Effects of Soil Moisture on Nodulation and Nitrogen Fixation

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ABSTRACT

The objectives of these studies were to evaluate the effects of soil moisture content on nodulation, nitrogen fixation, growth and yield of SJ2 soybean inoculated with *Rhizobium japonicum*. Two sets of experiments were conducted, the first was designed to evaluate nodulation of soybean and the second for nitrogen fixation and yield observations. These were performed by mixing the seeds with *Rhizobium japonicum* powder using gum arabic as adhesive material and the inoculated seeds were planted in pots containing fertilized and limed Korat soil. The soil moisture was kept at 100% FC for 10 days after planting then adjusted to 100, 80 60 and 40% FC following with water addition at 1 2, 3, 4, and 5 days intervals. Results of these experiments revealed that nodulation in soil with high moisture contents were better than those of the soil with lower water contents. Addition of water at one day interval gave higher nodulation than those of the other treatments. At higher soil water contents plant growth and nitrogen fixation were relatively higher than those of soil with lower contents. Addition of water at one day interval gave batter growth, higher introgen fixation, and higher seed yield than those of the other treatments. It is suggested that to obtain good nodulation, nitrogen fixation, growth, and yield of soybean grown in Korat soil, moisture contents should be kept between 80 to 100% FC and water is added at 1 to 2 days intervals.

INTRODUCTION

One of the major technological problems concerning with attempt to increase production of economic legumes following inoculation technique is the control of moisture level of the soil during growing season. Optimal soil moisture content is known to be required for not only the growth of the plant itself (Akasing and Chalarak, 1977) but also the nodulation and nitrogen fixation activities of the *Rhizobium* associated with the plant (Vincent, 1965). The requirement is also known to differ at differrent stages of growth. This is especially true with soybean when the plant seed is inoculated with specific strain of *Rhizobium*. This research work is an attemp to evaluate the effects of soil moisture on nodulation and nitrogen fixation of soybean SJ2, inocolated with *Rhizobium* (Vangnai, 1981) cultivated in Korat soil, the sandy soil with low organic matter content and low water holding capacity.

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MATERIALS AND METHODS

Korat soil was collected from the 0–15 cm horison from the experiment field ef Khon Kaen University. The soil was air dried, screened through a 2 mm sieve and thoroughly mixed. Initial moisture content, field capacity (FC), and permanent wilting point (PWP) of the soil were meassured. A basal application of NPK (N, 18.75 kgN/ha; P, 37.5 kg P_2O_5/ha ; K, 37.5 kg K_2O/ha), molybdenum (Na_2MoO_4, 25 kg/ha) and lime (0.1 %) was applied to the soil. Plastic pots lined with clear polythene bags were filled with 3 and 9 kg of soil, for experiment 1 and 2, respectively.

The pots were planted with inoculated soybean SJ2 seeds (with a mixture of *Rhizobium japonicum* strains UB-80 and UB-8T (Vangnai *et al.* 1979) using 20% gum arabic as an adhesive material. The soil moisture content of each pot was maintained at 100% FC for 10 days, the seedlings were thinned to 3 plants/pot, then the soil moisture content was adjusted. A factorial experiment in randomized complete block design (with 3 replications) was used incorparating treatments as shown in Table I, and these were performed in the greenhouse of Kohn Kaen University.

Maintenance of moisture content (Jeomsiri and Verasen, 1980) was done according to the FC = AWC + PWP relationship and gravimetric procedures. Conventional methods for moisture determinations were used to determine initial moisture content (105–110°C for 74 hr); FC (pressure cooker at 25 cm Hg), and PWP (pressure membrane apparatus at 220 psi).

The seedlings were allowed to grow for 47 days (experiment 1) for nodule observation, and 83 days (experiment 2) for nitrogen fixation and yield investigations.

Total nitrogen was analized using autoanalyzer.

RESULTS AND DISCUSSION

Numbers of nodules of soybean SJ2 grown in Korat soil containing various moisture contents are presented in Figure I. There were marked differences in nodule numbers especially between soil with 80–100% FC and 40–60% FC, indicating that relatively high moisture content is required for nodule formation and development. Constant supply of water to the soil to maintian soil moisture level also appeared to be important. It is noted from this Table thal relatively larger nodule numbers were obtained when water was added at 1–2 days intervals. The requirement of sufficient moisture for

Table 1 Treatment combination of the experiment

Moisture Contents (% FC)	Interval of Water Addition (days)				
	1	2	3	4	5
100	T_1	T_5	T_9	T_{13}	T_{17}
80	T_2	T_6	T_{10}	T_{14}	T_{18}
60	T_3	T_7	T_{11}	T_{15}	T_{19}
40	T_4	T_8	T_{12}	T_{16}	T_{20}

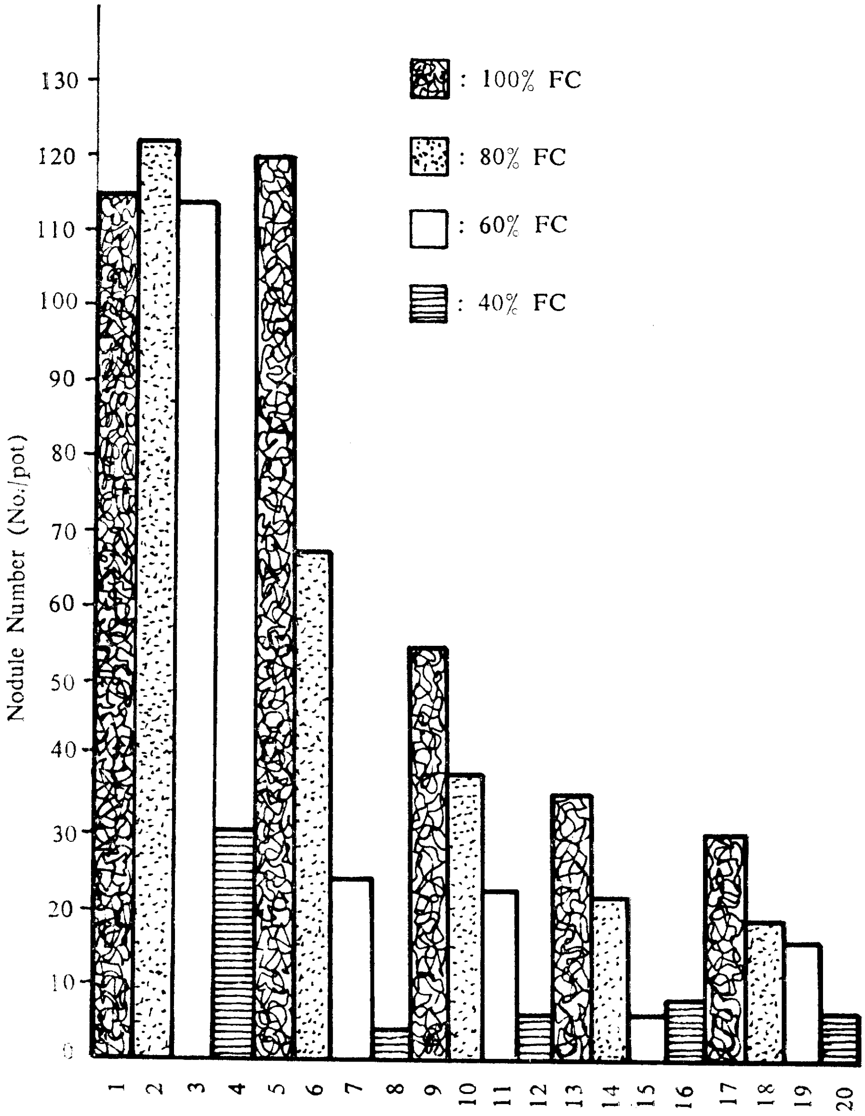

Figure 1 Nodule number of soybean (47 days after planting)

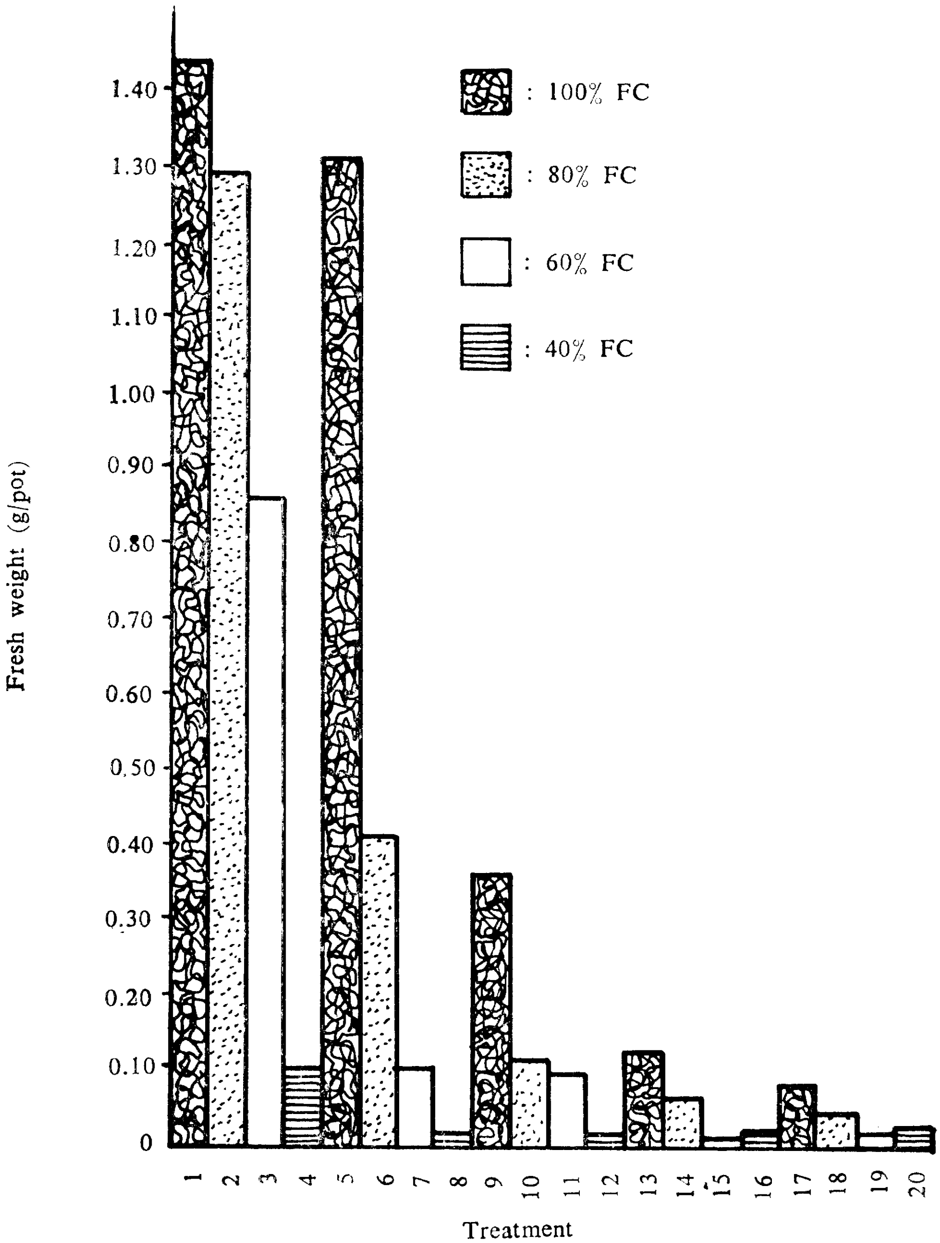

Figure 2 Fresh weight of nodule of soybean (47 days after planting)

Table 2 Total nitrogen and dry weights of vegetative parts and seeds of soybean (83 days after planting)

Treatments	Total Nitrogen (mg/pot)		Dry Weights (g/pot)	
	Vegetative Parts	Seeds	Vegetative Parts	Seeds
1	291.6	946.0	11.40	119.97
2	129.9	867.5	9.97	11.30
3	61.4	612.9	10.67	7.63
4	24.2	217.1	3.27	2.93
5	178.5	1120.1	9.37	13.20
6	79.4	584.6	10.23	5.53
7	27.1	364.0	4.95	4.36
8	9.5	129.0	1.43	1·67
9	147,6	757.2	8.20	9.17
10	59.3	453.2	4.90	5.90
11	58.6	221.5	2.87	2.77
12	25.9	54.1	2.20	0.63
13	123.4	516.7	7.20	6.17
14	65.5	232.9	4.70	3.57
15	43.5	154.8	3.40	1.93
16	29.9	50.5	2.40	0.67
17	81.9	184.3	5.33	2.50
18	46.3	176.0	4.33	2.20
19	27.9	132.2	2.47	1.27
20	8.3	8.7	1.13	0.13
LSD .05	57.34	108.80	1.20	1.43
.01	76.72	154.61	1.60	1.91
CV (%)	46.65	16.77	13.90	17.85

nodule formation and development is in agreement with results repotred by many researchers (Kuo and Boersma, 1971; Pankhurst and Sprent, 1975). Kuo and Boersma (1971) reported that good nodulation could occur when soil moisture content was above 50% FC, and that if the moisture content was below this level water supply was absolutely essential. Ponkhurst and Sprent(1975)also observed low nodulation under drought conditions, detachment of nodules even occured if the soil was completely dried.

The fresh weight of the nodules is shown in Figure II. Variation in fresh weight, as affected by soil moisture contents, trended to resemble those of the nodule numbers. These indicate that high levels of soil moisture coutents are required for nodule development, and these results were supported by Pankhurst and Sprent (1975).

Total nitrogen in vegetative parts and seeds of soybean is shown in Table II. It is noted that relatively high total nitrogen was observed with soybean grown in soil with high moisture contents, especially at 80–100% FC. Water supply, to maintain the correspondence soil moisture contents, at 1–2 days intervals gave higher total nitrogen compared to those of other treatments. These results would indicate higher nitrogen fixation activities under sufficient soil moisture contents. These were supported by Sooksaran *et al.* (1976) and

Sprent (1971) who observed that nitrogen fixation by legume was absolutely affected by soil moisture stress and that sufficient soil moisture content was essential for nitrogen fixation activities.

Dry weights of vegetative parts and seeds of soybean are shown in Table II. It is also noted that high soil moisture supported better growth and higher yield of soybean grown in this soil. It is important to note that good nodulation and nitrogen fixation activities, as a result of sufficient soil moisture contents, also reflected higher growth and yield of soybean. It is therefore, suggested that experiment on water budget is conducted for each soil type used for soybean cultivation, expecially when inoculated seeds are to be planted and active nitrogen fixation is expected to occur.

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