CHAPTER-IV
RESULTS AND DISCSSION

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4.1 RESULTS

The experiment was carried out to study the effect of PSM on growth and metabolism of *Arachis hypogaea* L.

For growth analysis the plants were grown in ten polythene bags for each treatment (2 plants per polythene bag). The results were recorded on height of shoot, length of root, number of nodules per plant, fresh weight of nodules per plant and dry wt. of the plant.

The metabolic studies were conducted considering the parameters such as chlorophyll content. NR activity nitrogen content, leghaemoglobin content and PO_4, N and K content.

The results are prestented in the tables 1 to 9 and fig.1 to 12.

4.1.1 Shoot and root length.

The data on shoot and root length is presented in table No.1 and fig No.1,2 and 3. The results suggest that the plants inoculated with PSM show increased root length and shoot length.

The plants in Soil + RP+ PSM showed maximum root and shoot length

(24cm. and 23.5 cm.respectively). The plants in Soil + PSM and Soil+RP+PSM showed approximately equal length of root and shoot (22 cm, 21.0 cm and 20 cm, 21.0 cm respectively). The control showed minimum root and shoot length. (18.0 cm 18.6 cm respectively).

4.1.2 Dry matter production per plant.

The data on dry matter production per plant is presented in Table No. 2 and Fig.4.

The maximum dry wt per plant was recorded in Soil+RP+PSM treatment (6.2g/plant) followed by Soil+PSM (5.90 g/plant) and Soil + RP (5.2 g/plant). The minimum dry wt. per plant was recorded in control (5.02g/plant)

4.1.3 Number of nodules per plant and fresh wt. of nodules per plant.

The data on no. and fresh wt. of nodules per plant. is presented in the table no.3 and fig.5 and 6.

The maximum number of nodules were observed in plants of Soil + RP + PSM treatment. (35/plant) followed by Soil+PSM (23/pl) and Soil + RP (21 (Plant). The control showed minimum number of nodules. (15/plant). The nodulation was enhanced due to inoculation of PSM. The number of nodules per plant were doubled due to the PSM inoculation along with RP.

The fresh wt. of nodules per plant was also found to be increased due to inoculation of PSM. The maximum fresh wt. of nodules per plant was recorded in Soil+RP+PSM (2.3 g/pl) followed by Soil+PSM (1.2 g/pl) and Soil+RP (1.1 g/pl). The control showed (0.9 g/pl).

Fig. 1. Effect of PSM on growth of *Arachis hypogaea* L.

Fig. 2. Effect of PSM on growth of root and shoot

Table. No.1 Effect of PSM inoculation on length of root and shoot of *Arachis hypogaea* L.

Treatments		Length of root	Length of shoot
		(cm)	(cm)
A)	Soil (control)	18.6	18.0
B)	Soil + PSM	26.0	21.0
C)	Soil + RP	25.0	21.0
D)	Soil + RP + PSM	28.0	23.5

Table No. 2 Effect of PSM inoculation on dry matter production per plant in *Arachis Hypogaea L.*

Treatments		Dry Weight gms/Plant
A)	Soil (control)	5.02
B)	Soil + PSM	5.90
C)	Soil + RP	5.2
D)	Soil + RP + PSM	6.2

Fig.3 EFFECT OF PSM INOCULATION ON LENGTH OF ROOT AND SHOOT OF *ARACHIS HYPOGAEA* L.

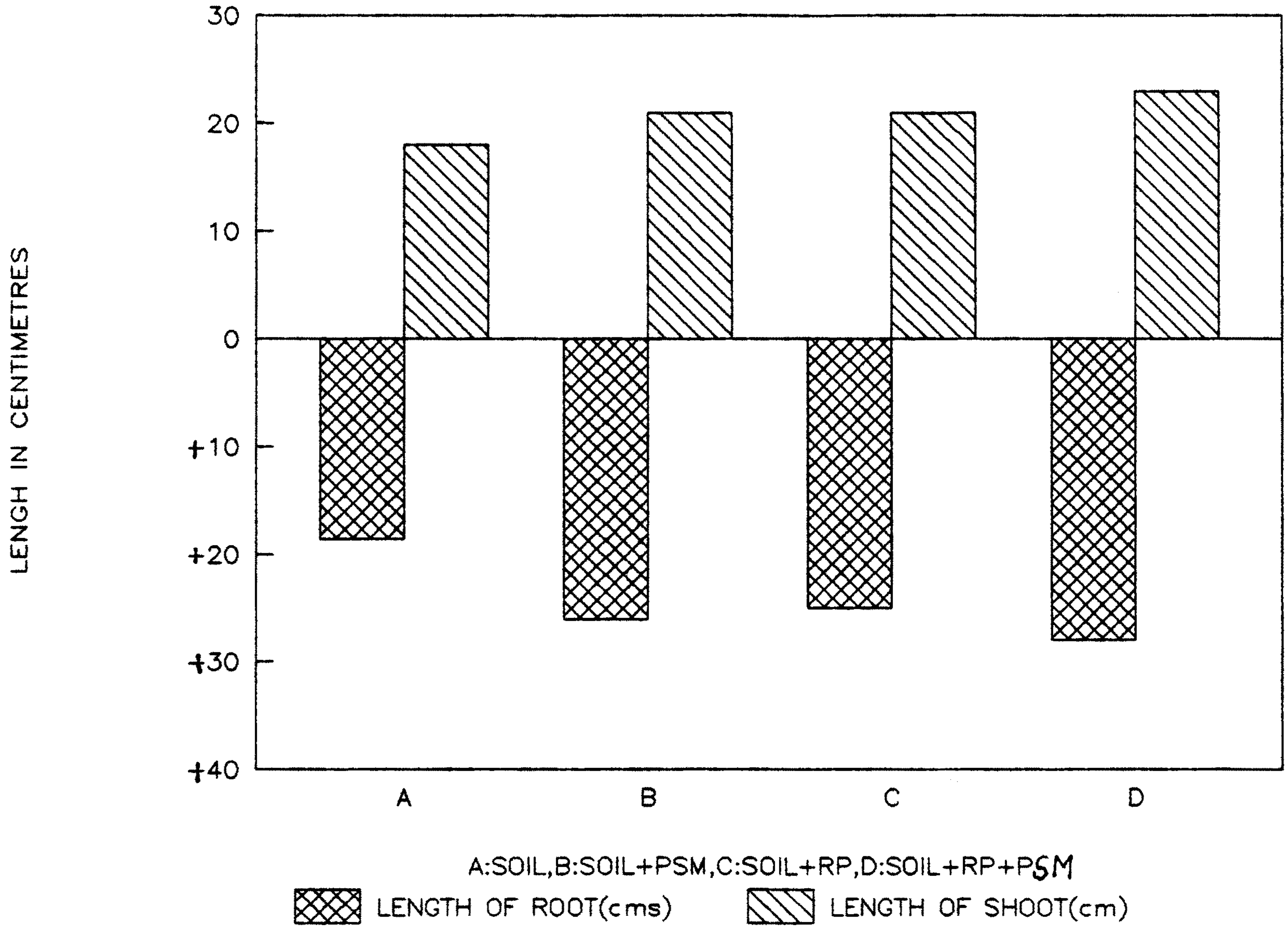
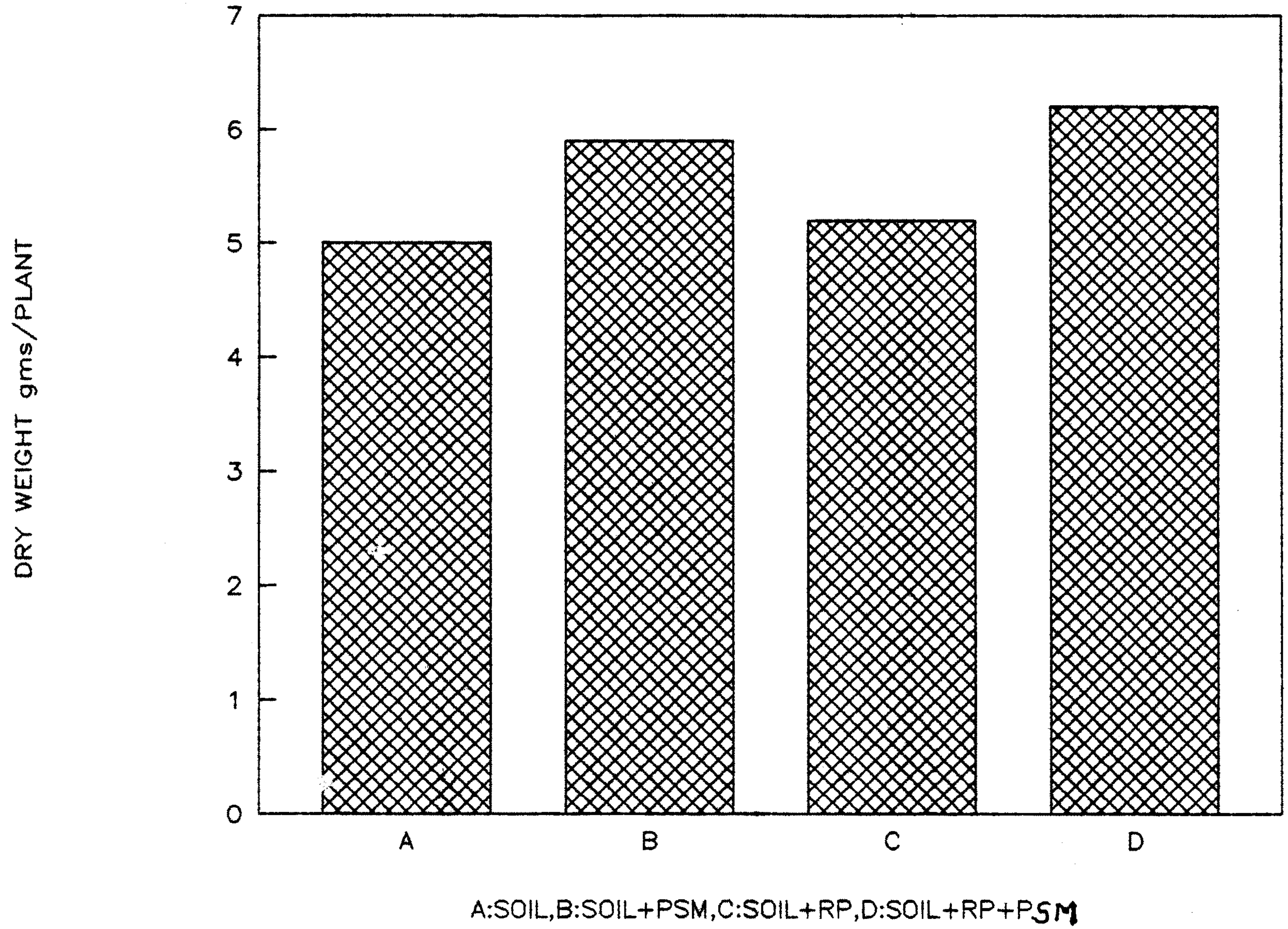


Fig. 4 EFFECT OF PSM ON DRY MATTER PRODUCTION

PER PLANT



4.1.4 Chlorophyll content

The data on effect of PSM on chlorophyll content in the leaves of *Arachis hypogaea* L. is presented in the table no.4 and Fig.No.7.

The application of RP and PSM inoculation caused increase in chlorophyll content. The maximum chlorphyll content was recorded in Soil + RP (1.8mg/100 g fresh tissue), followed by Soil + RP + PSM (1.4mg/100g fresh tissue) and Soil+PSM (1.2mg/100g fresh tissue) treatment. The minimum chlorophyll content was recorded in control (0.2 mg/100g fresh tissue).

4.1.5 Leghaemoglobin content in nodules of *Arachis hypogaea* L.

The data on Leghaemoglobin content in the nodules is presented in the table No.5 and Fig No.8.

The O.D./g of nodules was recorded and it was maximum in soil + RP+PSM (0.436) followed by Soil+PSM (0.420) and Soil + RP (0.399). The minimum O.D. was recorded in the control. (0.316) Thus an increase in Leghaemoglobin content was observed due to inoculation of PSM.

4.1.6 NR activity.

The data on NR activity is presented in the table no.6 and fig. No.9.

It reveals that the PSM inoculation enhances the NR activity in the root. stem as well as the leaf tissue. However the results show that the maximum NR

Table No.3

Effect of PSM inoculation on number of nodules per plant and fresh wt. of nodules per plants.

Treatments	No. of nodules/plant	Fresh wt. of nodules gm/plant
A) Soil (control)	15	0.9
B) Soil + PSM	23	1.2
C) Soil +RP	21	1.1
D) Soil +RP+PSM	35	2.3

Table No.4

Effect of PSM inoculation on chlorophyll content in the leaves of *Arachis hypogaea* L.

	Treatment	Chlorophyll content (mg/100g fresh tissue).
A	Soil (control	0.2
B	Soil + PSM	1.0
C	Soil + RP	1.8
D	Soil + RP + PSM	1.4

Fig. 5 EFFECT OF PSM INOCULATION ON NUMBER OF NODULES PER PLANT.

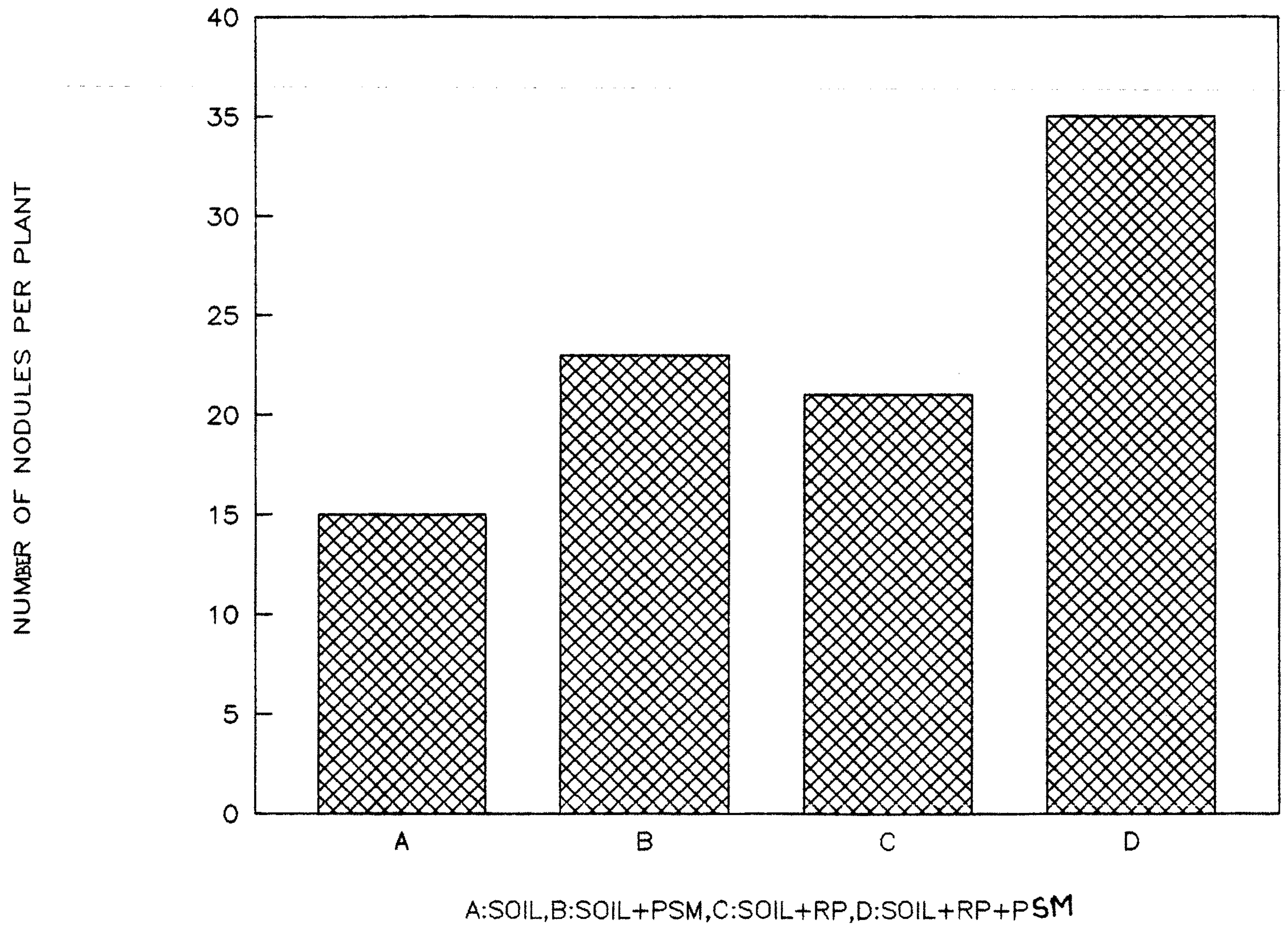
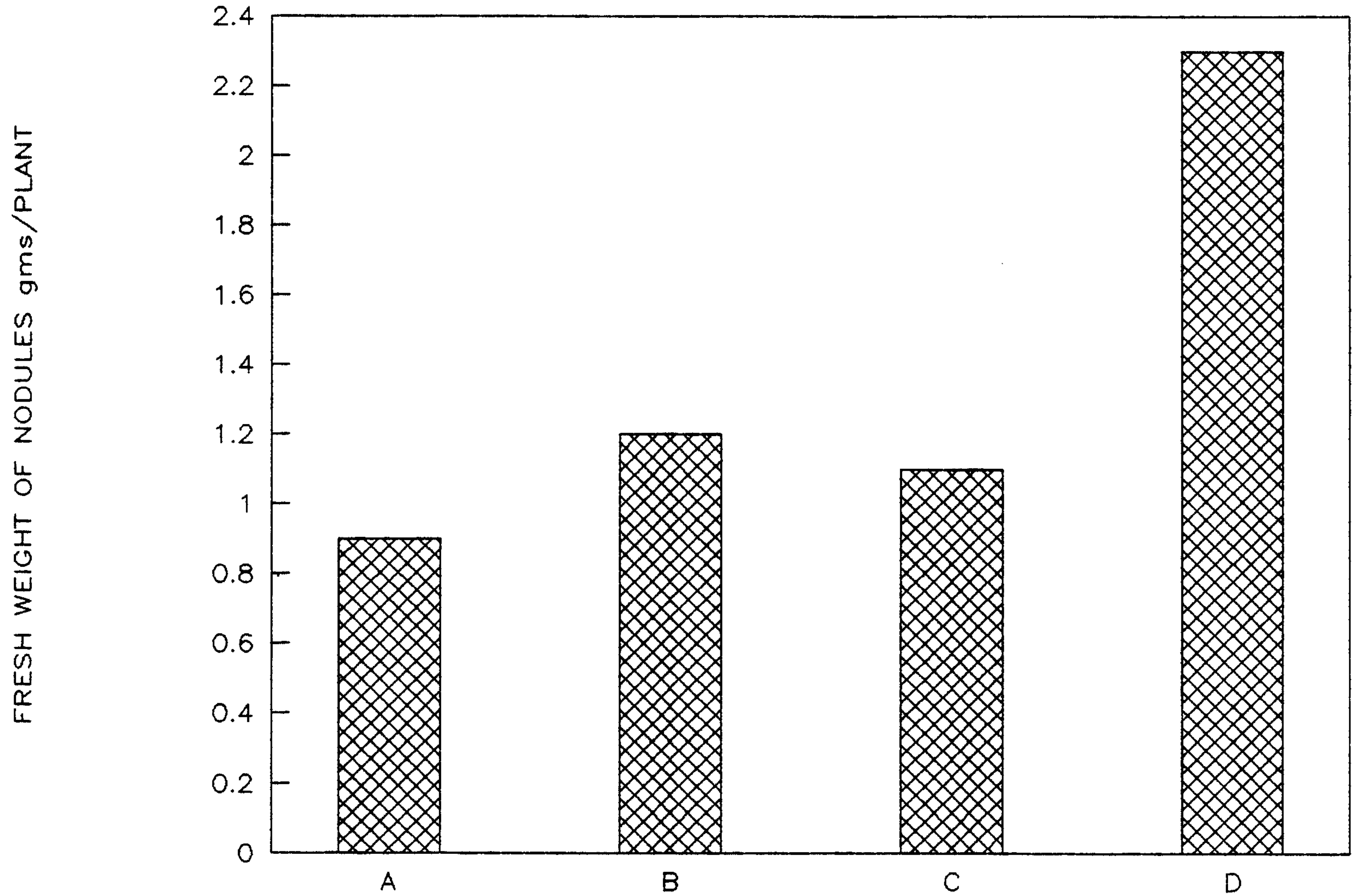
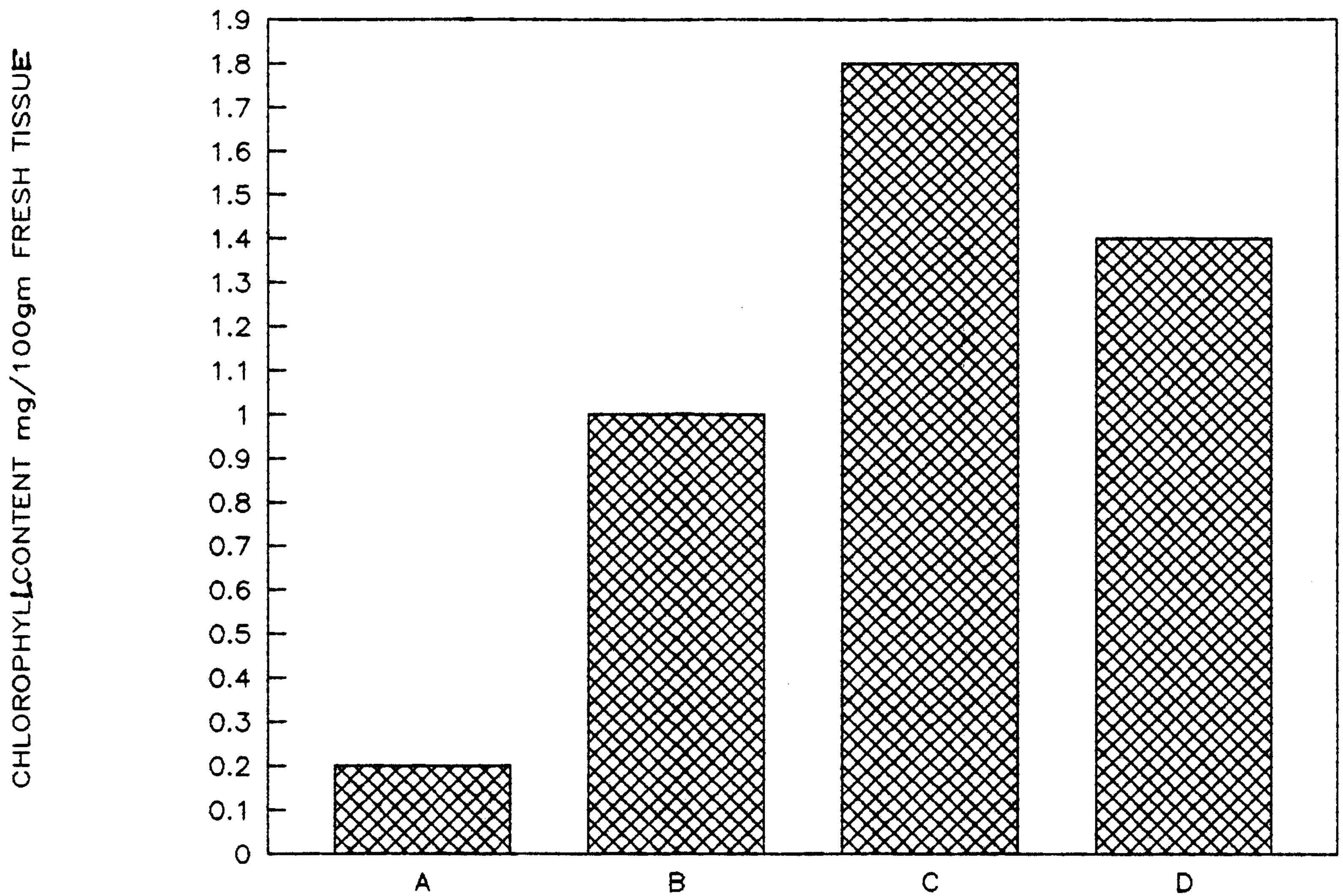


Fig. 6 EFFECT OF PSM INOCULATION AND FRESH WEIGHT OF NODULES PER PLANT.



A:SOIL,B:SOIL+PSM,C:SOIL+RP,D:SOIL+RP+PSM

Fig. 7 EFFECT OF PSM INOCULATION ON CHLOROPHYLL CONTENT IN THE LEAVES OF *ARACHIS HYPOGAEA* L.



A:SOIL,B:SOIL+PSM,C:SOIL+RP,D:SOIL+RP+PSM activity was recorded in leaf tissue.

The maximum NR was recorded in Soil + RP + PSM (leaf NR, 1.94, stem N.R. 1.20; Root NR 1.73) followed by Soil + PSM (leaf 1.8, stem 0.94, Root 1.71) and Soil + RP (leaf 1.64, stem 0.86 and root 1.31)

4.1.7. Nitrogen content

The data on nitrogen content in the *Arachis hypogaea* L. plant is presented in the table no.7 and fig.10.

The nitrogen content was maximum in the root tissue, followed by leaf and stem tissue.

The results reveal that the PSM inoculation improved the nitrogen uptake of the plant. Application of rock phosphate alone, did not show significant increase in the nitrogen uptake over control. The Soil+RP+PSM and Soil +PSM treatments showed approximately equal nitrogen content in the leaf and root tissue. (Leaf 8.4mg, 8.2 mg/100g dry wt. of tissue and root 9.9 mg, 9.7 mg/100g dry wt. of tissue respectively).

In the leaf tissue maximum nitrogen uptake was recorded in Soil + RP + PSM (8.4 mg/100g dry wt. of tissue) followed by Soil + PSM (8.2 mg/100 gm. dry wt. of tissue) and Soil + RP (6.8 mg/100 gm dry wt of tissue).The control showed minimum nitrogen content (5.1 mg/100g dry wt. of tissue).

Table No.5.

Effect of PSM on leghaemoglobin content in nodules of *Arachis hypogea* L.

	Treatment	Leghaemoglobin O.D./g of nodules
A.	Soil (control)	0.316
B.	Soil+PSM	0.420
C.	Soil+RP	0.399
D.	Soil+RP+PSM	0.436

Table No.6.

Effect of PSM on NR activity in *Arachis hypogaea* L.

		NO2 formed. $h^{-1}.g^{-1}$fresh tissue		
	Treatment	**Leaf**	**Stem**	**Root**
A)	Soil (control	0.5	0.32	0.8
B)	Soil + PSM	1.8	0.94	1.71
C)	Soil + RP	1.64	0.86	1.31
D)	Soil + RP + PSM	1.54	1.20	1.73

Fig. 8 EFFECT OF PSM ON LEGHAEMOGLOBIN CONTENT

IN NODULES OF *ARACHIS HYPOGAEA* L.

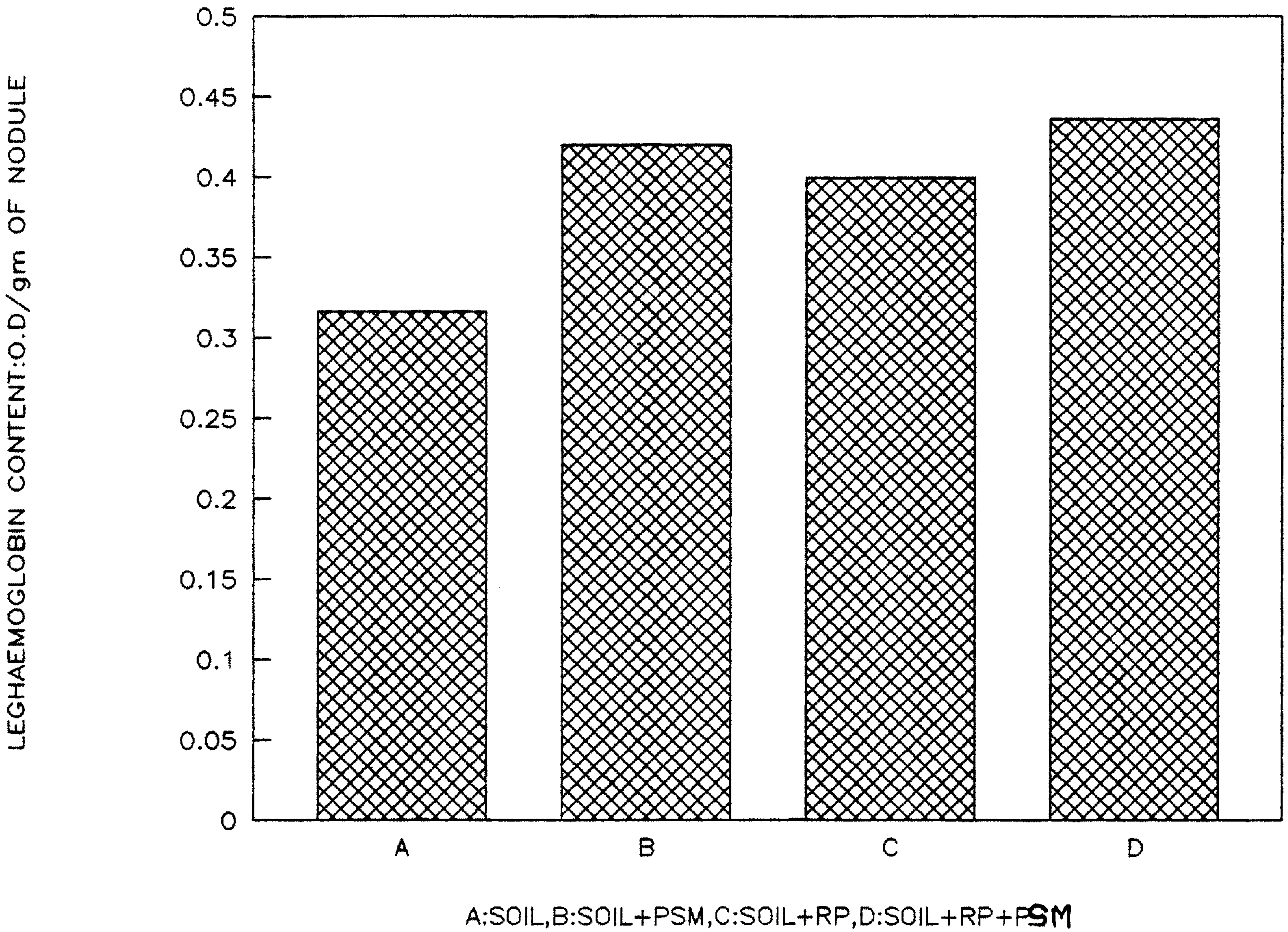
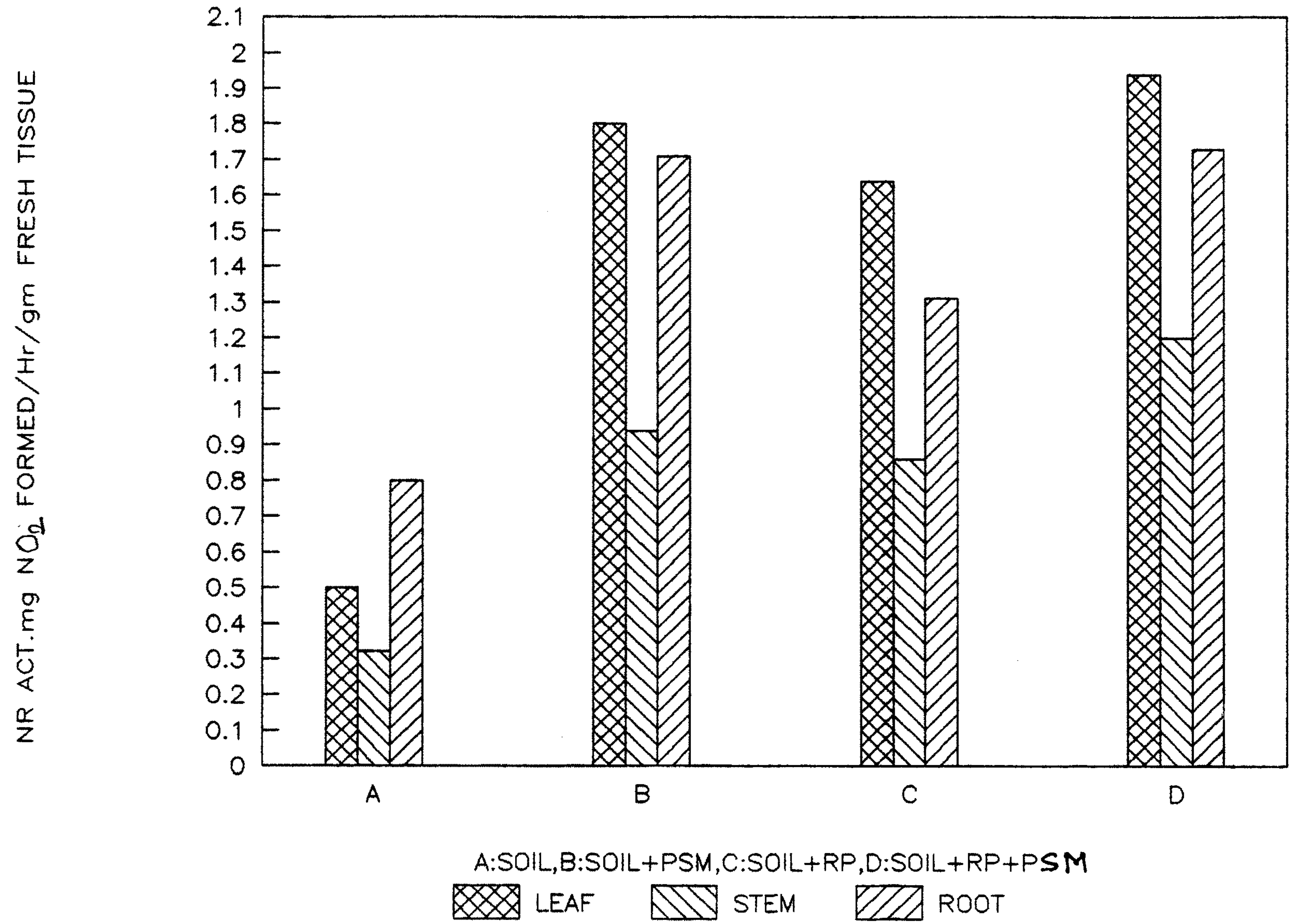


Fig. 9 EFFECT OF PSM ON NR ACTIVITY

IN ARACHIS HYPOGAEA L.



In the stem tissue maximum nitrogen uptake was recorded in Soil + RP + PSM (8.9 mg/100g dry wt. of tissue) followed by Soil + PSM (7.3 mg/100g dry wt. of tissue) and Soil + RP(4.8 mg/100g dry wt. of tissue , he minimum nitrogen content was recorded in control. (4.1 mg/100g dry wt. of tissue).

In the root tissue, maximum nitrogen content was recorded in Soil + RP + PSM (9.9 mg/100g dry wt. of tissue) followed by Soil + PSM (9.7 mg/100g dry wt. of tissue) and Soil + RP (6.9 mg/100g dry wt. of tissue). The minimum nitrogen content was recorded in control (6.1 mg/100g dry wt. of tissue).

4.1.8 Phosphate content

The data on phosphate content in the *Arachis hypogaea* L is presented in the table No.8 and fig No.11.

The leaf tissue showed maximum phosphate content followed by stem tissue and root tissue.

An increase in phosphate uptake was observed due to the inoculation of PSM. The Soil + RP + PSM showed maximum phosphate content (leaf 9.9 mg/100g dry wt. of tissue, stem 8.6 mg/100g dry wt. of tissue, root 6.9 mg/100g dry wt. of tissue).followed by Soil + PSM (leaf, 9.3 mg/100g dry wt. of tissue, stem 8.4 mg/100g dry wt. of tissue, root 6.8 mg/100g dry wt.of tissue) and Soil + RP (leaf 8.3 mg/100g dry wt. of tissue, stem 7.6 mg/100g dry wt. of tissue, root 6.2 mg/100g dry wt. of tissue). The minimum phosphate content was

Table No.7

Effect of PSM on nitrogen uptake of *Arachis hypogaea*.L

Treatment	Nitrogen content (mg/100 g. dry wt).		
	Leaf	**Stem**	**Root**
A. Soil	5.1	4.1	6.1
B. Soil + PSM	8.2	7.3	9.7
C. Soil +RP	6.8	4.8	6.9
D. Soil + RP +PSM	8.4	8.9	9.9

Table No. 8 Effect of PSM on phosphate content of plant.

Treatment	Phosphate content (mg/100 g. dry wt).		
	Leaf	**Stem**	**Root**
A. Soil	6.4	5.6	4.9
B. Soil + PSM	8.3	7.6	6.8
C. Soil +RP	9.7	8.4	6.7
D. Soil + RP +PSM	9.9	8.6	6.9

Fig. 10 EFFECT OF PSM ON NITROGEN UPTAKE

OF *ARACHIS HYPOGAEA* L

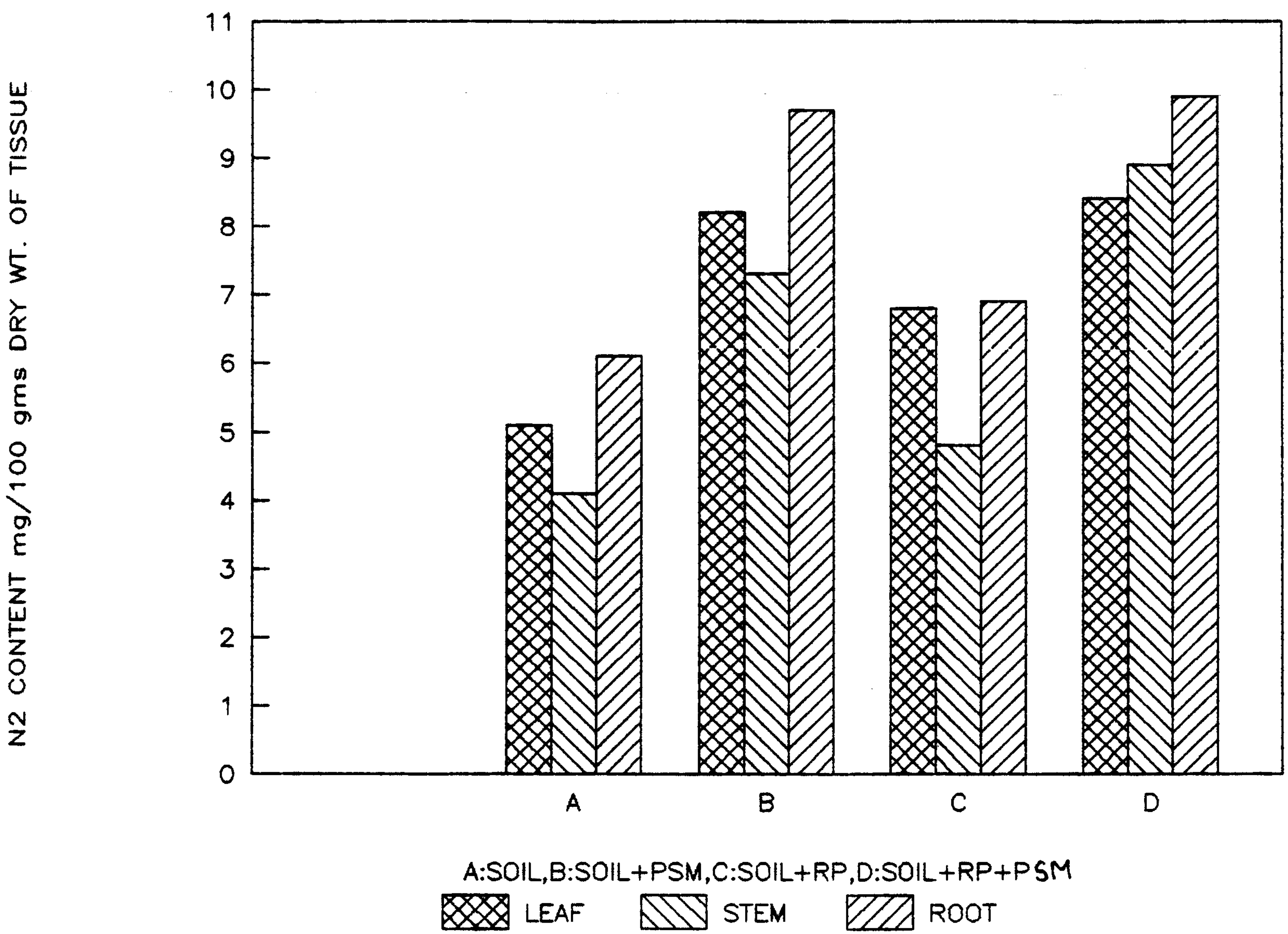


Fig 11 EFFECT OF PSM ON PHOSPHATE CONTENT OF *ARACHIS HYPOGAEA* L.

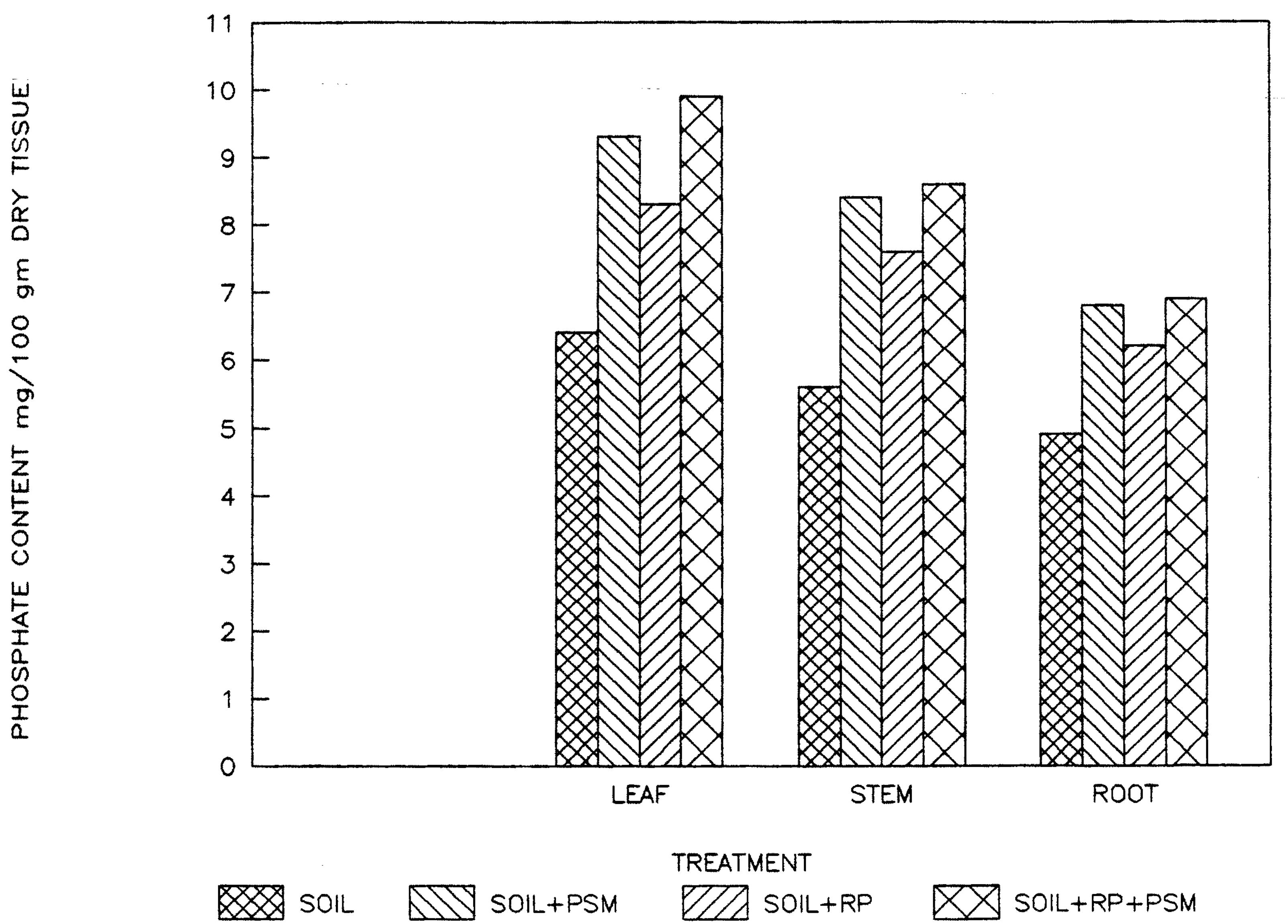


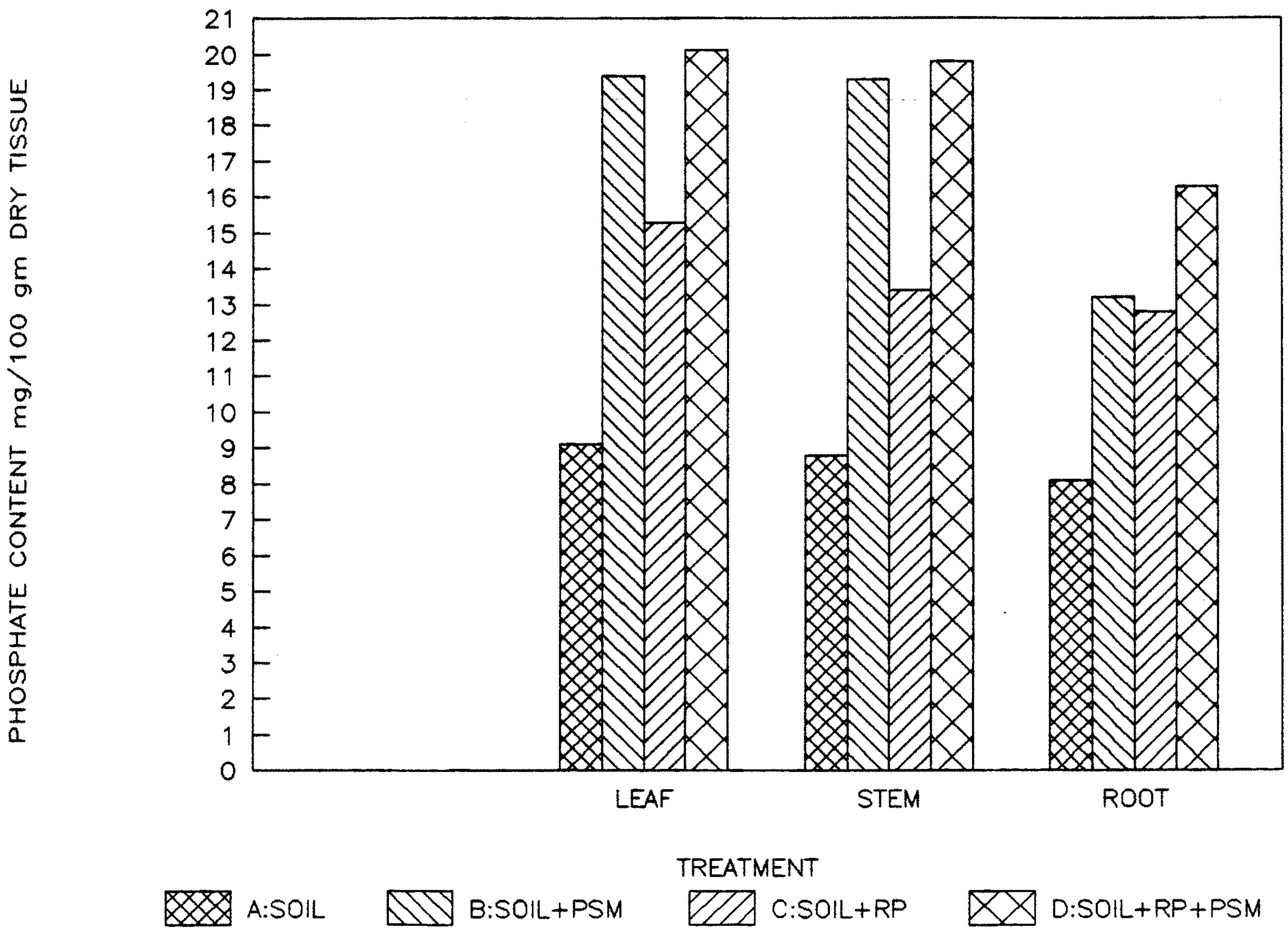
Table NO. 9

Effect of PSM on potassium uptake of *Arachis hypogaes* L.

	Treatment	Potassium content mg/100 f dry wt of tissue		
		Leaf	Stem	Root
A.	Soil (Control)	9.1	8.8	8.1
B.	Soil + PSM	19.4	19.3	13.2
C.	Soil + RP	15.3	13.4	12.8
D.	Soil + RP +PSM	20.1	19.8	16.3

Fig12 EFFECT OF PSM ON POTASSIUM CONTENT OF

ARACHIS HYPOGAEA L.



recorded in control (leaf 6.4 mg/100g dry wt. of tissue, stem 5.6 mg/100g dry wt. of tissue and root 4.9 mg/100g dry wt. of tissue).

4.1.9. Potassium uptake

The data on the potassium content is presented in the Table No.9 and fig.12.

Potassium content was recorded approximately equal in leaf and stem tissue it was less in the root tissue.

The Soil + RP + PSM showed maximum potassium content (Leaf 20.1 mg/100g dry wt. of tissue, stem 19.8 mg/100g dry wt. of tissue, root 16.3 mg/100g dry wt. of tissue) followed by Soil +PSM (leaf 19.4 mg/100g dry wt. of tissue stem 19.3 mg/100g dry wt. of tissue, root 13.2 mg/100g dry wt. of tissue) and Soil + RP (leaf 15.3 mg/100g dry wt. of tissue, stem 13.4 mg/100g dry wt. of tissue, root 12.8 mg/100g dry wt. of tissue). The minimum potassium content was recorded in control. (leaf 9.1 mg/100g dry wt. of tissue, stem 8.8 mg/100g dry wt. of tissue and root8.1 mg/100g dry wt. of tissue).

4.2 Discussion

Encouraging results were obtained fromt the experiment carried out to study the effect of PSM of growth and metabolism of *Arachis hypogaea* L.

The data on the growth analysis as well as metabolic studies reveals that the PSM inoculation has significantly improved the growth, dry matter production, mineral nutrition, nitrogen metabolism and chlorophyll content of the plant.

Many fungi and bacteria are potential solubilizers of bound phosphate. But they vary in their efficiency to dissolve tricalcium phosphate. Although bacteria have been used in the commercial preparations of phosphate dissolving cultures to improve the growth of plants, fungi seem to be better agents in the dissolution of phosphate than bacteria. (Muromtsev 1958, Sperber 1958 a, Medina De Wernali 1968, Bardiya and Gaur 1974). Number of workers have calculated and determined the extent of phosphate solubilization by different phosphate dissolving fungi and bacterial cultures. Among the fungi *Aspergillus awamori* was proved to be the most efficient phosphate solubilizer by many workers. (Bardiya and Gaur 1974, Agnihotri 1976, Singh et al, 1984). In the present studies we used *Apergillus awamori* as the PSM inoculant.

4.2.1 Effect of PSM on growth of *Arachis hypogaea* L.

The results presented in the table no.1,2 and fig. no.1 to 4 indicate in general that the PSM inoculation causes increased growth of the plant.

Increase in the length of root and shoot was recorded. This suggests that the innoculation with *A.awamori* causes solubilization of unavailable soil phosphorus and rock phophate and thus makes it available to the plant. We also observed the increased dry matter production due to PSM inoculation.

The maximum dry matter production and length of root and shoot was recorded in Soil+RP+PSM treatments. This was due to the inoculation with *Aspergillus awamori* along with application of 500 mg/pot rock phosphate.

Rock phosphate which is insoulble must have been solubilized by the inoculation of phosphate solubilizer, (Bajpai and Sunder Rao 1971, Kavimadan and Gaur 1971) thereby providing the plant with available phosphorus. Thus improving the phosphate nutrition of the plant which has been resulted in increased growth of the plant.

The length of root and shoot and dry matter production per plant in Soil+PSM treatment was recorded more than that of Soil+RP treatment. When only PSM was added into the soil, it converts the unavailable form of phosphat into soluble form of phosphate. Thus more amount of phosphat was available to the plant. The Soil+RP treatment showed increased growth and dry matter production which was due to the phosphate solubilizing activity of some microorganisms present in the soil (as nonsterlized soil was used in the expt.)

The results reveal that the addition of rock phosphate alone (Soil + RP) was less effective than PSM inoculation (Soil +PSM). But the addition of RP along with PSM inoculation significantly increased the growth and dry matter production of the plant. The increase in dry wt of the plant and length of root and shoot were attributed to improved phosphate supply to the plant and the growth promoting substances produced by the PSM inoculants. (Brown 1974, Baren et al. 1976, Sattar and Gaur 1987).

Increase in the growth and dry wt. of plant was observed due to the inoculation of PSM by Gerretsen (1948) in oats, mustard, sunflower and rape. Similar reports were obtained in case of barley (Taha, 1969), Cowpea and wheat (Bajpai, 1965), tobacco (Stephen et al 1961), wheat, maize, berseem, pigeon pea and paddy (Sundar Rao and Venkatraman 1971); maize (Kavimadan and Gaur), gram (Wani et al 1978 and Ahamad and Jha 1977), rice (Banik and Dey 1981) Datta et al. 1982 in sorghum.

4.2.2. Effect of PSM on nitrogen metabolism of *Arachis hypogaea* L.

The results reveal that the number of nodules per plant, fresh wt of nodules per plant, leghaemoglobin content of the nodules and the leaf stem and root NR activity in plants (table no.3, 5 & 6. fig 5,6,8,9) were always superior in PSM inoculated plants than in control. The inoculation of A.awamori along application of rock phosphate showed maximum nodules per plant leghaemoglobin content and NR activity. Such an effect can be attributed to the increased supply of phosphorus to the host plant or due to the production of plant harmones by the micro-organisms. The supply of phosphorus to the host plant influences nodulation and nitrogen fixation in higher plants. (O'hara et al 1988)

It has been recognised that the growth promoting substances produced by bacteria improve the plant growth. (Brown, 1974) and the plant hormones also play a role in the infection mechanism of Rhizobium (Lu et al.1958) A further increase in nodulation, NR activity and lehaemoglobin content with PSM inoculation can be attributed to the general healthy growth of plant in the initial stage till the plant became independent of nitrogen. Also the applied RP must have been solubilized by the inoculation of phosphate solubilizer, (Bajpai and Sundar Rao 1971, Kavimadan and Sundar Rao 1971, Kavimadan and Gaur 1971), there by providing the plant with available phosphorus whose defficiency otherwise might have led to poor nodulation and nitrogen fixation. Alagawadi and Gaur (1987) studied the interaction of Rhizobium and Phosphate solublizing bacteria, *Pseudomonas striata* and *Bacillus polymyxa* in chick pea. They observed increase in nitrogenase activity, no. of nodules per plant and dry wt. of nodules per plant in the plants with single inoculation of PSM as well as combined or dual inoculation of *Rhizobium* and PSM

4.2.3 Effect of PSM on Chlorophyll contents

Sahu and Singh (1987) showed that phosphorus accumulation in the leaf causes chlorosis in groundnut. Perhaps phosphorus in plants interfere with the translocation of iron and causes iron chlorosis. (Brown 1961). Sahu et al. (1988) also found similar results in garden peas. (*Pisum sativum*).

The results recorded in Table no. 4 and Fig. no 7. revealed the maximum chlorophyll content was recorded in Soil + RP treatment followed by Soil + RP + PSM and Soil + PSM. The control showed minimum chlorophyll content.

When RP was added to the soil (Soil + RP), there was an increase in phosphorus uptake of the plant, which enhanced the overall growth of the plant. This might have been responsible for increase in chlorophyll content. The Soil + PSM and Soil + RP + PSM treatments showed more phosphorus uptake and plant growth than Soil + RP. But decrease in chlorophyll content was observed due to PSM inoculation. It might be due to the excess of phosphorus availability to the plants. Thus it might be said that an adequate supply of phosphorus enhances the chlorophyll formation but when the phosphorus is in excess it is harmful for the chlorophyll.

4.2.4 Effect of PSM on nitrogen, phosphate and potassium uptake of *Arachis hypogaea* L.

The results presented in the table no. 7,8,9 and fig 10,11,12 suggest that there is an increase in nitrogen, phosphate and potassium content in the plants inoculated with PSM.

The increase in P uptake due to PSM inoculation was recorded in many experiments. [Gerretsen, (1948) Bajpai (1965), Taha (1969), Sundar Rao (1971) Smalli (1958) Ahamad and Jha (1977), Wani et al (1978)].

There was also an increase in nitrogen content of plant due to PSM inoculation such an increase in nitrogen uptake could be due to enhanced nitrogen fixation or due to enhanced nitrogen absorption by roots. Phosphate solubilizing fungus Aspergillus awamori by virtue of its capacity to increase the available P in soil could increase nitrogen fixation in nodules. Increase in nitrogen uptake due to PSM inoculation was recorded in chik pea by Alagwadi and Gour (1987).

There was also an increase in potassium uptake of the plant due to PSM inoculation. This can be attributed to the enhanced growth of roots of the plants inoculated with PSM. which provided more surface area to absorb the potassium from the soil.