarum* bv. *viceae* strain 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

4.2.1.1.1.2.2. <u>The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula:</u>

The shelf-time storage interaction significantly increased the number of nodules/plant especially at zero and 30 days after storage which gave the highest values of interaction of nodules 5 and 5 nodules/plant, respectively compared to the values for both of 45 days (4 nodules/plant) and 60 days (3 nodules/plant).

The interaction between adhesive materials and the shelf-time storage was significantly positive. The values of the number of nodules/plant achieved at sowing without storage were 7 and 7 nodules/plant for gum arabic and molasses, respectively and at 30 days were 7 and 7 nodules/plant for gum arabic and molasses, respectively.

The interaction between adhesive and carrier materials had significantly increased the number of nodules/plant. The highest number of nodules/plant were ascendingly recorded with fine peat x gum arabic (10), vermiculite x gum arabic (9) and fine peat x molasses (8). The interaction value of fine peat x gum arabic was significantly different from those of vermiculite x gum arabic and fine peat x molasses while the interaction of vermiculite x gum arabic had no significant difference from that of fine peat x molasses. The interaction between shelf-time and carriers had elevated significantly the number of nodules/plant, in case of fine peat x zero time (9) was not statistically different from fine peat x 30 days (8), while they were different from those of vermiculite x zero-time (8) and vermiculite x 30 days (8). Also, there was no significant differences between those aforementioned.

On the other hand, interaction between the three factors (shelf-time storage x adhesives x carriers was not significant.

4.2.1.1.1.3. Nodules dry weight:

Data in Table (8) illustrated by Fig. (10) indicate the effect of seed pelleted inoculum with different adhesives and carriers on the dry weight of faba bean nodules after zero, 30, 45 and 60 days shelf-time storage.

4.2.1.1.1.3.1. Effect of adhesive agents and carrier-based inocula:

Application of the adhesive or carrier agents tested at any of the shelf-time storage periods, generally, increased significantly the dry weight of nodules of faba bean.

Application of the adhesive materials tested at sowing (zero-time), generally, increased the dry weight of nodules compared to using water as adhesive control material. However, the highest values recorded were 58.08 mg/plant (gum arabic) and 53.95 mg/plant (molasses). These two adhesives were not significantly different, while they were significantly higher than those of mineral oil (32.41 mg/plant) and water (31.51 mg/plant).

At the same shelf-time storage (zero time), carrier-based inoculants exhibited the same behavior shown by adhesive agents, fine peat gave the superior value of nodules dry weight (81.81 mg/plant) followed by vermiculite (74.25 mg/plant). Both fine peat and vermiculite achieved no significant difference from each other. Whereas, the increments in dry weight of nodules given by fine peat and vermiculite were significantly different from those of the other carriers.

At shelf-time storage of 30, 45 and 60 days before sowing, it appeared that gum arabic was the favorite one followed by molasses. The corresponding values for gum arabic were 59.24, 57.30 and 55.79 mg/plant and for molasses were (51.74, 56.22 and 46.01 mg/plant).

Meanwhile, carriers had also the same trend exhibited by adhesive materials at 30, 45 and 60 days shelf-time. The corresponding dry weight of nodules values

Table (8): Nodules dry weight of faba bean plants (mg/plant) as affected by inoculation with different carrier-based rhizobial inocula *Rhizobium leguminosarum* bv. *viceae* 441 and adhesive agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	0	0	0	0	0
	Fine peat	104.63	110.10	97.83	121.17	108.43
	Vermiculite	89.40	79.43	57.20	77.73	75.94
	Talc powder	71.90	79.20	86.17	55.03	73.08
	$CaCO_3$	24.47	27.47	45.30	25.00	30.56
Mean		58.08	59.24	57.30	55.79	57.60
Molasses	*Unioc.*	0	0	0	0	0
	Fine peat	94.40	95.73	87.27	93.10	92.62
	Vermiculite	103.57	94.77	87.13	75.10	90.14
	Talc powder	44.10	39.33	76.50	32.27	48.05
	$CaCO_3$	27.67	28.87	30.20	29.60	29.08
Mean		53.95	51.74	56.22	46.01	51.98
Mineral oil	*Unioc.*	0	0	0	0	0
	Fine peat	63.70	76.73	82.73	80.60	75.94
	Vermiculite	56.80	52.00	37.43	59.23	51.36
	Talc powder	27.10	32.53	45.13	19.63	31.10
	$CaCO_3$	14.47	16.70	20.97	20.07	18.05
Mean		32.41	35.59	37.25	35.91	35.29
Water	*Unioc.*	0	0	0	0	0
	Fine peat	64.50	64.87	60.30	78.80	67.12
	Vermiculite	47.23	44.63	49.83	64.10	51.45
	Talc powder	30.40	17.13	37.53	21.80	26.72
	$CaCO_3$	15.43	12.77	17.10	20.23	16.38
Mean		31.51	27.88	32.95	36.99	32.33
Mean	*Unioc.*	0	0	0	0	0
	Fine peat	81.81	86.86	82.03	93.42	86.03
	Vermiculite	74.25	67.71	57.90	69.04	67.22
	Talc powder	43.38	42.05	61.33	32.18	44.74
	$CaCO_3$	20.51	21.45	28.39	23.72	23.52
Mean		43.99	43.61	45.93	43.67	44.30

	LSD 5 %				INTERACTION
Shelf-time storage					NS
Adhesive	10.49	7.60	7.14	9.88	4.34
Shelf-time x Adhesive					NS
Carrier	11.73	8.49	7.98	11.04	4.85
Shelf-time x Carrier					9.71
Adhesive x Carrier	23.45	16.98	15.97	NS	9.71
Shelf-time x Adhesive x Carrier					NS

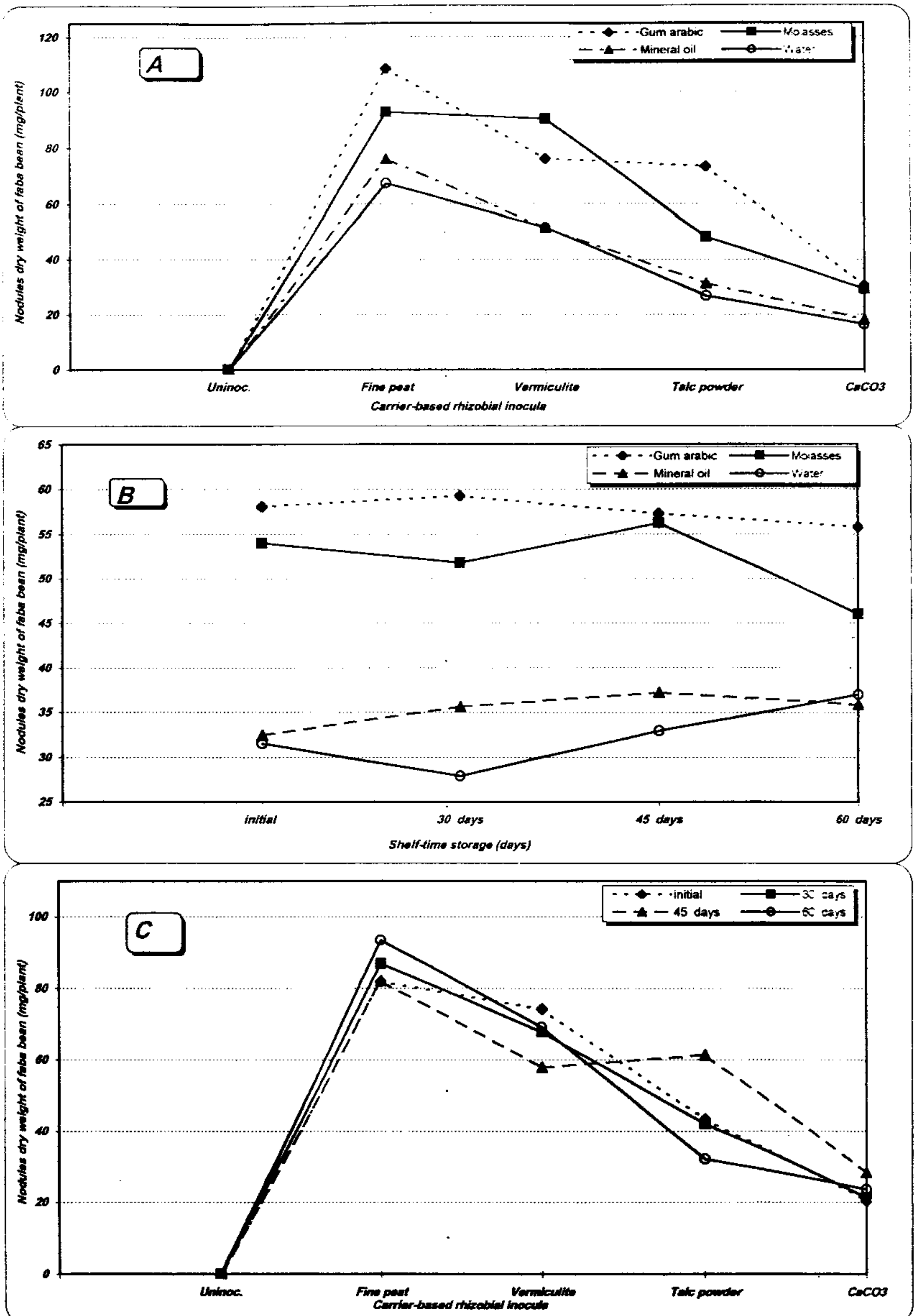


Fig.(10): Nodules dry weight of faba bean plants (mg/plant) as affected by inoculation with *R.leguminosarum bv.viceae* strain 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

of these periods were (86.86, 82.03 and 93.42 mg/plant) for fine peat and (67.71 , 57.90 and 69.04 mg/plant) for vermiculite.

4.2.1.1.1.3.2. <u>The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of nodules:</u>

The interaction between shelf-time and carriers had significantly increased the dry weight of nodules/plant. The highest value 93.42 mg/plant was recorded for the combination of fine peat x 60 days shelf-time followed by 86.86 mg/plant for fine peat x 30 days. These two interactions were not differed statistically from each other.

The interaction of adhesive agents positively affected the dry weight of nodules. The highest interaction was for gum arabic (57.60 mg/plant) followed by 51.98, 35.29 and 32.33 mg/plant for molasses, mineral oil and water (control), respectively. It was clear also that gum arabic had the best interaction with positive significant difference compared to the other adhesives used.

The same as in adhesive agents, carrier types also interacted the dry weight of nodules in an increasable tends. The highest interaction recorded with fine peat (86.03 mg/plant) and the lowest one was 23.52 mg/plant for calcium carbonate. However, fine peat interaction was significantly different and higher than the other carriers-based inoculants used.

Whenever, using adhesive in combination with carrier agents in faba bean seed pelleting, generally, upweighed significantly the dry weight of nodules/plant. The highest interaction was 108.43 mg/plant for gum arabic x fine peat followed by 92.62 mg/plant for molasses x fine peat and 90.14 mg/plant for molasses x vermiculite. The interaction of gum arabic x fine peat was not differed significantly from both the interactions of molasses x fine peat and molasses x vermiculite. However, the interactions of the shelf-time storage, shelf- time x adhesives and shelf- time x adhesives x carriers were not significant.

4.2.1.1.1.4. Shoots dry weight:

The effects of different adhesive agents, carrier-based inoculants and seed storage time and their interaction on faba bean shoots dry weight were investigated. Data presented in Table (9) illustrated by Fig.11 indicate the effect of inoculation with ***R. leguminosarum*** **bv.** ***viceae*** **441** using different adhesives and different carriers-based inoculants on the dry weight of faba bean shoots after different shelf-time storage periods of initial, 30, 45 and 60 days for the pelleted seeds.

4.2.1.1.1.4.1. Effect of adhesive agents and carrier-based inocula:

Seed pelleting using gum arabic, molasses and mineral oil as adhesive agents and sowing directly, (without storage), increased the dry weight of shoots compared with water as an adhesive agent (control treatment). However, molasses gave the highest shoots dry weight of 2.11 g/plant followed by 2.07 g/plant for gum arabic and 1.9 g/plant for mineral oil with no significant difference between them.

Considering the different carrier materials, fine peat-based inoculants significantly increased shoot dry weight (2.69 g/plant) then followed by vermiculite (2.34 g/plant). However, they were significantly different from each other.

After 30 days shelf-time seed storage, using gum arabic and molasses as adhesive agents gave the highest values of shoots dry weight of 2.13 and 1.97 g/plant, respectively with no significant difference. On the other hand, using mineral oil and water as adhesive materials scored the lowest values of shoot dry weight as compared with gum arabic and molasses.

The values of fine peat and vermiculite when used as carrier materials were significantly different. The values recorded were 2.76 and 2.34 g/plant, respectively.

Table (9): Shoots dry weight of faba bean plants (g/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441 using different carrier-based rhizobial inocula and adhesives agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
um arabic	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.79	3.38	2.95	3.33	3.11
	Vermiculite	2.53	2.50	2.46	3.39	2.72
	Talc powder	2.15	1.99	2.06	2.86	2.26
	$CaCO_3$	1.65	1.52	1.55	1.92	1.66
Mean		2.07	2.13	2.05	2.55	2.20
Molasses	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.86	2.74	2.59	3.16	2.84
	Vermiculite	2.62	2.46	2.44	2.16	2.42
	Talc powder	2.22	1.86	1.87	2.31	2.06
	$CaCO_3$	1.64	1.54	1.50	1.29	1.49
Mean		2.11	1.97	1.93	2.03	2.01
Mineral oil	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.76	2.40	2.55	2.73	2.61
	Vermiculite	2.22	2.07	2.34	2.27	2.22
	Talc powder	1.97	1.80	1.53	2.14	1.86
	$CaCO_3$	1.32	1.43	1.18	1.33	1.32
Mean		1.90	1.79	1.77	1.94	1.85
Water	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.33	2.51	2.37	2.75	2.49
	Vermiculite	1.97	2.35	1.70	2.17	2.05
	Talc powder	1.67	1.75	1.65	1.99	1.76
	$CaCO_3$	1.34	1.31	1.27	1.30	1.30
Mean		1.71	1.83	1.65	1.89	1.77
Mean	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.69	2.76	2.61	2.99	2.76
	Vermiculite	2.34	2.34	2.23	2.50	2.35
	Talc powder	2.00	1.85	1.78	2.33	1.99
	$CaCO_3$	1.49	1.45	1.37	1.46	1.44
Mean		1.95	1.93	1.85	2.10	1.96

LSD 5 %					INTERACTION
Shelf-time storage					0.17
Adhesive	0.26	0.24	0.22	0.21	0.11
Shelf-time x Adhesive					NS
Carrier	0.29	0.27	0.24	0.24	0.31
Shelf-time x Carrier					NS
Adhesive x Carrier	NS	NS	NS	0.47	0.26
Shelf-time x Adhesive x Carrier					NS

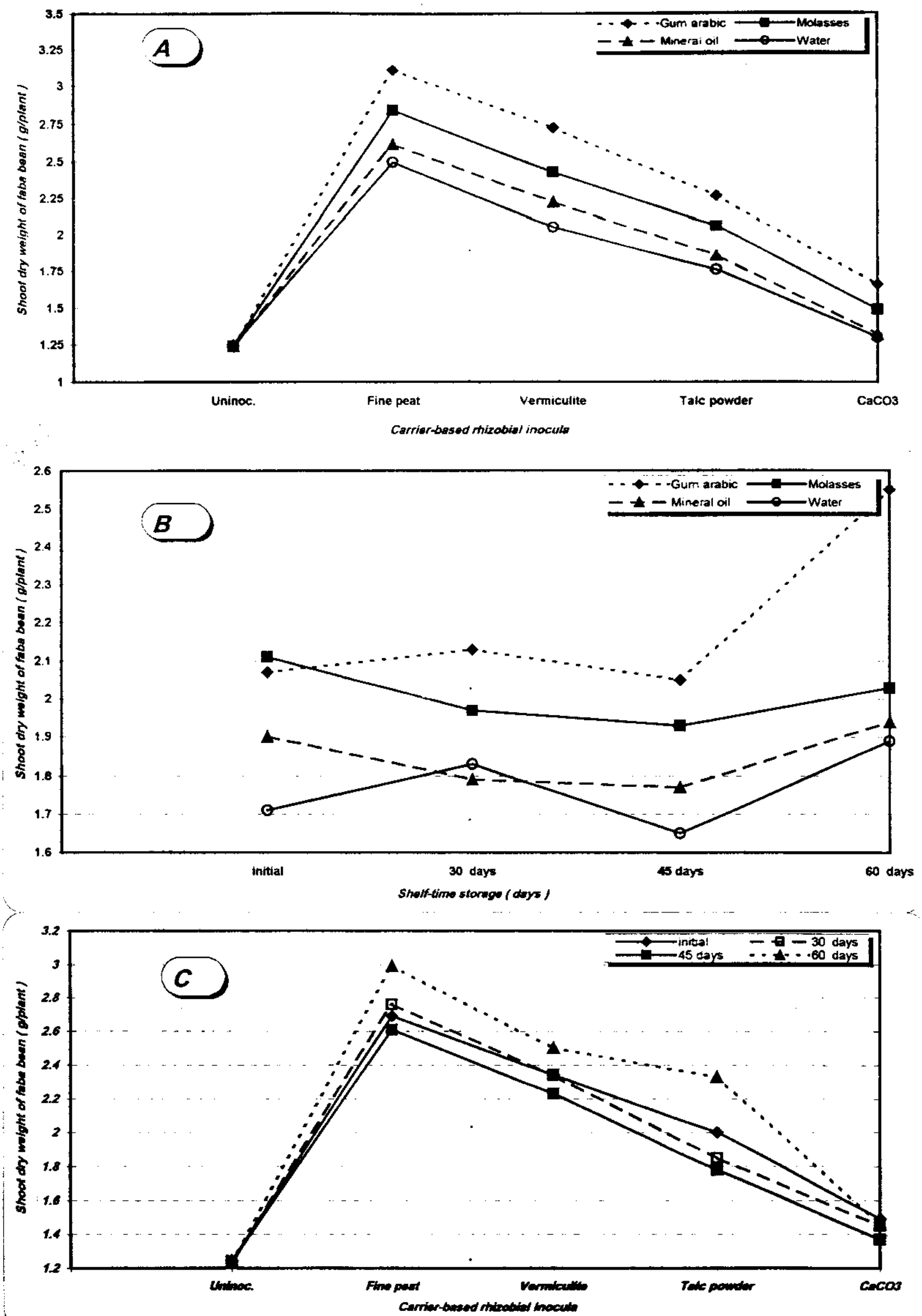


Fig. (11): Shoots dry weight of faba bean plants (g/plant) as affected by inoculation with *R. leguminosarum bv.viceae* strain 441using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

Consequently, these two carriers possessed significant difference with either talc powder or calcium carbonate but still fine peat is the best carrier.

4.2.1.1.1.4.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on shoots dry weight:

The interaction effects of carriers, adhesives and storage-shelf-time on shoots dry weight are indicated in Table (9) illustrated by Fig.(11). The results indicate the most efficient interactions and their effect on shoots dry weight of faba bean plants.

It is clear in Table (9), that the sixty days storage treatment gave the highest average of dry weight of shoots (2.10 g/plant) followed by 1.95 g/plant for zero shelf-time with no significant difference between them. Also, application of gum arabic as adhesive material increased the shoot dry weight (2.20 g/plant) compared with the other adhesives tested and achieved a positive significant difference. Considering the carrier materials, fine peat interaction gave the highest shoot dry weight value (2.76 g/plant) and was significantly different from vermiculite (2.35 g/plant)and these two carriers were significantly different from the other carriers tested.

The interaction between carrier and adhesive agents had a positive significant effect when fine peat-based inoculant was combined with gum arabic as an adhesive agent which earned dry weight of shoots of 3.11 g/plant followed by 2.84 g/plant (fine peat x molasses) and these two interactions were significantly different.

The aforementioned results indicated that pelleting of faba bean seeds and storage up to 60 days before sowing led to increase shoots dry weight of faba bean plants (Table 9 and Fig.11).

4.2.1.1.1.5. Nitrogen content:

Data in Table (10) illustrated by Fig. (12) present the total nitrogen content of faba bean plants as affected by different carrier-based inoculants and adhesive

Table (10): N-content of faba bean plants (mg/plant) as affected by inoculation with different carrier-based rhizobial inocula *Rhizobium leguminosarum* bv. *viceae* 441 and adhesive agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*66*	*Mean*
Gum arabic	*Unioc.*	19.33	19.33	19.33	19.33	19.33
	Fine peat	77.00	75.67	66.33	75.67	73.67
	Vermiculite	66.67	64.33	61.00	70.67	65.67
	Talc powder	50.67	48.00	50.33	57.67	51.67
	$CaCO_3$	41.33	38.00	37.67	43.33	40.08
Mean		51.00	49.07	46.93	53.33	50.08
Molasses	*Unioc.*	19.33	19.33	19.33	19.33	19.33
	Fine peat	75.33	71.67	66.00	75.00	72.00
	Vermiculite	64.00	64.67	61.00	55.67	61.34
	Talc powder	55.00	45.33	47.00	54.00	50.33
	$CaCO_3$	40.00	39.00	36.67	35.00	37.67
Mean		50.73	48.00	46.00	47.80	48.13
Mineral oil	*Unioc.*	19.33	19.33	19.33	19.33	19.33
	Fine peat	68.67	60.67	64.00	65.00	64.58
	Vermiculite	51.33	50.33	55.67	53.33	52.66
	Talc powder	43.00	43.00	38.67	50.00	43.67
	$CaCO_3$	32.67	31.67	28.67	32.00	31.25
Mean		43.00	41.00	41.27	43.93	42.30
Water	*Unioc.*	19.33	19.33	19.33	19.33	19.33
	Fine peat	58.33	59.67	58.00	63.33	59.83
	Vermiculite	48.67	51.33	43.00	54.67	49.42
	Talc powder	37.67	37.67	39.33	41.33	39.00
	$CaCO_3$	29.00	30.67	31.00	30.33	30.25
Mean		38.60	39.73	38.13	41.80	39.57
Mean	*Unioc.*	19.33	19.33	19.33	19.33	19.33
	Fine peat	69.83	66.92	63.58	69.75	67.52
	Vermiculite	57.67	57.67	55.17	58.58	57.27
	Talc powder	46.58	43.50	43.83	50.75	46.17
	$CaCO_3$	35.75	34.83	33.50	35.17	34.81
Mean		45.83	44.45	43.08	46.72	45.02

	LSD 5 %				INTERACTION
Shelf-time storage					2.41
Adhesive	4.27	4.43	4.56	3.34	2.04
Shelf-time x Adhesive					N.S.
Carrier	4.77	4.96	5.10	3.73	2.28
Shelf-time x Carrier					N.S
Adhesive x Carrier	N.S	N.S	N.S	7.46	4.56
Shelf-time x Adhesive x Carrier					N.S

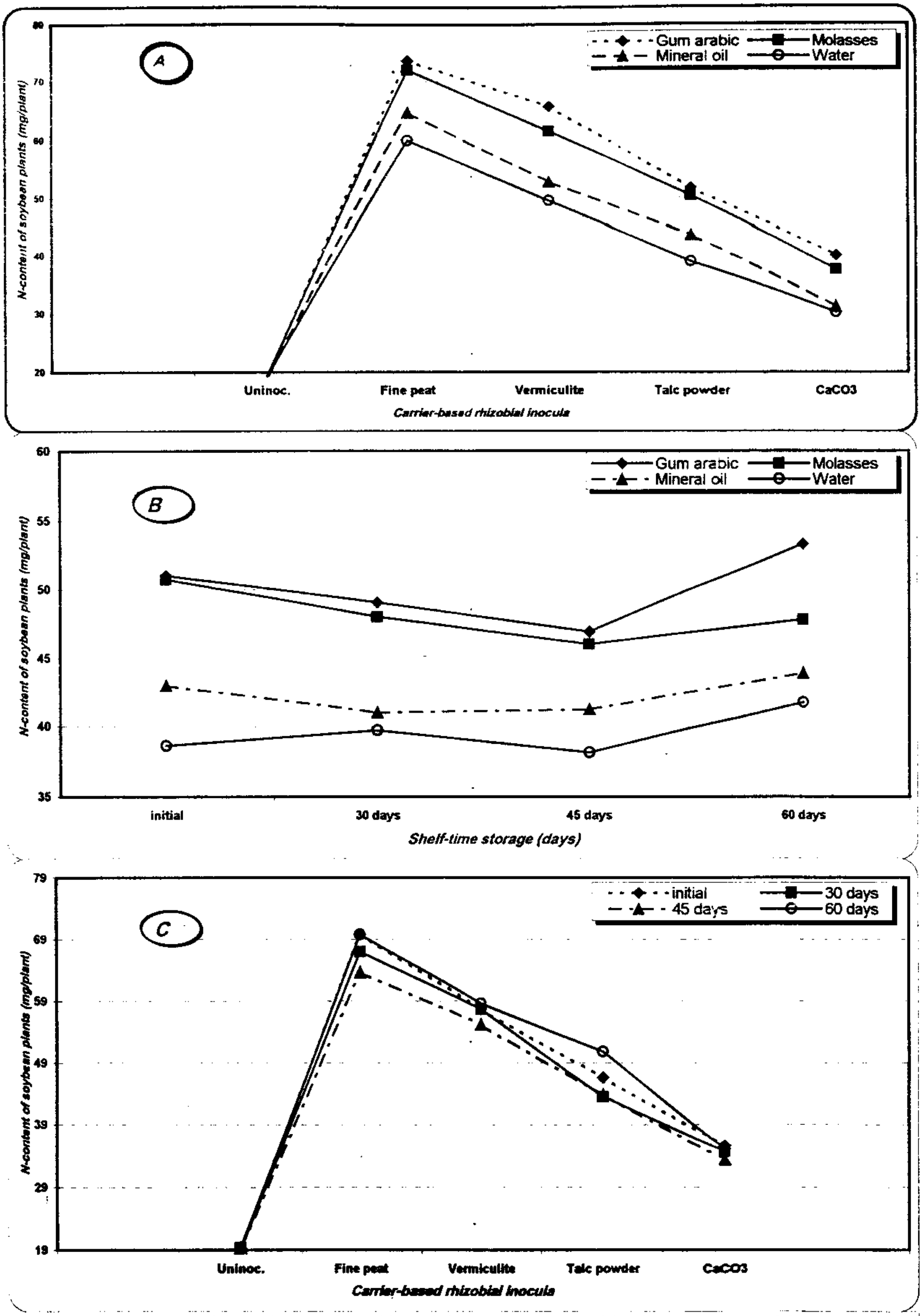


Fig.(12): N-content of faba bean plants (mg/plant) as affected by inoculation with *Rhizobium leguminosarum* bv.*viceae* strain 441 using different carrier-based rhizobial inocula and adhesive agents under shelf-time storage (45 DAP).

agents under different shelf-time storage of zero, 30, 45 and 60 days before sowing. The plants were uprooted fourty five days after planting.

4.2.1.1.1.5.1. Effect of adhesive agents and carrier-based inocula:

For shelf-time storage periods of zero, 30 and 45 days, both gum arabic and molasses as adhesive agents had exhibited the same trend with no significant differences between each other in the nitrogen content values obtained.

The corresponding values were 51.00 and 50.73 mg/plant (zero time), 49.07 and 48.00 mg/plant (30 days) and 46.93 and 46.00 mg/plant (45 days). However, the values achieved by any of gum arabic and molasses significantly differed from and exceeded the values yielded by both of mineral oil and water as adhesive agents.

After 60 days shelf-time the results showed a priority for gum arabic as an adhesive agent which gave 53.33 mg/plant and this exceeded the values obtained by any of molasses (47.80 mg/plant), mineral oil (43.93 mg/plant) and water (41.80 mg/plant). These values were significantly less and different from that of gum arabic.

Concerning the carrier-based rhizobial inocula used in seed pelleting of faba bean, fine peat was the superior one at all shelf-time storage periods under study. The corresponding amounts of nitrogen contents were 69.83, 66.92, 63.58 and 69.75 mg/plant for zero, 30, 45 and 60 days shelf-time storage, respectively. These values were more than and significantly different from those given by any of vermiculite, talc powder and calcium carbonate as carrier-based inoculants at all shelf-time storage periods.

4.2.1.1.1.5.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on the nitrogen content:

The application of adhesive agents had significantly increased the nitrogen content of faba bean plants. However, the highest values interaction were for gum arabic (50.08 mg/plant) and molasses (48.13 mg/plant) with no significant difference between each other. On the other hand, their interaction values were higher than and significantly different from those of mineral oil (42.30 mg/plant) and water (39.57 mg/plants).

The interaction effect of pelleting seeds using carrier-based rhizobial inocula had also affected positively the nitrogen content of faba bean plants. Fine peat had shown the highest interaction value (67.52 mg/plant) compared to the other carrier-based inocula used. The value recorded was significantly higher than those of vermiculite, talc powder, calcium carbonate and uninoculated (control) with corresponding values of 57.27, 46.17, 34.81 and 19.33 mg/plant.

Adhesive agents and carrier-based rhizobial inocula when combined together in seed pelleting had increased significantly the nitrogen content of faba bean plants. The combination of gum arabic or molasses with fine peat had achieved the highest interaction values of 73.67 and 72.0 mg/plant, respectively without significant difference. However, these values were significantly different than those of gum arabic x vermiculite (65.67 mg/plant) and mineral oil x fine peat (64.58 mg/plant).

The interactions of shelf-time x carrier-based inocula, shelf-time x adhesive agents and shelf-time x adhesive agents x carrier-based inocula had no significant effect on the nitrogen content of faba bean plants.

4.2.1.1.2. Sampling at 90 days after planting (DAP).

4.2.1.1.2.1. Roots dry weight:

The effect of pelleting faba bean seed using different adhesive agents and carrier-based inoculants on nodulation and growth parameters has been investigated 90 days after planting (Table 11).

4.2.1.1.2.1.1. Effect of adhesive agents and carrier-based inocula:

All adhesives negatively affected the dry weight of roots at 0, 30 and 45 shelf-time storage. However, storage of pelleted seeds for 60 days, and

Table (11): Roots dry weight of faba bean plants (g/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441 using different carriers-based rhizobial inocula and adhesives agents under different shelf-time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	1.97	2.20	2.65	2.14	2.24
	Vermiculite	1.76	2.25	1.83	1.74	1.90
	Talc powder	1.61	1.79	1.81	1.96	1.79
	$CaCO_3$	1.28	1.32	1.63	1.11	1.34
Mean		1.57	1.76	1.83	1.64	1.70
Molasses	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.25	2.35	2.24	2.23	2.27
	Vermiculite	2.92	2.20	1.98	2.43	2.38
	Talc powder	1.72	1.98	1.66	2.33	1.29
	$CaCO_3$	1.05	1.30	1.07	1.67	1.27
Mean		1.84	1.81	1.64	1.98	1.82
Mineral oil	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	1.93	2.12	1.84	1.51	1.85
	Vermiculite	1.70	1..88	1.91	1.84	1.83
	Talc powder	1.68	1.75	1.45	1.70	1.64
	$CaCO_3$	1.21	1.44	1.34	1.41	1.35
Mean		1.55	1.68	1.55	1.54	1.58
Water	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.29	1.65	1.86	1.66	1.86
	Vermiculite	2.04	1.46	1.83	1.57	1.72
	Talc powder	1.37	1.87	1.53	1.53	1.58
	$CaCO_3$	1.21	1.22	1.19	1.37	1.25
Mean		1.63	1.49	1.53	1.47	1.53
Mean	*Unioc.*	1.24	1.24	1.24	1.24	1.24
	Fine peat	2.11	2.08	2.15	1.88	2.06
	Vermiculite	2.10	1.59	1.88	1.89	1.96
	Talc powder	1.60	1.85	1.61	1.88	1.74
	$CaCO_3$	1.19	1.32	1.30	1.39	1.30
Mean		1.65	1.69	1.64	1.66	1.66

	LSD 5%				INTERACTION
Shelf-time storage					NS
Adhesive	NS	NS	NS	0.23	0.12
Shelf-time x Adhesive					NS
Carrier	0.28	0.30	0.26	0.26	0.14
Shelf-time x Carrier					NS
Adhesive x Carrier	NS	NS	NS	NS	0.27
Shelf-time x Adhesive x Carrier					NS

application of molasses as adhesive material gave the highest dry weight of roots (1.98 g/plant) and differed significantly from all the other adhesive materials. On contrast, all materials tested as carriers showed positive effects on the dry weight of roots at all shelf-time storage up to 60 days before sowing compared with the control treatment.

At sowing (without storage) fine peat carrier gave better roots dry weight (2.11 g/plant) with no significant difference from vermiculite (2.10 g/plant), while both of them were statistically higher than both of talc powder (1.60 g/plant) and calcium carbonate (1.90 g/plant).

By increasing shelf-time storage up to 30 days, fine peat as carrier recorded the highest significant root dry weight (2.08 g/ plant). By increasing shelf-time storage up to 45 days, fine peat-based inoculant was superior and significantly increased the dry weight of roots up to 2.15 g/plant.

However, storage of pelleted seeds for 60 days, the carriers of fine peat, vermiculite, and talc powder-based inocula gave the highest values and were not significantly different from each other. The corresponding values recorded were 1.88, 1.89 and 1.88 g/plant

4.2.1.1.2.1.2. <u>The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of roots:</u>

Molasses gave the highest interaction of the dry weight of roots (1.82 g/plant) followed by gum arabic (1.70 g/plant) with significant difference between each other, also both of them differed significantly from those of mineral oil and water.

The interaction of fine peat and vermiculite gave the highest root dry weight values without no significant difference between them.

The interaction of adhesives and carriers successfully increased the roots dry weight when they combined together. Statistically at 0.05% level, molasses x vermiculite (2.38 g/plant), molasses x fine peat (2.27 g/plant) and gum arabic x fine peat 2.24 g/ plant were not significantly different from each other.

No significant interaction was found for shelf-time storage in combination with adhesive, carrier types and shelf-time storage x adhesives x carriers.

4.2.1.1.2.2. Nodules number:

Data in Table (12) illustrated by Fig. (13) manifest the number of nodules/plant formed on faba bean roots as affected by pre-inoculation pelleting, shelf-time storage, adhesive agents and carrier-based inoculants.

4.2.1.1.2.2.1. Effect of adhesive agents and carrier-based inocula:

Application of both adhesive and carrier-based inocula significantly exceeded the number of nodules/plant of faba bean at all shelf-time intervals studied. However, at all storage intervals, no significant effect was noticed between gum arabic and molasses as adhesive agents and consequently between fine peat and vermiculite as carrier-based inocula. The highest values of nodules/plant were achieved by gum arabic (10) and fine peat (11) at sowing (zero-time).

It is important to show that at all storage intervals gum arabic and molasses were significantly differed as compared to mineral oil and water. Also the same trend was noticed when both fine peat and vermiculite were statistically different positively from those of talc powder and calcium carbonate.

4.2.1.1.2.2.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on the number of nodules:

The interaction effect of all shelf time storage intervals significantly increased the number of nodules/plant. The highest number of nodules/plant was recorded for unstored pelleted seeds (7) followed by 7 after 30 days storage interval (Table 12 and Fig.13).

4.2.1.1.2.3. Nodules dry weight:

The values in Table (13) illustrated by Fig. (14) describe the dry weight of nodules/plant as affected by different adhesive and carrier materials in seed pelleting of faba bean stored for 0, 30, 45, and 60 days before sowing.

4.2.1.1.2.3.1. Effect of adhesive agents and carrier-based inocula:

The dry weight of nodules/plant at all shelf-time storage intervals studied were influenced by the application of all adhesive agents and carrier-based inocula in tested seed pelleting of faba bean.

Using gum arabic as an adhesive agents, irregularly gave a high dry weight of nodules, 71.26 mg/plant at 60 days shelf-time storage, and, is slightly increased (71.05 mg/plant) than at 30 days, at zero time (70.59 mg/plant) and finally at 45 days (70.37 mg/plant) . It is also noticed that at all shelf-time storage, molasses was significantly different from gum arabic except for zero-shelf-time storage.

Carrier materials affected the dry weight of nodules/plant positively at all shelf-time intervals. Successfully, fine peat recorded the highest values at all storage intervals. The corresponding dry weight of nodules were 107.62 mg/plant (60 days), 107.28 mg/plant (30 days), 105.32 mg/plant (zero-time) and 102.28 mg/plant (45 days). There was a significant difference between both of fine peat and vermiculite at all shelf-time storage tested, and fine peat gave better dry weight of nodules.

4.2.1.1.2.3.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of nodules:

The interaction of adhesive materials as sticker for seed pelleting significantly increased the dry weight of nodules/faba bean plants. The adhesive agents could by ranked as gum arabic (70.82 mg/plant), molasses (65.02 mg/plant), mineral oil (52.57 mg/plant) and at last water as a control treatment

Table (13): Nodules dry weight of faba bean plants (mg/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	0	0	0	0	0
	Fine peat	117.07	127.00	119.37	128.40	122.96
	Vermiculite	115.07	107.73	107.70	103.80	108.58
	Talc powder	85.90	88.20	94.50	90.20	89.70
	$CaCO_3$	34.93	32.30	30.27	33.90	32.85
Mean		70.59	71.05	70.37	71.26	70.82
Molasses	*Unioc.*	0	0	0	0	0
	Fine peat	113.07	113.37	105.53	104.27	109.06
	Vermiculite	109.47	92.20	95.73	97.93	98.83
	Talc powder	80.03	80.20	82.90	82.20	81.33
	$CaCO_3$	36.03	35.47	36.10	35.80	35.85
Mean		67.72	64.25	64.05	64.04	65.02
Mineral oil	*Unioc.*	0	0	0	0	0
	Fine peat	90.60	95.03	94.20	98.13	94.49
	Vermiculite	80.03	86.57	82.70	75.63	81.23
	Talc powder	67.93	54.00	66.17	67.93	64.01
	$CaCO_3$	27.47	23.93	21.27	19.90	23.14
Mean		53.21	51.91	52.87	52.32	52.57
Water	*Unioc.*	0	0	0	0	0
	Fine peat	100.57	93.73	90.03	99.67	96.00
	Vermiculite	78.63	77.13	79.20	85.80	80.19
	Talc powder	36.40	29.07	35.07	42.43	35.74
	$CaCO_3$	19.73	13.03	15.97	16.13	16.22
Mean		47.07	42.59	44.05	48.81	45.63
Mean	*Unioc.*	0	0	0	0	0
	Fine peat	105.32	107.28	102.28	107.62	105.62
	Vermiculite	95.8	90.91	91.33	90.79	92.21
	Talc powder	67.57	62.87	69.66	70.69	67.70
	$CaCO_3$	29.54	26.18	25.90	26.43	27.01
Mean		59.65	57.45	57.84	59.11	58.51

	LSD 5%				INTERACTION
Shelf-time storage					**NS**
Adhesive	5.60	6.84	4.84	5.77	**2.84**
Shelf-time x Adhesive					**NS**
Carrier	6.26	7.65	5.42	6.45	**3.17**
Shelf-time x Carrier					**NS**
Adhesive x Carrier	12.51	15.30	10.84	12.91	**6.34**
Shelf-time x Adhesive x Carrier					**NS**

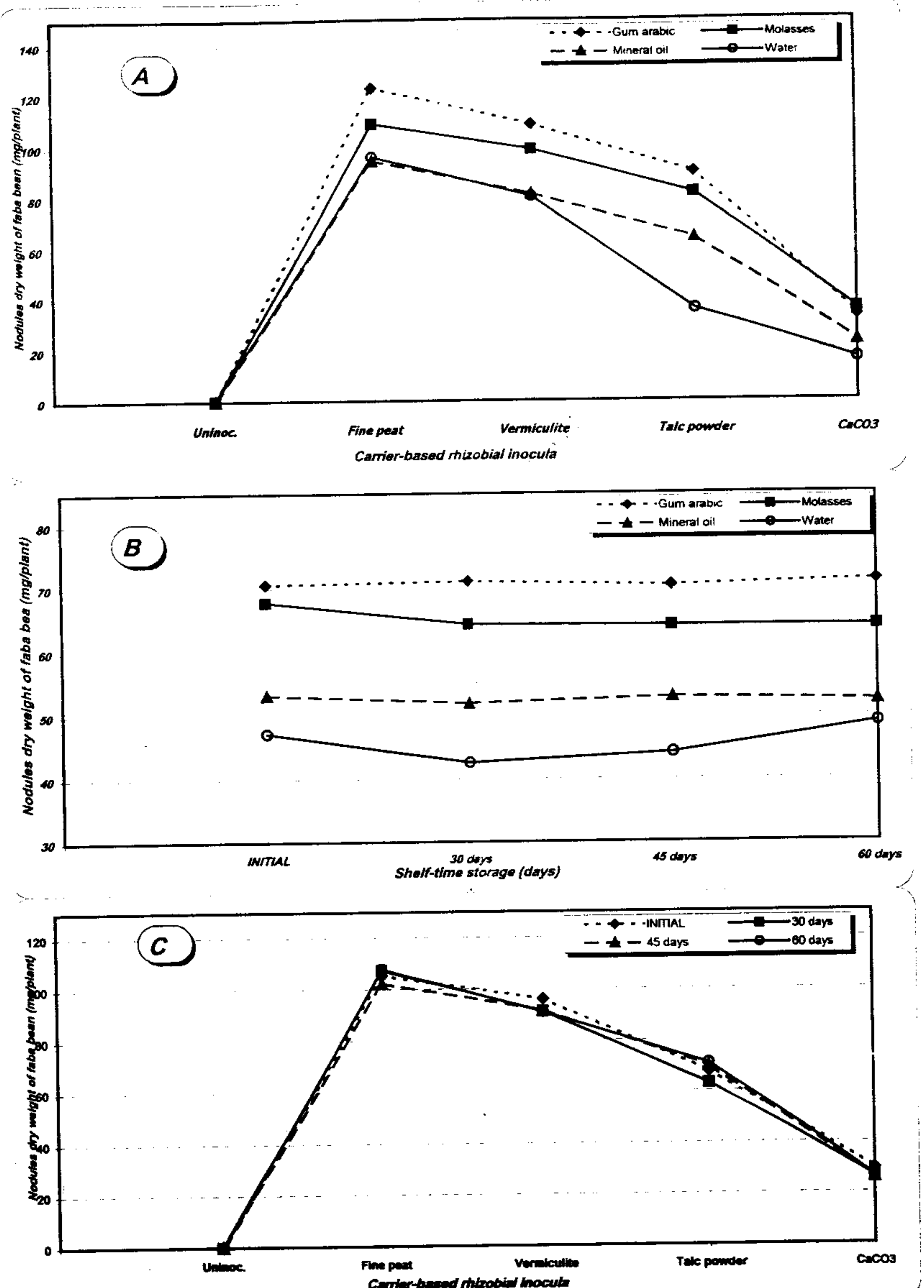


Fig.(14): Nodules dry weight of faba bean plants (mg/plant) as affected by inoculation with *R. leguminosarum* bv. *viceae* strain 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

(45.63 mg/plant). However, there was a significant difference between gum arabic and molasses.

The use of carrier materials in seed pelleting of faba bean significantly affected the dry weight of nodules/plant. The interaction effect of these carrier materials was descendingly as: fine peat (105.62 mg/plant), vermiculite (92.21 mg/plant), talc powder (67.70 mg/plant) and calcium carbonate (27.01 mg/plant).

However, the two values of dry weight of nodules/plant of fine peat and vermiculite were highly significant different from each other.

The interaction of adhesive and carrier materials combination in seed pelleting was significant. The superior results of dry weight of nodules (122.96 mg/plant) had achieved with the combination of gum arabic x fine peat followed by (109.06 mg/plant) for molasses x fine peat and (108.58 mg/plant) for gum arabic x vermiculite. However the value of gum arabic x fine peat was significantly different from those of molasses x fine peat and gum x vermiculite.

The interaction for those of shelf-time storage, shelf time x adhesives shelf-time x carrier materials and shelf time x adhesives x carrier materials were not significant.

4.2.1.1.2.4. Shoots dry weight:

Data in Table (14) illustrated by Fig. (15) indicate the effect of different carrier-based inocula and adhesive agents on dry weight of shoots under different shelf-time periods (zero, 30, 45 and 60 days) for stored faba bean pelleted seeds.

4.2.1.1.2.4.1. Effect of adhesive agents and carrier-based inocula:

Adhesive materials used showed no significant effect on the dry weight of shoots at both of zero and 30 days shelf-time storage. Also, after 45 and 60 days shelf-time storage, adhesives seemed to behave the same trend. However, molasses at both intervals gave the highest shoots dry weight being 4.03 and 4.05 g/plant for 45 and 60 days, respectively. Also, gum arabic had not differed statistically from molasses at these two storage intervals.

Table (14): Shoots dry weight of faba bean plants (g/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441 using different carrier-based rhizobial inocula and different adhesive agents under different shelf-time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	2.59	2.59	2.59	2.56	2.59
	Fine peat	4.91	4.81	4.84	4.87	4.86
	Vermiculite	4.69	4.70	4.41	4.80	4.65
	Talc powder	3.15	2.91	3.34	3.41	3.20
	$CaCO_3$	3.26	3.15	3.26	3.35	3.26
Mean		3.72	3.63	3.69	3.80	3.71
Molasses	*Unioc.*	2.59	2.59	2.59	2.59	2.59
	Fine peat	5.09	4.71	5.07	5.27	5.07
	Vermiculite	4.94	4.78	4.86	4.80	4.84
	Talc powder	3.90	2.35	4.26	4.26	3.69
	$CaCO_3$	3.38	2.31	3.39	3.34	3.10
Mean		3.98	3.35	4.03	4.05	3.85
Mineral oil	*Unioc.*	2.59	2.59	2.59	2.59	2.59
	Fine peat	4.55	4.59	4.54	4.54	4.53
	Vermiculite	4.66	4.82	4.13	4.13	4.52
	Talc powder	3.19	2.22	3.6	3.61	3.11
	$CaCO_3$	2.34	2.45	2.40	2.40	2.41
Mean		3.46	3.33	3.45	3.45	3.43
Water	*Unioc.*	2.59	2.59	2.59	2.59	2.59
	Fine peat	4.55	4.71	4.22	4.22	4.50
	Vermiculite	4.36	4.34	4.46	4.46	4.32
	Talc powder	3.08	2.73	3.40	3.40	3.18
	$CaCO_3$	3.40	3.09	3.11	3.11	3.08
Mean		3.60	3.49	3.56	3.56	3.53
Mean	*Unioc.*	2.59	2.59	2.59	2.59	2.59
	Fine peat	4.77	4.70	4.72	4.72	4.73
	Vermiculite	4.66	4.66	4.46	4.54	4.58
	Talc powder	3.33	2.55	3.63	3.67	3.30
	$CaCO_3$	3.10	2.75	2.95	3.05	2.96
Mean		3.69	3.45	3.67	3.72	3.63

	LSD 5 %				INTERACTION
Shelf-time storage					0.17
Adhesive	NS	NS	0.34	0.43	0.19
Shelf-time x Adhesive					NS
Carrier	0.50	0.38	0.38	0.48	0.21
Shelf-time x Carrier					0.43
Adhesive x Carrier	NS	NS	NS	NS	NS
Shelf-time x Adhesive x Carrier					NS

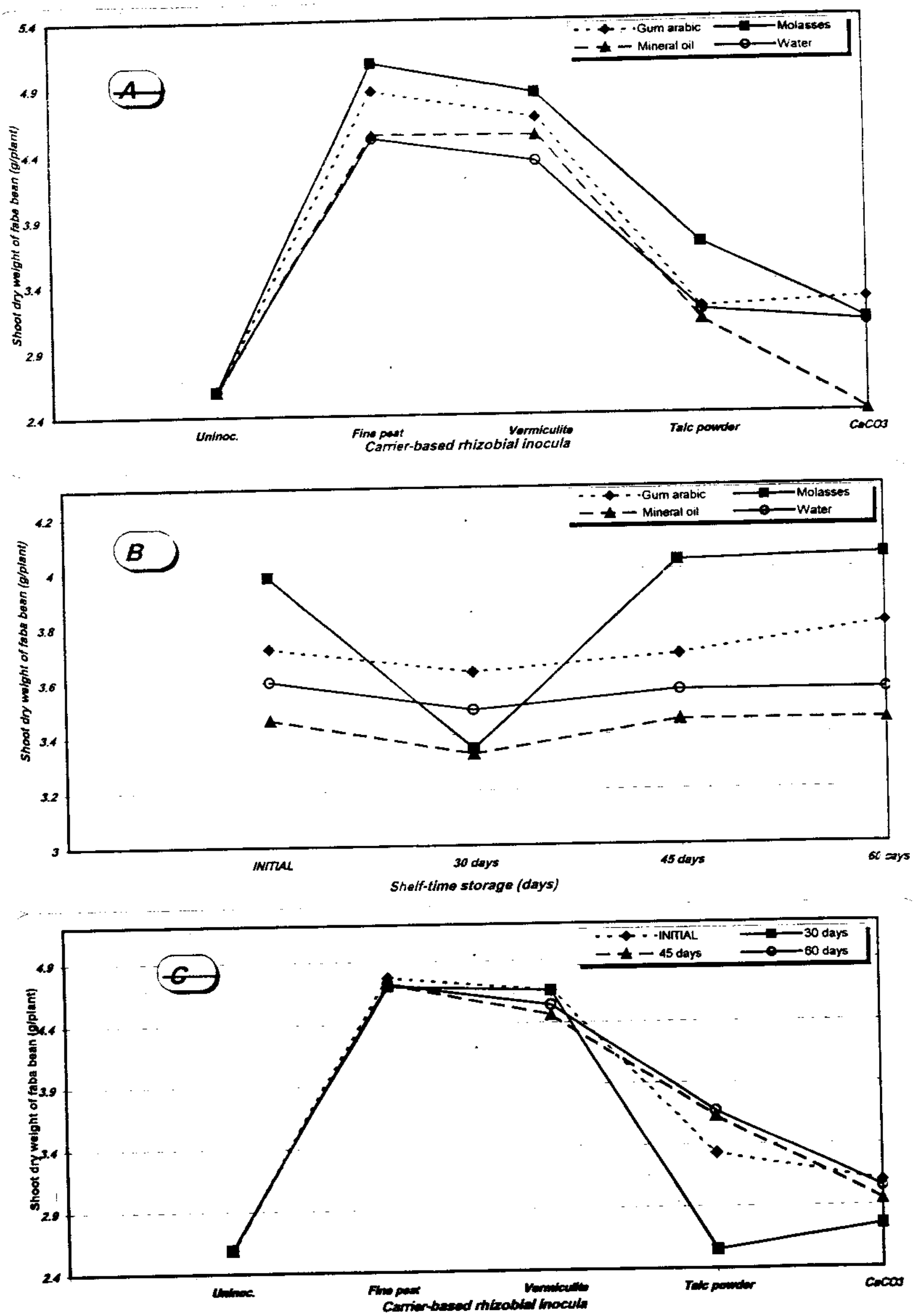


Fig.(15): Shoots dry weight of faba bean plants (g/plant) as affected by inoculation with *R. leguminosarum* bv. *viceae* strain 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

Concerning the type of the carrier materials, at all shelf-time tested, fine peat and vermiculite-based inocula accessed the favorite dry weight of shoots with no significant difference. The corresponding values (g/plant) were 4.77 and 4.66 (zero time storage), 4.70 and 4.66 (30 days), 4.72 and 4.46 (45days) and 4.72 and 4.54 (60 days). Meanwhile, both fine peat- and vermiculite-based inocula were significantly different and higher than those of talc powder- and calcium carbonate-based inocula.

4.2.1.1.2.4.2. <u>The interactions effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of shoots:</u>

The interaction of shelf-time storage significantly increased the dry weight of shoots. The best shelf- time storage was 60 days before sowing (3.72 g/plant). However, the other storage intervals of 0, 30 and 45 recorded lower shoot dry weight of 3.69, 3.45 and 3.67 (g/plant), respectively.

The interaction effect of adhesives on dry weight of shoots was significantly increasable. The highest results were for molasses (3.85 g/plant) and they were not significantly different.

The interaction of carrier materials had a significant increment effect on the dry weight of shoots. Fine peat and vermiculite achieved the highest dry weight of shoots of 4.73 and 4.58 g/plant, respectively. There was no significant difference between fine peat and vermiculite while they differed significantly from those of talc powder and calcium carbonate.

Fine peat-based inoculant used at all shelf-time storage tested, had significantly increased the dry weight of shoots with values (g/plant) of 4.77, 4.70, 4.72 and 4.72 at initial, 30, 45and 60 days, respectively.

All the combinations of (adhesives x carriers), (adhesives x shelf -time storage) and (adhesives x carriers x shelf-time storage) had no significant effect on the dry weight of faba bean shoots.

4.2.1.1.2.5. Nitrogen content:

Data in Table (15) illustrated by Fig. (16) show the effect of different adhesive agents and carrier-based inocula in faba bean seed pelleting stored before sowing for zero, 30, 45 and 60 days on the nitrogen content of faba bean plants sampled at 90 days after planting (DAP).

4.2.1.1.2.5.1. Effect of adhesive agents and carrier-based inocula:

At zero time, when adhesive agents were used in faba bean seed pelleting, no significant effect had been noticed on the nitrogen content of plants. The highest value (105.47 mg/plant) was for molasses followed by 98.93 mg/plant (gum arabic), 93.87 mg/plant (water) and 91.20 mg/plant (mineral oil). However, these values had no significant difference between any of them.

The same trend at 30 days shelf-time storage period was continued but the highest value was for gum arabic (96.60 mg/plant) followed by 90.07 mg/plant (water), 87.87 mg/plant (molasses) and 85.00 mg/plant (mineral oil).

At 45 days shelf-time storage period molasses was the superior adhesive agent with corresponded highest value of 104.80 mg/plant, which was significantly different from those of gum arabic (96.60 mg/plant), 88.27 mg/plant (water), and 87.73 mg/plant (mineral oil).

However, the amount of nitrogen/plant recorded at 60 days shelf-time storage period by the different adhesive agents used were not significantly different from each other and the highest one was obtained by gum arabic (98.67 mg/plant) and the lowest was 88.80 mg/plant for mineral oil.

The use of different carrier-based rhizobial inocula resulted in priority for both of fine peat and vermiculite than any of talc powder and calcium carbonate or the uninoculated (control treatment). However, these values for fine peat and vermiculite were, 136.50 and 131.00 mg/plant (zero time), 132.08, 129.27 mg/plant (30 days), 130.83, 122.92 mg/plant (45 days) and 129.42, 124.75 mg/plant (60 days).

Table (15): N-content of faba bean plants (mg/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* 441 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	42.67	42.67	42.67	42.67	42.67
	Fine peat	143.00	138.67	136.67	136.67	138.75
	Vermiculite	134.00	133.67	122.67	130.67	130.25
	Talc powder	87.00	81.67	94.00	92.67	88.84
	$CaCO_3$	88.00	88.00	87.00	90.67	88.42
Mean		98.93	96.93	96.60	98.67	97.78
Molasses	*Unioc.*	42.67	42.67	42.67	42.67	42.67
	Fine peat	144.67	133.67	141.67	145.00	141.25
	Vermiculite	138.33	135.67	138.00	133.00	136.25
	Talc powder	107.67	63.67	113.67	116.33	100.34
	$CaCO_3$	94.00	63.67	88.00	88.33	83.50
Mean		105.47	87.87	104.80	105.07	100.80
Mineral oil	*Unioc.*	42.67	42.67	42.67	42.67	42.67
	Fine peat	130.67	125.33	121.33	123.00	125.08
	Vermiculite	131.33	130.67	122.00	113.67	124.42
	Talc powder	87.33	60.00	87.00	99.33	83.42
	$CaCO_3$	64.00	66.33	65.67	65.33	65.33
Mean		91.20	85.00	87.73	88.80	88.18
Water	*Unioc.*	42.67	42.67	42.67	42.67	42.67
	Fine peat	127.67	130.67	123.67	113.00	123.75
	Vermiculite	120.33	118.67	109.00	121.67	117.42
	Talc powder	87.00	73.33	91.67	91.33	85.83
	$CaCO_3$	91.67	85.00	74.33	85.67	84.17
Mean		93.87	90.07	88.27	90.87	90.77
Mean	*Unioc.*	42.67	42.67	42.67	42.67	42.67
	Fine peat	136.50	132.08	130.83	129.42	132.21
	Vermiculite	131.00	129.67	122.92	124.75	127.08
	Talc powder	92.25	69.67	96.58	99.92	89.60
	$CaCO_3$	84.42	75.75	78.75	82.50	80.35
Mean		97.37	89.97	94.35	95.85	94.38

	LSD 5 %				INTERACTION
helf-time storage					4.42
dhesive	NS.	NS.	8.10	10.41	4.82
helf-time x Adhesive					NS.
arrier	13.13	9.88	9.06	11.64	5.39
helf-time x Carrier					10.78
dhesive x Carrier	NS.	NS.	NS.	NS.	10.78
helf-time x Adhesive x Carrier					NS.

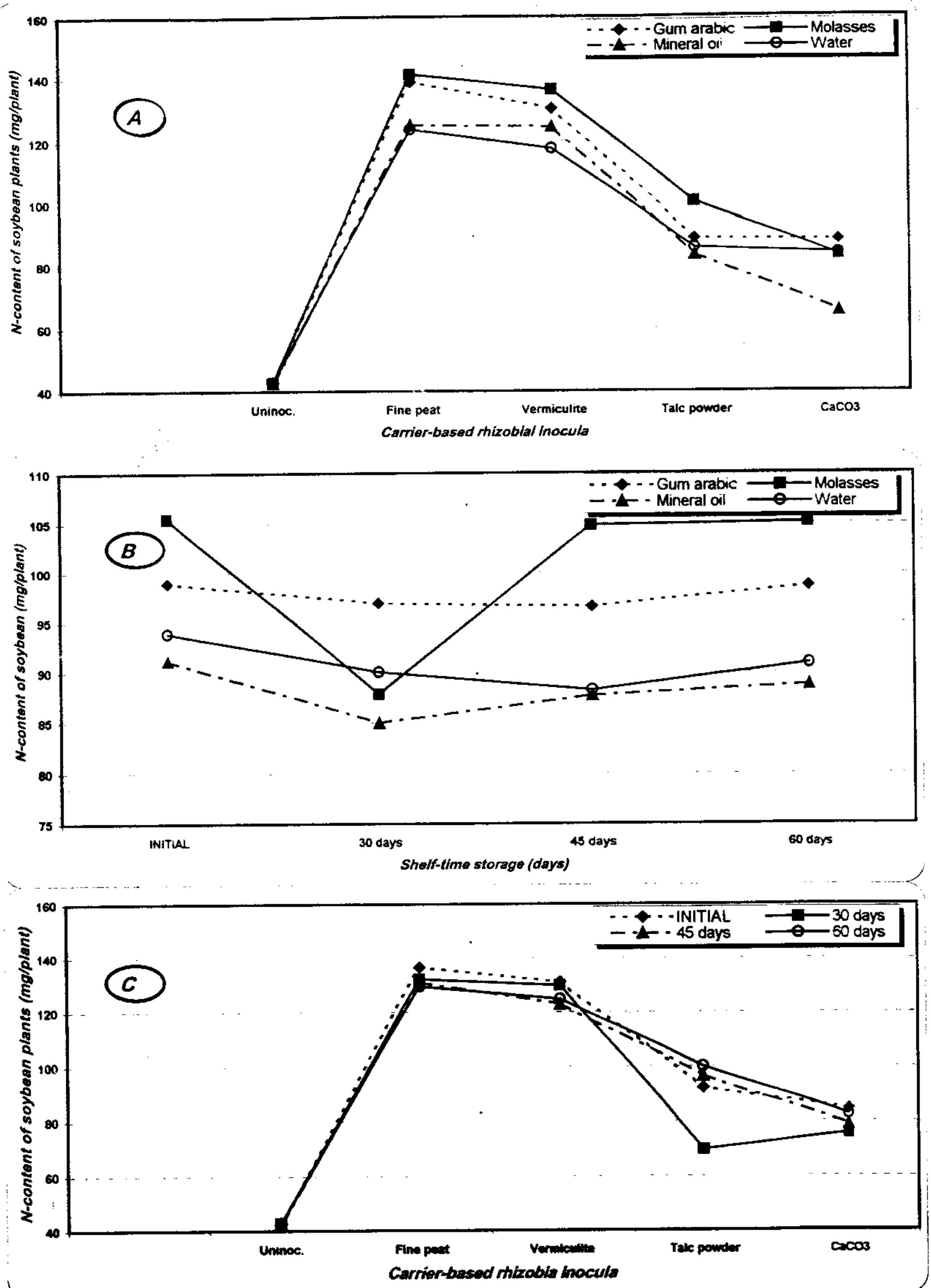


Fig.(16): N-content of faba bean plants (mg/plant) as affected by inoculation with *Rhizobium leguminosarum* bv. *viceae* strain 441 using different carrier-based rhizobial inocula and adhesive agents under shelf-time storage (90 DAP).

These values at each shelf-time storage period were not significantly different from each other while they were significantly different from and higher than those of talc powder, calcium carbonate and the control treatment.

4.2.1.1.2.5.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on the nitrogen content:

The interaction of adhesive agents on nitrogen content was clear with the use of molasses (100.80 mg/plant) and gum arabic (97.78 mg/plant). These two values were not significantly different from each other while they differed positively from those of water (90.77 mg/plant) and mineral oil (88.18 mg/plant).

The positive interaction for carrier-based inocula had been noticed for the values achieved by fine peat (132.21 mg/plant) and vermiculite (127.08 mg/plant) without any significant difference between both carriers, while they were higher than and differed statistically from the interaction values recorded by any of talc powder (89.60 mg/plant), calcium carbonate 80.35 mg/plant and the control treatment (42.67 mg/plant).

The interaction of shelf-time had affected the amount of nitrogen/plant at zero time (97.37 mg/plant), 45 days (94.35 mg/plant) and 60 days (95.85 mg/plant. These results were not statistically different from each other while they were positively higher than and different from that of 30 days shelf-time (89.97 mg/plant).

The interaction effect of the combination of adhesive agents and carrier-based inoculants in exchange had significantly increased the amount of nitrogen/plant. This was achieved by the use of molasses x fine peat (141.25 mg/plant), gum arabic x fine peat (138.75 mg/plant) and molasses x vermiculite (136.25 mg/plant). These interactions values were not significantly different from each other. However, only the combination of molasses with fine peat (141.25 mg/plant) was significantly different from that of gum arabic x vermiculite (130.25 mg/plant).

For shelf-time storage and carrier-based inocula interaction effect on the nitrogen content of faba bean plants, it was noticed that any of zero days x fine peat (136.50 mg/plant), zero days x vermiculite (131.00 mg/plant), 45 days x fine peat (130.83 mg/plant) and 45 days x vermiculite (122.92 mg/plant) might interact the nitrogen content in equal way because there were no significant differences in the interaction values obtained by them.

However, no significant effect was noticed for the interactions of shelf-time x adhesive agents and shelf-time x adhesive agents x carrier-based inocula on the nitrogen content of faba bean plants.

4.2.1.2. SOYBEAN TRIAL

Growth and nodulation status of soybean plants as affected by rhizobial inoculation using different carrier-based inocula, adhesive agents and different shelf-time storage had been studied.

As in faba bean experiment, seeds of soybean were previously pelleted with inocula of ***Bradyrhizobium japonicum*** and kept under room temperature for 72 hours then stored for periods of 30, 45 and 60 days before sowing. Unstored seeds (zero time storage) were pelleted directly at sowing. After sowing soybean plants were uprooted at 45 and 90 days to determine the dry weight of roots (g/plant), number of nodules/plant, dry weight of nodules (mg/plant), dry weight of shoots (g/plant) and N-contents (mg/plant).

4.2.1.2.1. Sampling at 45 days after planting (DAP)

4.2.1.2.1.1. Roots dry weight:

Data in Table (16) record the roots dry weight of soybean as influenced by seed pelleting using different carrier-based inocula and different adhesive agents at different shelf-time intervals of 0, 30, 45, and 60 days before sowing.

4.2.1.2.1.1.1. <u>Effect of adhesive agents and carrier-based inocula:</u>

Mineral oil as an adhesive agent at zero shelf-time exhibited significant greater root dry weight of 0.95 g/plant compared to the other adhesive agents tested. The root dry weight achieved by using water, gum arabic and molasses were 0.78, 0.67 and 0.64 g/plant, respectively. However, increasing shelf-time storage up to 30 days was not significantly affecting the dry weight of root. Increasing storage up to 45 and 60 days, showed the same trend as mineral oil and unstored pelleted seeds. The highest root dry weights recorded were 1.09 and 1.0g/plant when mineral oil was used as adhesive agent for pelleted seeds stored for 45 days and 60 days before sowing, respectively.

All carrier-based inocula tested showed significant increases towards the root dry weight at all shelf-time storage. However, fine peat as a carrier agent recorded the highest root dry weight (0.90 g/plant) at zero time with significant increment difference from the other carrier-based inocula. The roots dry weights recorded were 0.82, 0.81, 0.80 and 0.47 g/plant for vermiculite, talc powder, calcium carbonate and control (uninoculated seeds).

When pelleted seeds stored for 30 days before sowing the roots dry weights achieved by the carrier-based inocula were 1.12, 1.02, 1.02, 0.86 and 0.47 g/plant as respective for vermiculite, talc powder, calcium carbonate, fine peat and uninoculated control treatment. However, vermiculite gave the highest root dry weight (1.12 g/plant) which was significantly different from those of fine peat and uninoculated treatment (control).

At 45 days, calcium carbonate gave the highest root dry weight of 0.99 g/plant followed by 0.94 g/plant (vermiculite), 0.92 g/plant (fine peat) and finally 0.91 g/plant for talc powder. These values appeared to be not significantly different from each other.

It seemed that application of vermiculite as a carrier agent scored slightly higher roots dry weights of 0.96 g/plant for seeds stored for 60 days than calcium

Table (16): Roots dry weight of soybean plants (g/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesives agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	0.47	0.47	0.47	0.47	0.47
	Fine peat	0.86	0.95	0.90	0.70	0.85
	Vermiculite	0.87	1.07	0.76	0.88	0.90
	Talc powder	0.63	0.88	0.72	0.69	0.73
	$CaCO_3$	0.55	1.21	0.67	0.63	0.74
Mean		0.67	0.90	0.70	0.67	0.74
Molasses	*Unioc.*	0.47	0.47	0.47	0.47	0.47
	Fine peat	0.65	0.64	0.74	0.80	0.71
	Vermiculite	0.49	0.94	0.80	0.79	0.76
	Talc powder	0.72	1.01	0.91	0.58	0.80
	$CaCO_3$	0.89	1.17	1.06	1.10	1.06
Mean		0.64	0.85	0.80	0.75	0.76
Mineral oil	*Unioc.*	0.47	0.47	0.47	0.47	0.47
	Fine peat	1.27	0.94	1.14	0.82	1.04
	Vermiculite	1.09	1.33	1.49	1.18	1.27
	Talc powder	0.96	1.15	1.06	1.43	1.15
	$CaCO_3$	0.98	1.19	1.27	1.08	1.13
Mean		0.95	1.01	1.09	1.00	1.01
Water	*Unioc.*	0.47	0.47	0.47	0.47	0.47
	Fine peat	0.84	0.91	0.89	0.91	0.89
	Vermiculite	0.86	1.15	0.70	0.96	0.92
	Talc powder	0.93	1.05	0.96	0.93	0.97
	$CaCO_3$	0.81	0.59	0.95	0.93	0.82
Mean		0.78	0.83	0.79	0.84	0.81
Mean	*Unioc.*	0.47	0.47	0.47	0.47	0.47
	Fine peat	0.90	0.86	0.92	0.80	0.87
	Vermiculite	0.82	1.12	0.94	0.96	0.96
	Talc powder	0.81	1.02	0.91	0.91	0.91
	$CaCO_3$	0.80	1.02	0.99	0.94	0.94
Mean		0.76	0.90	0.84	0.81	0.83

	LSD 5 %				INTERACTION
Shelf-time storage					NS.
Adhesive agents	0.19	NS.	0.18	0.16	0.08
Shelf-time x Adhesive					NS.
Carrier-based inocula	0.21	0.18	0.20	0.18	0.09
Shelf-time x Carrier					NS.
Adhesive x Carrier	NS.	NS.	NS.	0.35	0.19
Shelf-time x Adhesive x Carrier					NS.

carbonate (0.94 g/plant), talc powder (0.91 g/plant) and fine peat (0.80) for the same period of storage. It is important to explain that there was no significant difference between any of the carrier agents tested at this storage interval.

4.2.1.2.1.1.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on roots dry weight:

The application of adhesive agents had significantly increased the roots dry weight of stored pelleted soybean seeds. The highest interaction values were for mineral oil (1.01 g/plant) and water (0.81 g/plant) without any significant difference. While the values of molasses (0.76 g/plant) and gum arabic (0.74 g/plant) were not significantly different from each other or of water as adhesive agents.

The interaction effect of carrier-based inocula used on root dry weight was significantly increasable. The superior interaction was for vermiculite (0.96 g/ plant), calcium carbonate (0.94 g/plant) and talc powder (0.91 g/plant) without any significant difference from each other. However, the value of fine peat (0.87 g/plant) significantly different from that of vermiculite (0.96 g/plant).

The combination of adhesive and carrier agents positively interacted the roots dry weight of soybean. The greatest values were obtained when mineral oil was combined with any of vermiculite, talc powder and calcium carbonate with corresponding roots dry weights of 1.27, 1.15 and 1.13 g/plant .

The interactions of shelf-time storage, shelf-time x adhesives , adhesives x carriers and shelf-time x adhesives x carriers did not significantly affect the roots dry weight of soybean.

4.2.1.2.1.2. Nodules number:

Data in Table (17) illustrated by Fig. (17) show the number of nodules/plant of pelleted soybean seeds using different adhesive agents and carrier-based inocula at different storage periods of 0, 30, 45 and 60 days intervals.

4.2.1.2.1.2.1. Effect of adhesive agents and carrier-based inocula:

Results in (Table 17 and Fig.17) revealed that application of adhesive agents and carrier-based inocula significantly increased the number of nodules/plant at all shelf-time intervals investigated.

Using molasses as an adhesive agent gave the greatest number of nodules/plant at all shelf-time storage up to 60 days with significant difference from those of gum arabic, mineral oil and water. The corresponding numbers of nodules/plant were 24.80 (zero time), 19.53 (30 days), 12.87 (45 days) and 12.60 (60 days).

The lowest numbers of nodules/plant were recorded by using water as an adhesive agent (control) at all shelf-time-storage intervals tested. The corresponding values were 8.67, 6.93, 6.0 and 5.20 for 0, 30, 45 and60 days, respectively. On the other hand, at all storage intervals, the values for those of molasses, gum arabic and mineral oil did significantly differ from those of water.

Consequently, carrier-based inocula showed the same trend exhibited by adhesives but using fine peat as carrier-based inoculant gave the greatest nodulation number of 34.92, 31.25, 17.50 and 15.67 nodules/plant for 0, 30, 45 and60 days shelf-time intervals, respectively.

Meanwhile, for carrier-based inocula, the lowest numbers of nodules at all storage intervals were found with calcium carbonate of 9.58, 7.0, 4.75 and 4.0 nodules / plant for 0, 30, 45, and 60 days intervals, respectively. Also it was obvious that fine peat, vermiculite and talc powder significantly exceeded those of calcium carbonate and (uninoculated) plant under all shelf-time storage intervals.

4.2.1.2.1.2.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on umber of nodules:

Table (17): Nodules number of soybean plants (nodules/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	0	0	0	0	0
	Fine peat	44	42	23	11	30
	Vermiculite	31	28	19	9	22
	Talc powder	15	11	8	9	11
	$CaCO_3$	11	8	7	4	8
Mean		20	18	11	7	14
Molasses	***Unioc.***	0	0	0	0	0
	Fine peat	41	34	27	28	32
	Vermiculite	37	31	17	16	25
	Talc powder	35	23	16	14	22
	$CaCO_3$	11	9	4	5	7
Mean		25	20	13	13	17
Mineral oil	***Unioc.***	0	0	0	0	0
	Fine peat	37	32	11	15	24
	Vermiculite	31	28	7	14	20
	Talc powder	20	8	5	5	9
	$CaCO_3$	10	6	3	3	6
Mean		20	15	5	7	12
Water	***Unioc.***	0	0	0	0	0
	Fine peat	18	17	9	9	13
	Vermiculite	10	8	10	9	9
	Talc powder	9	5	6	4	6
	$CaCO_3$	6	5	4	4	5
Mean		9	7	6	5	7
Mean	***Unioc.***	0	0	0	0	0
	Fine peat	35	31	18	16	25
	Vermiculite	27	24	13	12	19
	Talc powder	20	12	9	8	12
	$CaCO_3$	10	7	5	4	6
Mean		18	15	9	8	13

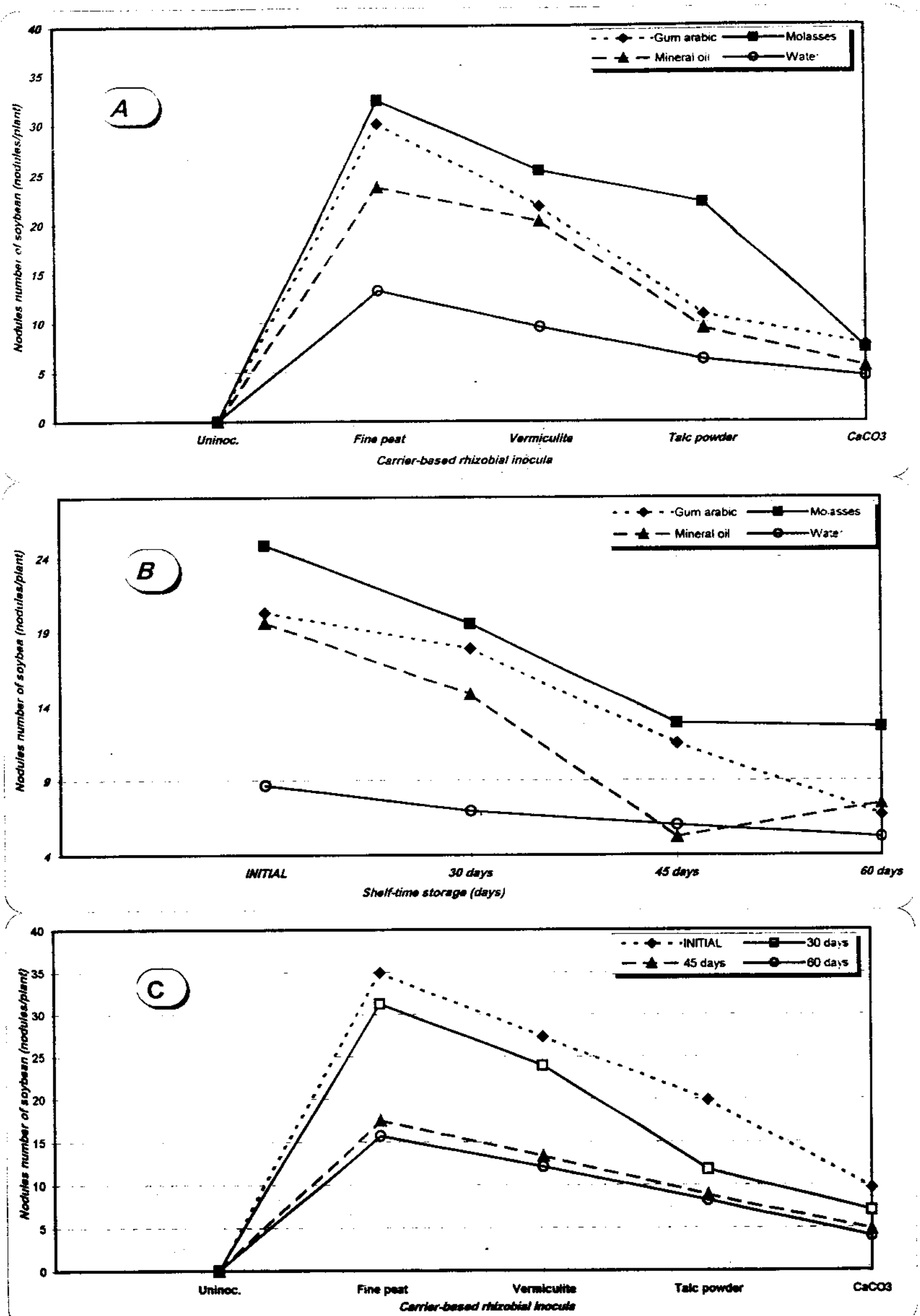


Fig. (17): Nodulesn umber of soybean plants(number/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407 using different carriers-based rhizobial inocula and adhesives agents under different shelf-time storage (45 DAP).

The interaction of shelf-time storage was significant in an increasable trend. The highest number of nodules/plant (18) was achieved at zero-time followed by 15 nodules/plant at 30 days.

The interaction of adhesive agents indicated that molasses significantly increased the nodulation with corresponding value of 17 nodules/plant followed by 14 nodules/plant for gum arabic.

The interaction of the combination of shelf-time and the carrier-based inocula showed a significant increasing influence on the number of nodules/plant. The significancy was quite clear at zero time and 30 days storage intervals with fine peat. The corresponding values were 35 and 31 nodules/plant, respectively.

The interaction of carrier-type showed positive significant influence on the number of nodules/plant. The highest influence on the number of nodules/plant (25) was achieved with fine peat followed by 19 nodules/plant for vermiculite.

The interaction of shelf-time x adhesive agents was positively significant. The splendid interactions were for molasses and gum arabic at zero time with respective values of 25 and 20 nodules/plant. The differences between these two values were significantly different.

The interaction of adhesive agent x carrier-based inocula had scored 32 nodules/plant for molasses x fine peat and 30 nodules/plant for gum arabic x fine peat and they were noticed to be the highest.

The interaction of shelf-time x adhesive agents x carrier-based inocula was potentially positive and elevated the number of nodules/plant. This trend was clear with the interaction of zero-time x gum arabic x fine peat (44 nodules/plant) followed by 30 days x gum arabic x fine peat (42 nodules/plant) which were not significantly different from each other.

4.2.1.2.1.3. Nodules dry weight:

Data in Table (18) illustrated by Fig. (18) indicate the effect of pelleted soybean seeds stored at intervals of 0.30, 45 and 60 days before sowing on the dry weight of nodules (mg/plant).

4.2.1.2.1.3.1. Effect of adhesive agents and carrier-based inocula:

It was clear that seed pelleting of soybean seeds using carrier-based inoculants and adhesive agents significantly increased the dry weight of nodules.

Under the storage intervals tested, gum arabic and molasses gave the highest dry weight of nodules. However, at zero-time storage, both gum arabic (78.26 mg/plant) and molasses (74.22 mg/plant) were not significantly different from each other but they differed from those of mineral oil (58.77 mg/plant) and water as control treatment (55.23 mg/plant). It is also noticed that gum arabic, molasses and mineral oil significantly exceeded that of water. The same behavior of gum arabic and molasses was observed at the other storage intervals of 30, 45 and 60 days. The dry weight of nodules ranged between 66.47 and 50.12mg/plant (30 days), 50.22 and 34.37 mg/plant (45 days) and 42.91 and 15.63 mg/plant (60 days).

The same as in adhesive agents, the carrier-based inocula tested led to significant increases on the dry weight of nodules for all storage intervals. At 0, 30, 45 and 60 days shelf-time storage, both fine peat and vermiculite exhibited significant increases in the dry weight of nodules compared with talc powder and calcium carbonate.

Also, at all storage intervals, using fine peat as a carrier agent recorded the highest values of nodules dry weight which were significantly different from the other carrier-based inocula tested. The corresponding values recorded are 106.97, 99.66, 71.12 and 52.83 mg/plant for 0, 30, 45 and 60 days before sowing, respectively. On the other hand, the lowest values were recorded with the application of calcium carbonate and talc powder as carrier materials at 60 days

Table (18): Nodules dry weight of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using with different carrier-based rhizobial inocula and adhesives agents under different shelf-time storage (45 DAP).

Adhesives	Carriers	Shelf-time storage (days)				
		Initial	30	45	60	Mean
Gum arab	Unioc.	0	0	0	0	0
	Fine peat	116.90	104.90	77.43	76.10	93.83
	Vermiculite	100.77	95.97	75.90	58.37	82.75
	Talc powder	94.73	89.30	89.30	47.37	73.67
	$CaCO_3$	78.90	42.20	42.20	32.73	47.08
Mean		78.26	66.47	50.22	42.91	59.47
Molasses	Unioc.	0	0	0	0	0
	Fine peat	114.77	104.50	74.97	63.50	89.44
	Vermiculite	100.07	96.23	71.90	57.97	81.54
	Talc powder	87.90	61.23	47.40	37360	58.53
	$CaCO_3$	68.37	57.87	34.10	27.40	46.94
Mean		74.22	63.97	45.67	37.29	55.29
Mineral oi	Unioc.	0	0	0	0	0
	Fine peat	99.23	98.27	68.37	39.63	76.38
	Vermiculite	68.43	66.60	57.97	22.80	53.95
	Talc powder	64.97	57.90	35.33	21.43	44.91
	$CaCO_3$	61.23	53.63	28.17	13.43	39.12
Mean		58.77	55.28	37.97	19.46	42.87
Water	Unioc.	0	0	0	0	0
	Fine peat	96.97	90.97	63.73	32.10	70.94
	Vermiculite	69.37	67.80	55.50	20.13	53.20
	Talc powder	65.20	54.73	34.83	14.57	42.33
	$CaCO_3$	44.60	37.10	17.80	11.33	27.71
Mean		55.23	50.12	34.37	15.63	38.84
Mean	Unioc.	0	0	0	0	0
	Fine peat	106.97	99.66	71.12	52.83	82.64
	Vermiculite	84.66	81.65	65.32	39.82	67.86
	Talc powder	78.20	65.79	45.21	30.24	54.86
	$CaCO_3$	63.28	47.70	28.64	21.22	40.21
Mean		66.62	58.96	42.06	28.82	49.12

	LSD 5 %				INTERACTION
Shelf-time storage					2.37
Adhesive agents	4.33	3.70	2.76	1.95	1.62
Shelf-time x Adhesive					3.23
Carrier-based inocula	4.84	4.14	3.09	2.18	1.81
Shelf-time x Carrier					3.62
Adhesive x Carrier	9.68	8.27	6.18	4.36	3.62
Shelf-time x Adhesive x Carrier					7.23

(21.22 mg/plant) and 45 days (28.64 mg/plant) and finally 30.24 mg/plant for talc powder at 60 days storage interval.

4.2.1.2.1.3.2. The Interaction of shelf-time storage, adhesive agents and carrier-based inocula on nodules dry weight:

For shelf-time interaction the highest interaction was 66.62 mg/plant dry weight of nodules which achieved at zero-time and was significantly different from the other interaction adhesives.

The greatest interaction value (59.47 mg/plant) was clear and had achieved by gum arabic.

The most significant interaction of carrier-based inocula was 82.64 mg/plant for fine peat.

The interaction of shelf-time x carrier-based inocula appeared to increase significantly the dry weight of nodule. The best interaction (106.97 mg/plant) had achieved by using fine peat as carrier-based inoculant at zero-shelf-time.

Interaction of shelf-time x adhesive agents, showed that gum arabic and molasses at zero-shelf-time recorded the most significant interactions on dry weight of nodules of 78.26 and 74.22 mg/plant respectively.

Also, interaction of adhesive agent x carrier-based inocula was quite clear as it produced significant increments of the dry weight of nodules. However, the glorious interactions were for fine peat x gum arabic (93.83 mg/plant) followed by fine peat x molasses (89.44 mg/plant).

The interaction between shelf-time x adhesive x carrier-based inocula was significantly increased the dry weight of nodules when the combination was for zero-time x gum arabic x fine peat (116.90 mg/plant) and zero-time x molasses x fine peat (114.77 mg/plant) with no significant difference from each other.

4.2.1.2.1.4. Shoots dry weight:

Data in Table (19) illustrated by Fig. (19) indicate the effect of pelleted seeds with different adhesive agents and carrier-based inocula on the shoots dry weight of soybean under different storage intervals of 0, 30, 45 and 60 days.

4.2.1.2.1.4.1. Effect of adhesive agents and carrier-based inocula:

The application of adhesive agents in soybean pelleted seeds significantly increased the shoots dry weight compared with using water as a sticker agent at all shelf-time storage intervals.

In case of unstored pelleted seeds the mean values of the shoots dry weight were 1.59, 1.58, 1.52 and 1.29 g/plant for gum arabic, molasses, mineral oil and - water, respectively. The highest shoots dry weight was 1.59 g/plant for gum arabic which was not significantly different from those of molasses and mineral oil. However, application of the adhesive agents tested values resulted in shoot dry weight significantly higher than that of water.

The application of adhesive agents generally increased the shoots dry weight in comparison with water (control treatment) of the pelleted seeds stored for 30 days. The highest shoot dry weight of 1.60 g/plant was recorded for gum arabic followed by 1.55, 1.53 and 1.24 g/plant for mineral oil, molasses and water, respectively. Consequently, gum arabic had no significant difference from mineral oil while it was significantly different from those of molasses or water. On the other hand, the values of all adhesive agents were significantly different and higher than that of water. By increasing storage period of the pelleted soybean seeds up to 45 days, the shoots dry weight increased but these increments were not significant. The highest shoot dry weight of 1.50 g/plant was recorded by using gum arabic as a sticker agent, then followed by 1.48, 1.46 and 1.32 g/plant for molasses, mineral oil and water, respectively.

After 60 days storage interval, the adhesive agents tested in soybean seeds pelleting significantly increased the shoot dry weight. Mineral oil as an adhesive agent gave the highest shoot dry weights of 1.55 g/plant followed by gum arabic (1.51 g/plant), molasses (1.45 g/plant) and water (1.25 g/plant).

It was noticed that the shoot dry weights obtained by any of mineral oil, gum arabic and molasses were not significantly different from each other, while all of them differed from and were higher than that of water.

Carrier-based inocula, significantly increased the dry weight of shoots at all shelf-time storage compared to the uninoculated seeds. However, at zero-time, the favorite and higher dry weight of shoots was (1.83 g/plant) for fine peat followed by 1.74 g/plant (vermiculite), 1.62 g/plant (talc-powder) and 1.27 g/plant (calcium carbonate). Using fine peat or vermiculite as carrier materials, the shoots dry weight values were not significantly different from each other. Same trend was noticed between vermiculite and talc powder. While the shoots dry weight recorded by any of fine peat, vermiculite and talc powder were higher than and significantly different from the values of calcium carbonate as carrier-based inoculant.

Carrier-based inocula tested after storage for 30 days significantly increased the dry weight of shoots compared to either control treatment or calcium carbonate. Fine peat and vermiculite carrier materials gave the highest shoots dry weight of 1.85 and 1.66 g/plant, respectively which were differed significantly for each other. These results of fine peat, vermiculite and talc powder (1.59 g/plant) were positively higher and significantly different from that of calcium carbonate (1.30 g/plant).

At 45 days all the carrier-based inocula studied significantly increased the shoots dry weight. The best results were 1.75 g/plant for fine peat followed by 1.61 g/plant (vermiculite), 1.51 g/plant (talc powder) and finally 1.33 g/plant (calcium carbonate). However, no significant differences were noticed between any of fine peat, vermiculite and talc powder as carrier-based inocula. On the other respect, the shoots dry weight recorded by these three carrier-based inocula

Table (19): **Shoots dry weight of soybean plants (g/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).**

Adhesives	Carriers	Shelf-time storage (days) Initial	30	45	60	Mean
Gum arabic	Unioc.	1.01	1.01	1.01	1.01	1.01
	ine peat	1.96	1.99	1.92	1.88	1.94
	ermiculite	1.88	1.73	1.69	1.70	1.75
	alc powder	1.67	1.83	1.56	1.64	1.68
	aCO_3	1.45	1.44	1.33	1.33	1.39
Mean		1.59	1.60	1.50	1.51	1.55
Molasses	Unioc.	1.01	1.01	1.01	1.01	1.01
	ine peat	1.94	2.01	1.73	1.79	1.87
	ermiculite	1.87	1.71	1.63	1.73	1.74
	alc powder	1.82	1.57	1.65	1.34	1.60
	aCO_3	1.24	1.34	1.40	1.37	1.34
Mean		1.58	1.53	1.48	1.45	1.51
Mineral oi	Unioc.	1.01	1.01	1.01	1.01	1.01
	ine peat	1.96	1.97	1.83	1.80	1.89
	ermiculite	1.73	1.77	1.74	1.77	1.75
	alc powder	1.66	1.58	1.45	1.58	1.57
	aCO_3	1.24	1.40	1.29	1.58	1.38
Mean		1.52	1.55	1.46	1.55	1.52
Water	Unioc.	1.01	1.01	1.01	1.01	1.01
	Fine peat	1.46	1.41	1.51	1.42	1.45
	Vermiculite	1.49	1.41	1.39	1.48	1.44
	Talc powder	1.34	1.36	1.39	1.17	1.32
	$CaCO_3$	1.16	1.02	1.29	1.15	1.16
Mean		1.29	1.24	1.32	1.25	1.27
Mean	Unioc.	1.01	1.01	1.01	1.01	1.01
	Fine peat	1.83	1.85	1.75	1.72	1.79
	Vermiculite	1.74	1.66	1.61	1.67	1.67
	Talc powder	1.62	1.59	1.51	1.43	1.54
	$CaCO_3$	1.27	1.30	1.33	1.36	1.31
Mean		1.49	1.48	1.44	1.44	1.46

	LSD 5 %				INTERACTION
Shelf-time storage					NS
Adhesive materials	0.14	0.16	NS	0.17	0.09
Shelf-time x Adhesive					NS
Carrier materials	0.16	0.18	0.26	0.19	0.10
Shelf-time x Carrier					NS
Adhesive x Carrier	NS	NS	NS	NS	NS
Shelf-time x Adhesive x Carrier					NS

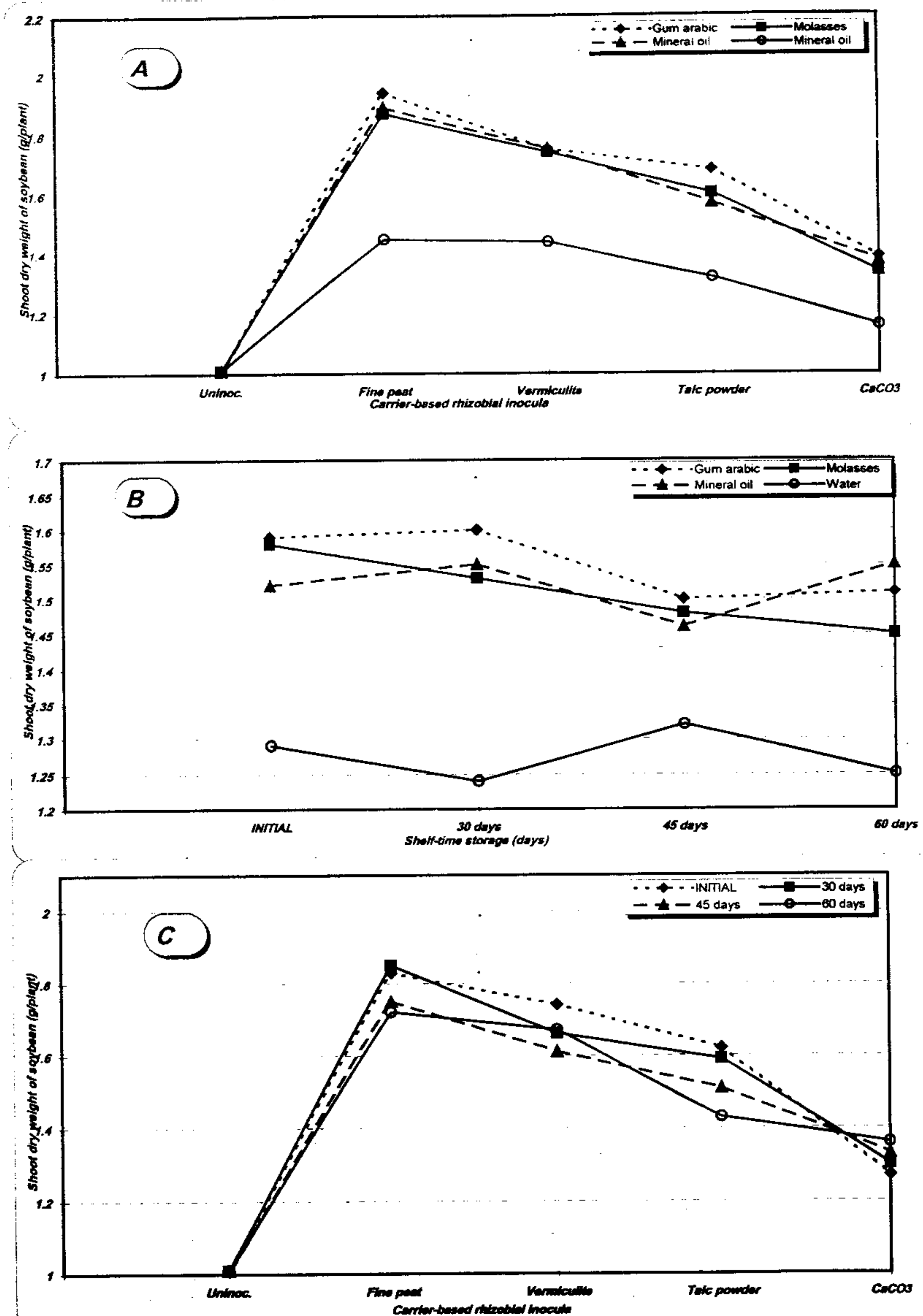


Fig.(19): Shoots dry weight of soybean plants (g/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

were significantly different from and higher than those of calcium carbonate and the control treatment (uninoculated seeds) 1.01 g/plant.

The carrier-based inocula stored for 60 days before planting showed the same attitude and significantly increased the shoots dry weight. The results ranged between 1.72 and 1.01 g/plant for fine peat and uninoculated control treatment. There was no significant difference between fine peat (1.72 g/plant) and vermiculite (1.67 g/plant) while they were higher and differed statistically from all of talc powder (1.43 g/plant), calcium carbonate (1.36 g/plant) and the control treatment (1.01 g/plant).

4.2.1.2.1.4.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of shoots:

The interactions of the adhesive agents significantly increased the soybean shoot dry weight. The greatest interactions were for gum arabic (1.55 g/plant), mineral oil (1.52g/plant) and molasses (1.51 g/plant) with no significant difference.

The interaction of carrier-type of the inoculants tested significantly affected the soybean shoot dry weight. The superior interaction was (1.79 g/plant) for using fine peat as carrier agent with significant difference from 1.67, 1.54, 1.31, and 1.01g/plant corresponding to vermiculite, talc powder, calcium carbonate and control (uninoculated treatment), respectively.

Finally, it was noticed that the interactions of shelf-time x adhesives, shelf-time x carriers, adhesives x carriers and shelf-time x adhesives x carriers did not significantly affect the shoot dry weight of soybean.

4.2.1.2.1.5. Nitrogen content:

Table (20) and Fig. (20) explain the nitrogen content of soybean plants as affected by different adhesive agents and carrier-based inoculants under different shelf-time storage of zero, 30, 45 and 60 days before sowing. Plant samples were uprooted at 45 days after planting to be tested for nitrogen content.

4.2.1.2.1.5.1. Effect of adhesive agents and carrier-based inocula:

All the shelf-time storage periods of zero, 30 and 60 days showed the same trend toward the plant nitrogen content concerning the different adhesive agents. Any of gum arabic, molasses and mineral oil had no significant effect between them while all of them were higher than and significantly differed from the nitrogen content values of water achieved at these shelf-time storage periods. The nitrogen content values recorded at zero shelf-time storage were 32.13, 31.87, 29.87 and 24.80 mg/plant in respective to gum arabic, molasses, mineral oil and water.

At 30 days the corresponding nitrogen content values were 32.33, 31.20, 30.07 and 24.07 mg/plant. Relatively, these values of nitrogen at 60 days shelf-time storage period were 30.33, 29.13, 28.53 and 24.40 mg/plant.

However, at 45 days shelf-time storage period, the use of gum arabic, molasses, mineral oil and water as adhesive agents did not increase and had no significant effect on nitrogen content/plants. The corresponding nitrogen content values were 30.27, 29.67, 28.53 and 25.47 mg/plant.

In relative to the carrier-based inocula used, all of them had significantly increased the amount of nitrogen content/plant compared to the control treatment (without carrier agents) and this was achieved at all shelf-time storage periods tested.

At the shelf-time storage periods of zero, 30, 45 and 60 days, both of fine peat and vermiculite as carrier-based inocula were superior and better than any of talc powder or calcium carbonate for nitrogen content values/plant. The values achieved by fine peat and vermiculite were increasable and significantly different from those of talc powder and calcium carbonate. The corresponding values were 38.00, 36.00 and 35.17 mg/plant for fine peat at zero, 45 and 60 days, respectively. While they were 35.92 mg/plant (zero days shelf-time), 32.83

Table (20): N-content of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (45 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)* Initial	30	45	60	Mean
Gum arabic	*Unioc.*	17.33	17.33	17.33	17.33	17.33
	Fine peat	42.00	42.67	40.33	39.67	41.17
	Vermiculite	39.33	37.67	35.00	35.67	36.92
	Talc powder	33.00	35.00	31.33	32.33	32.92
	$CaCO_3$	29.00	29.00	27.33	26.67	28.00
Mean		32.13	32.33	30.27	30.33	31.27
Molasses	*Unioc.*	17.33	17.33	17.33	17.33	17.33
	Fine peat	42.00	43.67	36.67	37.67	40.00
	Vermiculite	39.67	36.33	34.00	36.33	36.58
	Talc powder	36.00	32.00	33.00	27.33	32.08
	$CaCO_3$	24.33	26.67	27.33	27.00	26.33
Mean		31.87	31.20	29.67	29.13	30.47
Mineral oil	*Unioc.*	17.33	17.33	17.33	17.33	17.33
	Fine peat	39.00	39.33	37.00	35.00	3758
	Vermiculite	35.00	35.00	34.33	35.67	35.00
	Talc powder	33.67	31.33	28.33	31.67	31.25
	$CaCO_3$	24.33	27.33	25.67	31.33	27.16
Mean		29.87	30.07	28.53	28.53	29.67
Water	*Unioc.*	17.33	17.33	17.33	17.33	17.33
	Fine peat	29.00	27.67	30.00	28.33	28.75
	Vermiculite	29.67	28.33	28.00	30.00	29.00
	Talc powder	25.67	26.67	26.67	23.33	25.58
	$CaCO_3$	22.33	20.33	25.33	23.00	22.75
Mean		24.80	24.07	25.47	24.40	24.68
Mean	*Unioc.*	17.33	17.33	17.33	17.33	17.33
	Fine peat	38.00	38.33	36.00	35.17	36.88
	Vermiculite	35.92	34.33	32.83	34.42	34.38
	Talc powder	32.08	31.25	29.83	28.67	30.46
	$CaCO_3$	25.00	25.83	26.42	27.00	26.06
Mean		29.67	29.42	28.48	28.52	29.02

	LSD 5%				INTERACTION
Shelf-time storage					NS.
Adhesive agents	2.57	3.28	NS.	3.47	1.73
Shelf-time x Adhesive					NS.
Carrier-based inocula	2.87	3.67	5.13	3.88	1.94
Shelf-time x Carrier					NS.
Adhesive x Carrier	NS.	NS.	NS.	NS.	3.88
Shelf-time x Adhesive x Carrier					NS.

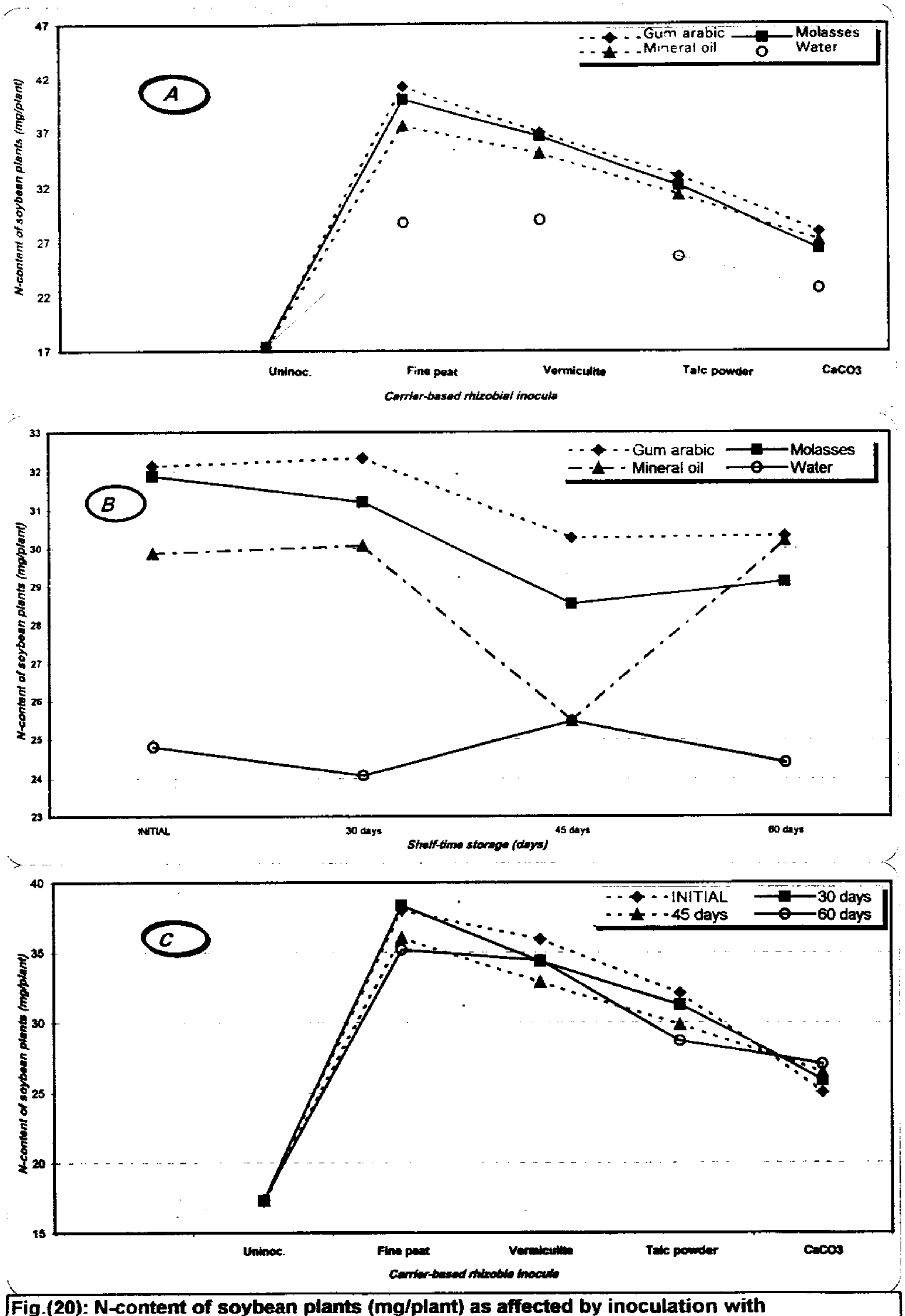


Fig.(20): N-content of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407 using different carrier-based rhizobial inocula and adhesive agents under shelf-time storage (90 DAP).

mg/plant (45 days shelf-time) and 34.42 mg/plant (60 days shelf-time) for vermiculite as carrier-based inoculant.

At 30 days shelf-time, the situation was different hence the fine peat had recorded the highest amount of nitrogen content (38.33 mg/plant) and was significantly different from those of vermiculite, talc powder and calcium carbonate. Their respective nitrogen amounts were 34.33, 31.25 and 25.83 mg/plant.

4.2.1.2.1.5.2. <u>The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on the nitrogen content:</u>

Applying of adhesive agents for soybean seed pelleting before sowing positively interacted the amount of nitrogen/plant. The interaction values of gum arabic (31.27 mg/plant), molasses (30.47 mg/plant) and mineral oil (29.67 mg/plant) were more than and significantly different from that of water (24.68 mg/plant) as adhesive agent. However, the interaction values of both gum arabic and molasses were not significantly different from each other. While the value of gum arabic was significantly different from that of mineral oil but the value of molasses was not.

All the carrier-based inoculants had positively increased the amount of nitrogen content/plant compared to uninoculated treatment. The highest interaction was for fine peat (36.88 mg/plant) followed by vermiculite (34.38 mg/plant), talc powder (30.46 mg/plant) and 26.06 mg/plant for calcium carbonate. The interaction values of fine peat, vermiculite and talc powder were higher than and significantly different from that of calcium carbonate. Also the interaction of fine peat was differed significantly than those of vermiculite, talc powder and calcium carbonate. However, a positive significant interaction was noticed between fine peat and vermiculite.

Any of carrier-based inocula and adhesive agents when alternated together for pelleting soybean seeds had increased the amount of nitrogen gained/plant.

The use of gum arabic x fine peat (41.17 mg/plant) and molasses x fine peat (40.00 mg/plant) had increased significantly the nitrogen content/plant without no significant difference between each other. However, they were significantly higher than of mineral oil x fine peat (37.58 mg/plant), gum arabic x vermiculite (36.92 mg/plant) and molasses x vermiculite (36.58 mg/plant).

The interactions of shelf-time x adhesive agents, shelf-time x carrier-based inocula and shelf-time x adhesive agents x carrier-based inocula had not significantly affected the amount of nitrogen content/plant.

4.2.1.2.2. Sampling at 90 days after planting (DAP)

4.2.1.2.2.1. Roots dry weight:

Table (21) shows results of the dry weight of roots (g/plant)of soybean as affected by seed pelleted with different adhesive agents and carrier-based inocula stored for different intervals of 0, 30, 45 and 60 days before planting.

4.2.1.2.2.1.1. Effect of adhesive agents and carriers-based inocula:

The effect of adhesive agents on the roots dry weight of soybean showed no significancy for unstored pelleted seeds (zero-time). Increasing shelf-time storage showed different adhesive effects on root dry weight. Pelleted seeds stored for 30 days and using gum arabic or molasses gave the highest values of roots dry weight of 1.70 and 1.59 g/plant, respectively. These values were not significantly different from each other. However, storage for 45 days, it was noticed that both mineral oil and molasses were not significantly different from each other and their corresponding values were 1.53 and 1.49 g/plant. At 60 days the trend was changed to find that the highest values were recorded with mineral oil (1.45 g/plant) and gum arabic (1.44 g/plant). Carrier-based inoculants tested at initial, 45 and 60 days shelf-time storage exhibited the same behavior effect on the dry weight of roots. Successive effect was noticed for both fine peat and vermiculite-based inocula at those shelf-times. At zero time the values were 1.72 g/plant

Table (21): Roots dry weight of soybean plants (g/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf- time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage () days*				
		0 days	*30 days*	*45 days*	*60 days*	*Mean*
Gum arabic	*Unioc.*	0.78	0.78	0.78	0.78	0.78
	Fine peat	1.79	2.32	1.85	1.95	1.98
	Vermiculite	1.42	2.00	1.83	1.59	1.71
	Talc powder	1.27	1.55	1.44	1.45	1.43
	$CaCO_3$	0.85	1.83	1.14	1.43	1.31
Mean		1.22	1.70	1.41	1.44	1.44
Molasses	*Unioc.*	0.78	0.78	0.78	0.78	0.78
	Fine peat	1.85	2.08	1.99	1.66	1.90
	Vermiculite	1.77	1.92	1.85	1.38	1.73
	Talc powder	1.11	1.79	1.52	1.31	1.43
	$CaCO_3$	0.93	1.36	1.33	1.05	1.17
Mean		1.29	1.59	1.49	1.24	1.40
Mineral oil	*Unioc.*	0.78	0.78	0.78	0.78	0.78
	Fine peat	1.70	1.78	1.89	1.85	1.80
	Vermiculite	1.70	1.60	1.83	1.90	1.76
	Talc powder	0.99	1.55	1.91	1.58	1.51
	$CaCO_3$	0.83	1.31	1.22	1.15	1.13
Mean		1.20	1.41	1.53	1.45	1.40
Water	*Unioc.*	0.78	0.78	0.78	0.78	0.78
	Fine peat	1.52	1.90	1.64	1.52	1.64
	Vermiculite	1.22	1.73	1.61	1.50	1.52
	Talc powder	1.16	1.55	1.43	1.28	1.36
	$CaCO_3$	0.88	1.14	1.09	1.03	1.04
Mean		1.11	1.42	1.31	1.22	1.27
Mean	*Unioc.*	0.78	0.78	0.78	0.78	0.78
	Fine peat	1.72	2.02	1.84	1.74	1.83
	Vermiculite	1.53	1.81	1.78	1.59	1.68
	Talc powder	1.13	1.61	1.58	1.40	1.43
	$CaCO_3$	0.87	1.41	1.20	1.16	1.16
Mean		1.21	1.53	1.43	1.34	1.38

	LSD 5%				INTERACTION
Shelf-time storage					0.12
Adhesive agents	NS	0.17	0.15	0.18	0.09
Shelf-time x Adhesive					0.18
Carrier-based inocula	0.25	0.18	0.17	0.20	0.10
Shelf-time x Carrier					0.20
Adhesive x Carrier	NS	NS	NS	NS	NS
Shelf-time x Adhesive x Carrier					NS

(fine peat) and 1.53 g/plant (vermiculite) , then at 45 days, the corresponding values were 1.84 g/plant and 1.78 g/plant. Finally they were 1.74 g/plant (fine peat) and 1.59 g/ plant (vermiculite) at 60 days shelf-time storage. However, using fine peat as a carrier agent was the superior with 2.02 g/plant at 30 days application.

4.2.1.2.2.1.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of roots:

All the factors tested were significantly interacted except those of adhesives x carriers and the shelf-time x adhesives x carriers.

The greatest interaction of shelf-time was noticed when pelleted seeds stored for 30 days before sowing (1.53 g/plant). The interaction of adhesive agents such as gum arabic, molasses and mineral oil gave values with no significancy with each other. The corresponding roots dry weights were 1.44, 1.40, and 1.40g/plant.

The interactions of carrier-based inocula showed that fine peat-based inocula had the favorite interaction effect on the roots dry weight recording the highest value of 1.83 g/ plant.

However, the interaction between shelf-time and carrier-based inocula scored that fine peat-based inoculant at 45 days (1.84 g/plant), vermiculite at 30 days (1.81 g/plant) and vermiculite at 45 days (1.78 g/plant) had the most effective interaction between carrier-based inocula and shelf-time storage with no significant difference between the two values.

Interaction of shelf-time and adhesive agents such as gum arabic at 30 days shelf time interacted the roots dry weight positively. It's value was 1.70 g/plant

4.2.1.2.2.2. Nodules number:

Data in Table (22) illustrated by Fig. (21) indicate the number of nodules /plant of soybean as affected by seed pelleting with different carrier-based inocula and adhesive agents and stored for 0, 30, 45 and 60 days before sowing.

4.2.1.2.2.2.1. Effect of adhesive agents and carrier-based inocula:

Planting of unstored pelleted seeds with adhesive agents gave 18, 16, 12 and 10 nodules/plant for gum arabic, molasses, mineral oil and water respectively. In general, all adhesives tested significantly increased the number of nodules/plant. The highest value of nodules/plant was recorded by gum arabic, which was significantly different from the other adhesives except molasses. Meanwhile, both molasses and mineral oil were significantly different from that of water.

Increasing storage interval up to 30 days, the numbers of nodules/plant were slightly lower than those at zero-time. The corresponding values were (15 nodules/plant)for gum arabic, (16 nodules/plant)molasses, (10 nodules/plant) mineral oil and 9 nodules/plant for water. The adhesive agents application still had a significant increasable effect on the number of nodules/plant with no significant difference between gum arabic and molasses. However, both of molasses (16 nodules/plant) and gum arabic (15 nodules/plant) were statistically different from those of mineral oil and water.

At 45 days, results showed that gum arabic gave the highest value of 15 nodules/plant followed by 13, 8 and 7 nodules/plant for molasses, mineral oil and water, respectively. The highest significant results were achieved by gum arabic (15 nodules/plant) which consequently differed significantly from the other adhesives. On the other hand, the values of molasses still significantly different from that of water.

At 60 days, adhesives behaved similarly as showed at initial and 45 days, hence gum arabic recorded both the highest and significant value (15 nodules/plant) compared to the other adhesives which gave 13, 9 and 8 nodules/

plant for molasses, mineral oil and water, respectively. Obviously molasses still differed positively from mineral oil and water (control treatment).

Carrier material types (fine fine peat, vermiculite, talc powder and calcium carbonate) and their effect on the number of nodules/plant as compared to the uninoculated soybean seeds (control), were investigated. The respective results of the number of nodules of those carrier materials were 23, 21, 15, 10 and 0 nodules/plant for unstored pelleted seeds (initial shelf-time). All the carrier -based inocula tested were positively affected the number of nodules/plant as compared to the control treatment. However, fine peat as a carrier agent was significantly higher than the other carrier-based inocula included. At 30 days , the effect of carrier agents on the number of nodules/plant was positively significant. Fine peat and vermiculite did not differed from each other significantly with relative values of nodules/plant were 20 (fine peat), 19 (vermiculite), 14 (talc powder), 10 (calcium carbonate) and zero nodules/plant for uninoculated control.

At 45 days, gum arabic recorded 19 nodules/plant and was significantly different from and higher than those of vermiculite, talc powder, $CaCO_3$ and control. Their values were 17, 11, 8 and zero nodules/plant, respectively.

Results of 60 days shelf-time storage were in accordance with those recorded at 30 days interval. Using fine peat and vermiculite, as carrier-based inocula were not significantly different from each other with relative values of 18 and 17 nodules/plant. While they were significantly different as compared to both talc powder (12 nodules/plant) and $CaCO_3$ (9 nodules/plant) .

The interaction of adhesive agents had a positive effect on the number of nodules/plant. The highest interaction was obtained by gum arabic (16 nodules/plant) which was significantly higher than molasses (15 nodules/plant), mineral oil (10 nodules/plant) and water (8 nodules/plant).

Table (22): Nodules number of soybean plants (nodules/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
um arabic	*Unioc.*	0	0	0	0	0
	Fine peat	37	31	30	30	32
	Vermiculite	24	23	19	19	21
	Talc powder	17	14	14	14	15
	$CaCO_3$	11	9	10	11	10
Mean		18	15	15	15	16
Molasses	*Unioc.*	0	0	0	0	0
	Fine peat	30	29	25	23	27
	Vermiculite	26	23	22	22	23
	Talc powder	13	13	10	11	12
	$CaCO_3$	12	12	9	10	11
Mean		16	16	13	13	15
Mineral oil	*Unioc.*	0	0	0	0	0
	Fine peat	18	14	15	14	15
	Vermiculite	19	16	14	14	16
	Talc powder	17	16	7	11	13
	$CaCO_3$	6	6	5	5	6
Mean		12	10	8	9	9
Water	*Unioc.*	0	0	0	0	0
	Fine peat	7	7	6	6	7
	Vermiculite	15	12	11	14	13
	Talc powder	15	13	11	10	12
	$CaCO_3$	12	11	9	8	11
Mean		10	9	7	8	8
Mean	*Unioc.*	0	0	0	0	0
	Fine peat	23	20	19	18	20
	Vermiculite	21	19	17	17	18
	Talc powder	15	14	11	12	13
	$CaCO_3$	10	10	8	9	9
Mean		14	12	11	11	12

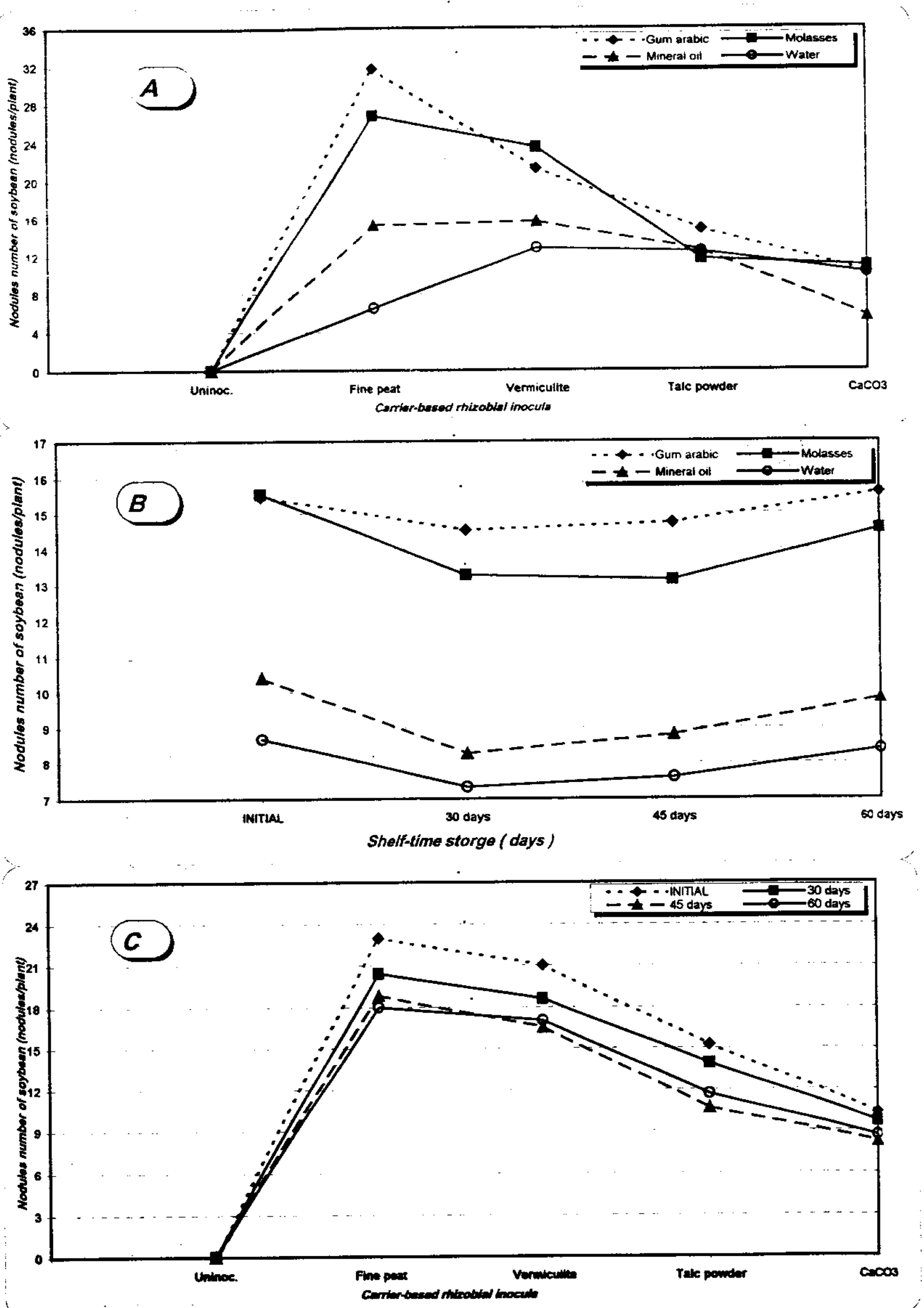


Fig.(21): Nodules number of soybean plants (nodules/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407.using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

4.2.1.2.2.2.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on number of nodules:

The interaction of shelf-time storage significantly affected the number of nodules/plant. The interactions results were 14, 13, 11 and 11nodules/plant at initial, 30, 45 and 60 days, respectively. However, zero time storage of the pelleted seed achieved the highest value of 14 nodules/plant which was significantly different from all the other shelf- time storage intervals.

The interaction of adhesive agents had a positive effect on the number of nodules/plant. The highest interaction was obtained by gum arabic (16 nodules/plant) which was significantly higher than molasses (15 nodules/plant), mineral oil (10 nodules/plant) and water (8 nodules/plant).

In general the interaction of carrier-based inoculants showed significant effect on the number of nodules/plant. The interaction of fine peat (20 nodules/plant) was the superior in significancy compared to the other carrier agents tested which gave 18, 13, 9 and 0 nodules/plant for vermiculite, talc powder, $CaCO_3$ and uninoculated treatment (control), respectively.

When adhesive agents and carrier-based inocula were used together with different combination (4 adhesives x 5 carrier) their interactions positively affected the number of nodules/plant. The highest three values had achieved when the combination was for gum arabic x fine peat (32 nodules/plant), molasses x fine peat (27 nodules/plant) and molasses x vermiculite (23 nodules/plant). However, the highest significant interaction was in case of gum arabic x fine peat (32 nodules/plant).

The interaction between shelf-time and carrier-based inocula (4 intervals x 5 carriers) gave 20 values with favor of 23 nodules/plant (zero time x fine peat) , 21 nodules/plant (zero x vermiculite) and 20 nodules/plant for the interaction of 30 days x fine peat. The interaction of zero x fine peat (23 nodules/plant) was the highest significant value.

The interaction for both shelf- time x adhesives and shelf-time x adhesives x carriers were not significant and slightly increased the number of nodules/ plant of soybean pelleted seeds.

4.2.1.2.2.3. Nodules dry weight:

Data in Table (23) illustrated by Fig. (22) show the values of nodules dry weight of soybean plants as pelleted with different carrier-based inocula and adhesive agents then stored for intervals of zero, 30 , 45 and 60 days.

4.2.1.2.2.3.1. Effect of adhesive agents and carrier-based inocula:

For adhesive agents, at zero shelf-time storage, it was clear that the use of adhesive to pellet seeds significantly increased the dry weight of nodules/plant. Results recorded were 75.65 mg/plant (gum arabic), 75.59 mg/plant (molasses), 61.27 mg/plant (mineral oil) and 43.13 mg/plant (water as control treatment). The values of gum arabic and molasses were the highest and not significantly different from each other. Both of them were differed positively from those of mineral oil and water. All adhesive agents significantly differed from that of control treatment (water).

At 30 days shelf-time storage, adhesive materials still had the same significant increment effect on the dry weight of nodules. In significant trend molasses exceeded all the other adhesive values. The values were 71.89, 64.45, 46.96 and 41.29 mg/plant for molasses, gum arabic mineral oil and water, respectively.

At 45 and 60 days shelf-time storage periods all adhesive agents significantly increased the dry weight of nodules/plant. Also gum arabic at both intervals was significantly different from and higher than other adhesives. At 45 days results were 53.70, 49.79, 44.59 and 39.44 mg/plant for gum arabic, molasses, mineral oil and water, respectively. The corresponding values at 60 days were 47.71, 44.33, 38.89 and 37.73 mg/plant.

The use of all carrier-based inocula in seed pelleting generally increased significantly the dry weight of nodules at all shelf-time storage. It was obvious at all shelf-time storage that fine peat is the superior with highly significant difference trend from the other carrier-based inocula used.

At zero shelf-time storage, the results were 116.88, 108.56, 55.75, 38.37 and 0.0 mg/plant corresponding to fine peat, vermiculite, talc powder, $CaCO_3$ and uninoculated seeds.

At 30 days shelf-time storage, fine peat gave 111.59 mg/plant while vermiculite, talc powder, $CaCO_3$ and uninoculated seeds recorded 100.42, 41.80, 26.92 and zero mg/plant, respectively. Fine peat was significantly different from and exceeded all the other carrier-based inocula. The same trend had been noticed for vermiculite against the other carrier agents. However, the value of talc powder was higher than and significantly different from that of calcium carbonate.

At 45 days shelf-time storage, the records were 98.09 mg/plant (fine peat), 77.15 mg/plant (vermiculite), 38.15 mg/plant (talc powder), 21.01 mg/plant ($CaCO_3$) and zero mg/plant (uninoculated seeds). Fine peat also gave the highest dry weight of nodules/plant, which was significantly different from the values of other carrier agents. In superiority, vermiculite followed fine peat and was positively significantly different from both values of talc powder and calcium carbonate. Consequently, the value of talc powder was higher than that of calcium carbonate and different from each other.

At 60 days shelf-time, the dry weights of nodules were 89.00, 64.72, 37.96, 19.15 and zero mg/plant for fine peat, vermiculite, talc powder, $CaCO_3$ and control treatment, respectively. However, fine peat gave the highest significant difference of the dry weight of nodules, which differed from the other carrier agents. Vermiculite positively differed from both of talc powder and calcium carbonate. Talc powder was higher than and significantly different from $CaCO_3$.

Table (23): Nodules dry weight of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

Adhesives	*Carriers*	*Shelf-time storage (days)*				
		Initial	*30*	*45*	*60*	*Mean*
Gum arabic	*Unioc.*	0	0	0	0	0
	Fine peat	135.10	131.03	105.83	102.77	118.68
	Vermiculite	120.27	97.73	96.87	64.90	93.44
	Talc powder	67.70	58.57	44.23	45.03	53.88
	$CaCO_3$	55.17	34.90	27.57	25.87	35.88
Mean		75.65	64.45	53.70	47.71	60.38
Molasses	*Unioc.*	0	0	0	0	0
	Fine peat	137.00	135.33	109.33	99.13	120.10
	Vermiculite	126.47	132.57	71.33	65.10	98.87
	Talc powder	59.20	58.07	42.80	35.10	48.79
	$CaCO_3$	55.30	33.47	25.47	22.33	34.14
Mean		75.59	71.89	49.59	44.33	60.40
Mineral oil	*Unioc.*	0	0	0	0	0
	Fine peat	106.80	95.80	92.87	84.47	94.98
	Vermiculite	104.47	91.43	76.80	62.90	83.90
	Talc powder	72.40	25.70	35.70	31.63	41.36
	$CaCO_3$	22.67	21.87	17.57	15.47	19.40
Mean		61.27	46.96	44.59	38.89	47.93
Water	*Unioc.*	0	0	0	0	0
	Fine peat	88.60	84.20	84.33	69.63	81.69
	Vermiculite	83.03	79.93	69.60	66.00	74.64
	Talc powder	23.70	24.87	29.87	40.07	29.63
	$CaCO_3$	20.33	17.43	13.43	12.93	16.03
Mean		43.13	41.29	49.44	37.73	40.40
Mean	*Unioc.*	0	0	0	0	0
	Fine peat	116.88	111.59	98.09	89.00	103.89
	Vermiculite	108.56	100.42	77.15	64.72	87.71
	Talc powder	55.75	41.80	38.15	37.96	43.41
	$CaCO_3$	38.37	26.92	21.01	19.15	26.36
Mean		63.91	56.14	46.88	42.17	52.28

	LSD 5 %				*INTERACTION*
Shelf-time					2.05
Adhesive	3.26	2.69	3.01	2.61	1.42
Shelf-time x Adhesive					2.84
Carrier	3.65	3.01	3.36	2.92	1.58
Shelf-time x Carrier					3.17
Adhesive x Carrier	7.29	6.02	6.73	5.83	3.17
Shelf-time x Adhesive x Carrier					6.34

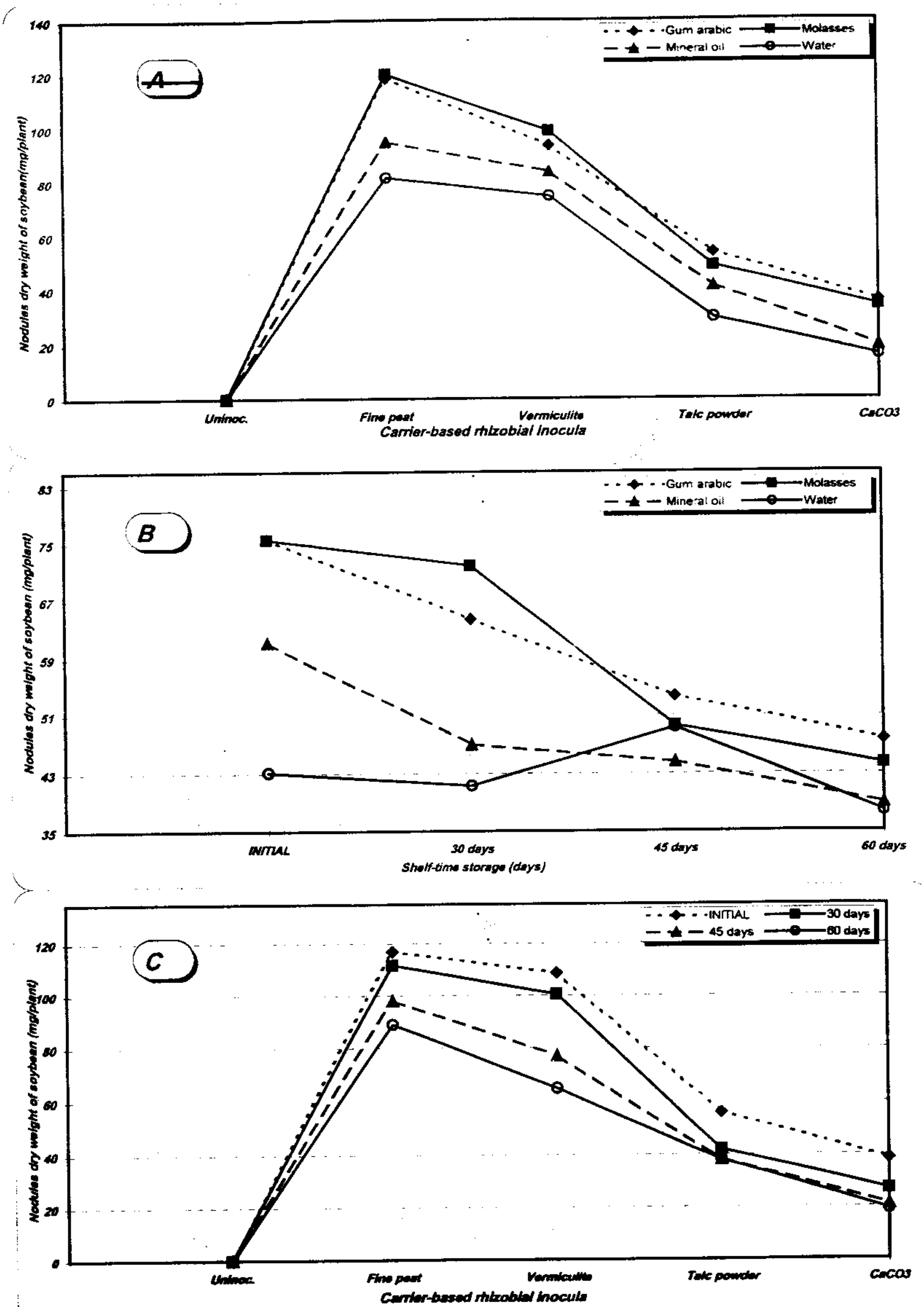


Fig.(22): **Nodules dry weight of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).**

4.2.1.2.2.3.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on dry weight of nodules:

This interaction generally had interacted and increased significantly the dry weight of nodule. The four of shelf-time storage intervals gave 63.91 mg/plant (zero-time), 56.14 mg/plant (30 days), 46.88 mg/plant (45 days) and 42.17 mg/plant (60 days) as shown in Table 23. However, the highest value was achieved at zero-time (63.91 mg/plant) and this was highly significant different from the other values recorded of the other shelf-time storage.

The interaction of adhesive agents had significant and increasable effect on the dry weight of nodules/plant. It scored 60.38 mg/plant (gum arabic), 60, 40 mg/plant (molasses), 47.93 mg/plant (mineral oil) and 40.40 mg/plant (water). There was no significant difference between the interaction for both gum arabic and molasses.

Carrier-based inocula interaction significantly increased the dry weight of nodules/plant. Their values were 103.89 mg/plant for fine peat which was the highly significant interaction compared to the other carrier agents, followed by vermiculite (87.71 mg/plant), talc powder (43.41 mg/plant), $CaCO_3$ (26.36 mg/plant) and control treatment (0.0 mg/plant).

From 4 adhesives and 5 carriers in alternative combinations, there were twenty interaction values, which exposed significant increments. The highest interactions were 120.10 mg/plant for (molasses x fine peat) and 118.68 mg/plant (gum arabic x fine peat) with no significant difference between both these two interactions.

Shelf-time storage x adhesives interactions significantly increased the dry weight of nodules/plant. This interaction produced by 4 shelf-time intervals x 4 adhesive agents which comprises 16 values for this interaction. Among these values of 75.65 mg/plant (zero x gum arabic) and 75.59 mg/plant (zero x molasses) which were the highest with no statistical difference from each other.

g/plant for gum arabic, molasses mineral oil and water. Consequently, gum arabic virtually differed from other adhesive agents.

The interaction of carrier-based inocula significantly increased the dry weight of soybean shoots. The interaction values were 3.44, 2.90, 2.28, 1.71 and 1.25 g/plant for fine peat, vermiculite, talc powder, $CaCO_3$ and control treatment, respectively. The interaction value of fine peat had significantly differed from the other carrier-based inocula values.

The interaction between adhesive agents and carrier-based inocula, when 5 carrier-based inocula and 4 adhesive agents were in exchange to have twenty interaction values from which the highest ones were selected. They were 4.17 g/plant (gum arabic x fine peat) 3.72 g/plant (molasses x fine peat), 3.39 g/plant (mineral oil x fine peat) and 3.37 g/plant for gum arabic x vermiculite. However, the interaction of gum arabic x fine peat was significantly different from the other interactions.

The interactions of shelf-time storage, shelf-time storage x adhesives, shelf-time storage x carriers, shelf-time storage x adhesives x carriers had no significant effect on the shoots dry weight of the pelleted soybean seeds.

4.2.1.2.2.5. Nitrogen content:

Data in Table (25) and Fig. (24) show the total nitrogen content of soybean plants (mg/plant) treated with different adhesive agents and carrier-based inocula stored for different shelf-time periods of zero, 30, 45 and 60 days before sowing. The tested plant samples aged 90 days (DAP).

4.2.1.2.2.5.1. Effect of adhesive agents and carrier-based inocula:

At zero shelf-time period, adhesive agents gum arabic, molasses, mineral oil and water gave the mean values of 79.00, 78.67, 60.20 and 54.31 mg/plant as nitrogen content, respectively. It was clear that application of gum arabic and molasses as adhesive agents had increased significantly the nitrogen content/plant compared to those of mineral oil and water. However, the amount of nitrogen obtained by any of gum arabic or molasses was not significantly different from each other.

For 30 days shelf-time, gum arabic earned the highest value of nitrogen content/plant (80.73 mg/plant) followed by molasses (67.40 mg/plant), mineral oil (65.07 mg/plant) and water (55.67 mg/plant). It was also noticed that gum arabic had differed significantly and higher than those of molasses, mineral oil and water.

The trend noticed at zero shelf-time had been appeared at 45 days shelf-time so as the nitrogen content values of gum arabic (73.93 mg/plant) and molasses (77.93 mg/plant) were higher than and significantly different from those of mineral oil (64.73 mg/plant) and water (53.13 mg/plant). However, both the nitrogen content values achieved by applying any of gum arabic or molasses were not significantly different.

At 60 days shelf-time period, the nitrogen content values/plant was 86.07 mg/plant (gum arabic), molasses (73.80 mg/plant), mineral oil (62.80 mg/plant) and water (54.87 mg/plant) which was the least nitrogen amount. Significant difference had been recorded for nitrogen content values between gum arabic and the other adhesive agents.

In concern the effect of the carrier-based inocula on the nitrogen content of soybean plants, fine peat showed splendid effect at all shelf-time periods and recorded 104.33, 106.58, 105.25 and 105.58 mg/plant for zero, 30, 45 and 60 days shelf-time periods, respectively. These values were higher than those of the other carrier-based inocula tested at these shelf-time periods. Also, it was noticed that the values of nitrogen content /plant for vermiculite was lower than fine peat at all shelf-time periods tested and was significantly different from those recorded by any of talc powder or calcium carbonate.

Table (25): N-content of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

Adhesives	Carriers	shelf-time storage (days)				
		Initial	30	45	60	Mean
Gum arabic	Unioc.	25.00	25.00	25.00	25.00	25.00
	Fine peat	116.00	132.33	127.67	137.102	128.42
	Vermiculite	112.33	105.33	96.67	102.00	104.08
	Talc powder	84.00	80.33	66.33	88.67	79.83
	$CaCO_3$	57.67	60.67	54.00	77.00	62.34
Mean		79.00	80.73	73.93	86.07	79.93
Molasses	Unioc.	25.00	25.00	25.00	25.00	25.00
	Fine peat	123.00	114.33	121.00	111.67	117.50
	Vermiculite	103.33	89.00	92.00	105.00	97.33
	Talc powder	83.33	55.00	86.67	68.67	73.42
	$CaCO_3$	58.67	53.67	65.00	58.67	59.00
Mean		78.67	67.40	77.93	73.80	74.45
Mineral oil	Unioc.	25.00	25.00	25.00	25.00	25.00
	Fine peat	106.67	98.33	101.67	99.67	101.58
	Vermiculite	82.00	83.33	81.33	82.67	82.33
	Talc powder	50.00	73.00	68.33	61.00	63.08
	$CaCO_3$	37.33	45.67	47.33	45.67	44.00
Mean		60.20	65.07	64.73	62.80	63.20
Water	Unioc.	25.00	25.00	25.00	25.00	25.00
	Fine peat	71.67	81.33	70.67	73.33	74.25
	Vermiculite	79.67	73.67	69.67	80.00	75.75
	Talc powder	56.67	54.33	57.00	59.00	56.75
	$CaCO_3$	37.67	44.00	43.33	37.00	40.50
Mean		54.13	55.67	53.13	54.87	54.45
Mean	Unioc.	25.00	25.00	25.00	25.00	25.00
	Fine peat	104.33	106.58	105.25	105.58	105.44
	Vermiculite	94.33	87.83	84.92	92.42	89.88
	Talc powder	68.50	65.67	69.58	69.33	68.27
	$CaCO_3$	47.83	51.00	52.42	54.58	51.46
Mean		68.00	67.22	67.43	69.38	68.01

	LSD 5 %				INTERACTION
Shelf-time					NS.
Adhesive	9.58	8.76	8.83	11.49	4.75
Shelf-time x Adhesive					NS.
Carrier	10.71	9.79	9.87	12.85	5.31
Shelf-time x Carrier					NS.
Adhesive x Carrier	NS.	NS.	19.74	NS.	10.62
Shelf-time x Adhesive x Carrier					NS.

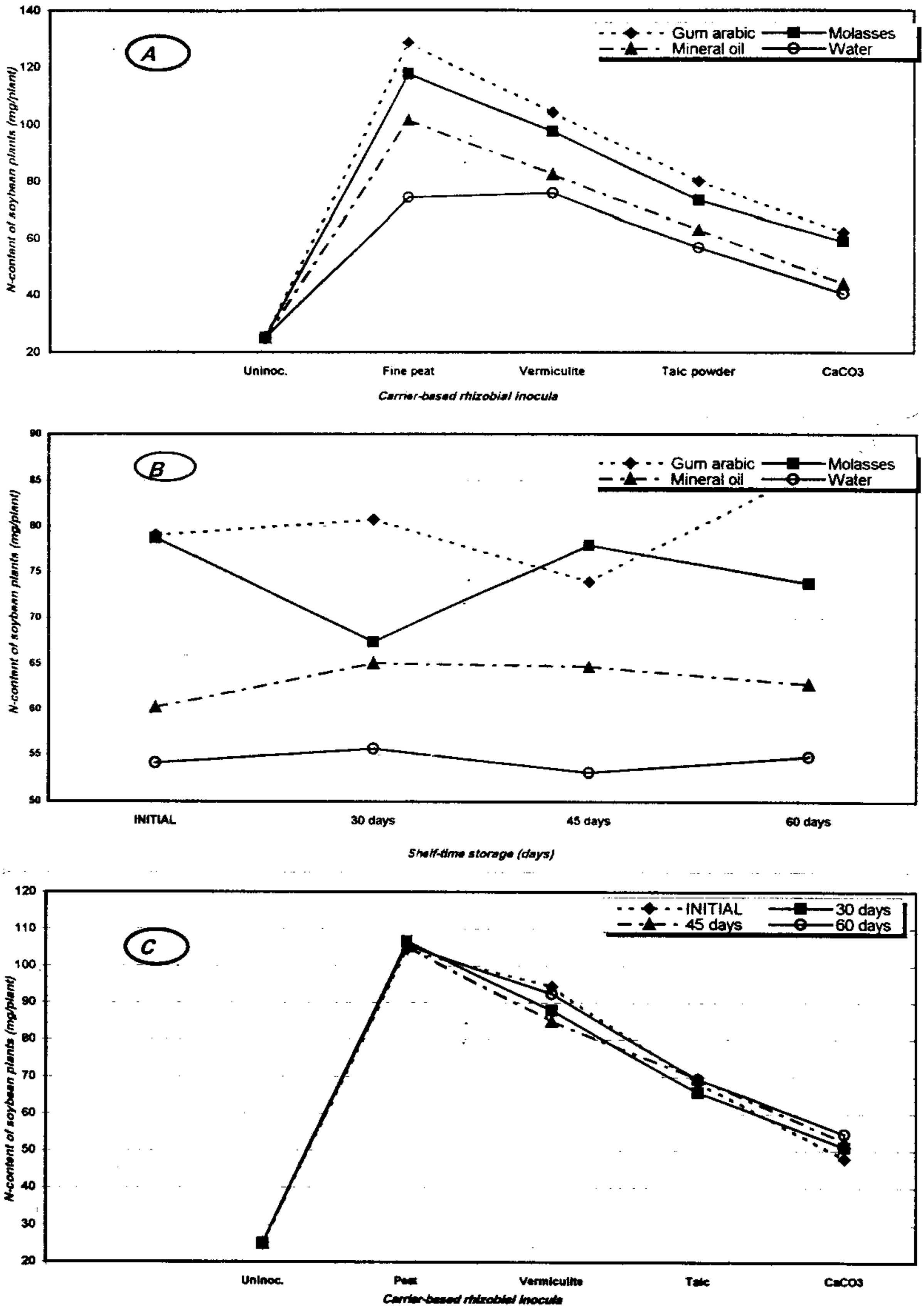


Fig. (24): N-content of soybean plants (mg/plant) as affected by inoculation with *Bradyrhizobium japonicum* strain 3407 using different carrier-based rhizobial inocula and adhesive agents under different shelf-time storage (90 DAP).

4.2.1.2.2.5.2. The interaction effect of shelf-time storage, adhesive agents and carrier-based inocula on nitrogen content:

The interaction effect of adhesive agents on the nitrogen content was highly pronounced with gum arabic (79.93 mg/plant) followed by molasses (74.45 mg/plant), mineral oil (63.20 mg/plant) and water (54.45 mg/plant). However, nitrogen content value of gum arabic interaction was significantly higher as compared to the other adhesive agents investigated.

The interaction effect of carrier-based inocula was clearly exhibited by fine peat (105.44 mg/plant) followed by . 89.88, 68.27 and 51.46 mg/plant for vermiculite, talc powder and calcium carbonate, respectively.

It was obvious that using fine peat as carrier-based inoculum resulted in the highest nitrogen content, which was different from the other values of nitrogen content recorded by the other carrier-based inocula examined.

The interactions of adhesive agents with carrier-based inocula for pelleting soybean seeds had increased significantly the nitrogen content of soybean plants and this was pronounced when the alternation was gum arabic x fine peat (128.42 mg/plant) followed by molasses x fine peat (117.50 mg/plant). These two values were significantly different from each other.

The interactions effect of shelf-time x adhesive agents, shelf-time x carrier-based inocula and shelf-time x adhesive agents x carrier-based inocula on the nitrogen content of soybean plants was not statistically significant.

The aim of rhizobial legumes inoculation is to maximize the rhizobial number/seed and nodulation for the biological nitrogen fixation which enhance and increase the legume crop yield. Failure of nodulation may happen because of some problems belonging to seeds or the field environment. Such problems are the antibacterial substances found in the seed coat, toxic effect due to acidity of soil or due to hazards of fertilizer and pesticide applications, unfavorable physical and chemical conditions in soil and seeds, microbial competition predators, antagonists and other microorganisms that compete for space, nutrients, and growth substances (**Thompson, 1960**). To overcome these problems in legume rhizobial inoculation, a pelleting technique had been tried in this study to inoculate faba bean and soybean seeds to provide much better conditions for survival of the rhizobia inoculant.

Legume seed inoculation with rhizobial practiced to cause biological nitrogen fixation, which leads to an increase of yields in leguminous crops. Inoculation is bringing rhizobia into contact with legume seeds or roots (**Hoben *et al.*, 1991**).

Thus different adhesive agents (gum arabic, molasses, mineral oil and water) and carrier-based inocula (fine peat, vermiculite, talc powder and calcium carbonate) were used in alternation to pellet faba bean or soybean seeds and stored for different shelf-times of zero, 30, 45 and 60 days before planting.

Rhizobium leguminosarum **bv.** ***viceae*** strain 441 and ***Bradyrhizobium japonicum*** strain 3407 were used in preparing the carrier-based inocula for pelleting faba bean (***Viceae faba***) and soybean ***(Glysine max (L.) merr)***, respectively. Plants of faba bean and soybean were sampled at 45 and 90 (DAP) to determine roots dry weight, number and dry weight of nodules, dry weight of shoots and nitrogen content of shoots.

Generally, obtained results revealed that pelleting of faba bean and soybean seeds had ensured good nodulation in numbers and dry weight of nodules either at 45 or 90 (DAP) sampling. The splendid results were when fine peat as a carrier-based inoculant had combined with gum arabic or molasses as adhesive agents followed by vermiculite mixed with the same adhesive agents (Figs. 9A, 10A, 13A, 14A, 17A, 18A, 21A and 22A). However, the convenient shelf-time storage before sowing was noticed for zero time followed by 30 days storage period {Figs. 9 (B&C), 10 (B&C), 13 (B&C), 14 (B&C), 17 (B&C), 18 (B&C), 21 (B&C) and 22 (B&C).

The same behavior achieved for nodulation by fine peat and vermiculite as carrier-based inocula and gum arabic or molasses as adhesive agents was revealed for their effect on the dry weight of shoots either for faba bean or soybean plants (Figs. 11A, 19A and 23A). However, at 90 (DAP) sampling, molasses had to be superior adhesive agent when combined with vermiculite for pelleting faba bean seeds (Fig. 15A).

For shelf-time effect, it was clear that at 45 days sampling time both gum arabic and molasses were merely the same at zero and 30 days shelf-time storage (Figs. 11B, 19B and 23B), while at 90 (DAP) the priority was for molasses at initial shelf-time storage for faba bean which had dropped at 30 days and then continued its priority at 45 and 60 days Fig. (15B). This drop could be explained as some experimental errors may be happened during this work.

Carrier-based inocula when affected by shelf-time storage showed that fine peat gave the highest results at zero shelf-time storage for 45, 90 (DAP) sampling either with faba bean or soybean (Figs. 11C, 19C, and 23C). While, irregular trend for faba bean at 90 (DAP) sampling was detected towards shelf-time storage that is fine peat and vermiculite had given the best results with all the shelf-time storage periods (Fig. 15C).

When carrier-based inocula had been alternated with adhesive agents in pelleting faba bean or soybean seeds, the nitrogen content in plants sampled at 45 and 90 (DAP) had showed different responses towards the nitrogen content of plants. Fine peat with gum arabic or molasses gave the highest nitrogen content values at 45 (DAP) with faba bean but for soybean the highest values were at 45 and 90 (DAP) sampling (Figs. 12A, 20A and 24A). However, it was noticed that at 90 (DAP), the priority was for fine peat with molasses followed by that of fine peat with gum arabic. Also, this trend had been showed for vermiculite with both of molasses and gum arabic (Fig. 15A).

Adhesive agents under the effect of shelf-time storage at 45 and 90 (DAP) had affected the nitrogen content of faba bean and soybean that it was clear that gum arabic and molasses gave the highest nitrogen content values at zero shelf-time storage with 45 (DAP) sampling.for faba bean and soybean plants (Figs. 12B and 20B), while, at 90 (DAP) sampling, molasses was superior followed by gum arabic for faba bean (Fig. 15B). For soybean, gum arabic at 90 (DAP) sampling continued to give the best results up to 30 days shelf-time storage period (Fig. 24B).

Shelf-time storage periods also interacted the nitrogen content of faba bean and soybean plants at 45 and 90 (DAP) sampling in the same way. The splendid results were achieved by fine peat with all the shelf-time storage periods. This was followed by vermiculite with lower value than those of fine peat (Figs. 12C, 15C, 20C and 24C).

Little works or researches had been discussed the matter of legume seeds pelleting process with its components i.e. carrier-based inocula and adhesive agents as well as their storage period before planting. However, such results obtained in this work are in agreement and confirmation with some authors and may contrast with others.

Brockwell (1962) who tried to overcome problems of nodulation failure in subterranean clover (***Trifolium subterranean L.)*** in weakly acid soils by wrapping the seed after inoculation in a coating material of $CaCO_3$ stuck on with a biological harmless adhesive such as 4% gum arabic, 5% cellofas. In addition a large and varried array of materials have been used for pellet coating. The aforementioned results showing that pelleting had increased significantly the roots and shoots weights, nodulation and nitrogen content of plants for both faba bean and soybean were in accordance with those described by **Chonkar *et al.,* (1971)** who found that seed pelleting with lime and gypsum significantly increased shoot and root growth, nodulation and symbiotic nitrogen fixation. They also added that seed pelleting provides protection against unfavorable soil conditions, like soil desiccation and soil acidity, resulting in increasing plant growth and nitrogen uptake, better root development in pelleted treatments, besides offering a large surface area for potential infection sites, might also help in increasing nitrogen uptake.

(**Norris, 1973**) inoculated ***Leucaena leucocephala*** with two contrasting types of ***Rhizobium*** applying peat culture to the seed as 2 and 4 % methyl cellulose sticker (m.c.) and 4 % sticker (m.c.) but with a lime coating. Inoculated seeds were sown after storage for one and 28 days. His results indicated that after one-day storage the acid-producing strain NGR8 formed nodules only when seeds were pelleted with lime, but the alkali-producing strain CB81 nodulated equally by all three inoculations procedures. After 28 days of storage strain CB81 did not survive on the seeds when applied simply with sticker but the strain NGR8 survived when seeds pelleted with lime. These findings showed that where ***Leucaena*** is to be established on acid soils, alkali-producing rhizobia must be used and the seeds should be always lime-pelleted. These results confirmed those obtained in the present study which explained that seed pelleting with zero and 30 days shelf-time storage periods were the most favorable for rhizobia survival either for faba bean or soybean.

Hamdi *et al*, (1978) found that seeds pelleting enhanced the survival of rhizobia whether seeds were inoculated at room temperature or refrigerated. Moreover, pelleting tended to prevent the harmful effect of the fungicides. This was clearly demonstrated with a tendency of an increase in the total nitrogen of the plants. On the contrary, normally inoculated and treated seeds grew into plants with reduced amounts of total nitrogen fixed.

Lowther and Littlejohn (1984) declared that when 1-7 ***Rhizobium*** lupine strains inoculated to seed of *L.* ***pedunculatus*** and treated with 10 % gum arabic (w/v) to the inoculant slurry increased establishment after 14-15 days storage in 2 of the 3 years studies.

Also the results of faba bean and soybean pelleting in the present study were in parallel with **Lu** *et al*, **(1987)** who declared that 1-3 % Mo as ammonium molybdate had no effect on the survival of rhizobia when added to the coating material (calcium carbonate or magnesium phosphate). They also added that pelleted seeds carried more viable rhizobia than non-pelleted seeds when indirect contact with calcium superphosphate fertilizer. The pelleting treatment increased the number of nodules/plant, nodule weight / plant, the number of seedlings /ha and plant dry weight. It was recommended that pelleted seed might be stored at low temperature and for no more than 1 week before sowing, while **Farria** *et al.*, **(1985)** recommended not to store seeds inoculated without pelleting.

Danso (1988) explained that ***Bradyrhizobium japonicum*** inoculated soybean seeds when pelleted with lime and rock phosphate in acid soil formed more nodules than those directly inoculated without seed coating. He also added that the best treatment was when the inoculated seeds were pelleted with lime. This treatment increased nodulation by about 13 times compared to that of the direct seed-inoculation only treatment.

In a field experiment **Vargas** *et al.*,**(1990)** showed that pelletization of legume seed with $CaCO_3$ alleviated soil acidity stress. They also pointed out that when inoculation methods were a mixture of seeds with water, sucrose solution, arabic gum solution, and seed pelletization with $CaCO_3$, inoculation increased the number and size of nodules and grain yields. There were no significant differences in the effects of inoculation methods except for nodule size, however, the use of water alone with inoculant gave the greatest number of small nodules. This confirmed the results of the present study, that water possessed the least ability as a sticker agent which ensure the least number of nodules/plant and the greater number of small nodules along with all carrier-based inoculants and shelf-