EFFECT OF FERTILIZER APPLICATION ON THE YIELD AND PROTEIN CONTENT OF SOYBEAN HARVESTED AT VARIOUS STAGES OF MATURITY

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ABSTRACT

Fertilizer application significantly increased the yield of soybean when harvested not earlier than 35 days after flowering. The crude protein content of soybean was not influenced by fertilizer application regardless of its stage of maturity. With or without fertilizer application, significant differences existed only between crude protein content of the sample harvested at 15 days after flowering and those harvested at the other three stages of maturity. However when fertilizer was applied, significant difference was also observed between the protein content of samples harvested at 25 and 45 days after flowering. Furthermore, fertilizer application significantly influenced the total protein yield of soybean. Without fertilization, there was no significant increase in the total protein yield when plants were harvested at 25 days after flowering instead of 15 days after. When the plants were fertilized, a significant increase in total protein yield for every 10-day increment in maturity was observed. Higher yield, crude protein content and total protein yield were obtained when the plants were harvested 45 days after flowering than when harvested at 15, 25 and 35 days after flowering. Yield and protein content of the beans increased linearly as time of harvest was delayed from 15 to 45 days after flowering.

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KEY WORDS: Fertilizer application. Soybean. Yield. Protein content. Stages of maturity. Total protein yield.

INTRODUCTION

Legumes, principally soybeans and mungbeans, are highly valued for their high protein content as food and for enriching the soil with nitrogen when used as a green manure (Mendiola, 1958). Its economic value primarily lies in its fat and protein content. Ellis and Bird (1956, as cited by Kipps, 1970) reported that soybean meal has increasingly become a more popular leading protein supplement, and this high protein product could be an answer to the malnutrition problem of many people. Moreover, the problem of getting good quality protein in the amounts needed by young children and adults has been compounded by the limited supply.

Researchers are trying to improve the quality of the soybean protein and increase both the quantity of seed protein and the overall yield of the crop. For instance, soybean appears to respond best to balanced fertility level over a period of years. However, applying high rates of fertilizer to improve already fertile soils seldom achieves the expected yield increase (Kipps, 1970).

Results of Delorit et al. (1974) showed that different soybean varieties varied in their response to available soil nutrients. Generally, varieties at low fertility levels have similar yields but yield differences existed at high fertility levels. Moreover, application of commercial fertilizer to poor soils may result in changes in seed composition. Protein and phosphorus contents of the seeds may be increased by adding phosphorus-containing fertilizer. However, Hartwig (1962, as cited by Martin et al., 1964) claimed that no benefit was obtained from nitrogen fertilization on well nodulated soybeans.

In order to resolve these claims and to test the response of soybean, specifically the TK-5 variety, to fertilization; this study was conducted. Although theoretically, yield could be increased by fertilizer application, a need to determine the relationship between yield levels and protein contents was deemed necessary. Moreover, studying the effect of stages of maturity on the yield and protein content would provide information on the best time to harvest the beans in terms of increased yield and improved nutritive value.

MATERIALS AND METHODS

A split-plot arranged in a randomized complete block design with three replications was laid out in this study. Fertilizer levels served as the main-plots and stages of maturity as the sub-plots.

The treatments were as follows:
Fertilizer Levels (Main plots)

M_1 – with fertilizer application at the rate of 45 kg each of N, P_2O_5 and K_2O per hectare

M_2 – without fertilizer application

Stages of Maturity (Sub-plots)

T_1 – harvested at 15 days after flowering

T_2 – harvested at 25 days after flowering

T_3 – harvested at 35 days after flowering
T_4 – harvested at 45 days after flowering

About 80 soybean (var. TK-5) seeds were sown about 3 to 4 cm deep in each row. A row spacing of 75 cm was employed for convenience in cultivation. There were four rows (4 m long each) per sub-plot.

Complete fertilizer (14-14-14) was applied in the row all at planting time at the rate of 45 kg each of N, $P_2 0_5$ and $K_2 0$ per hectare in the fertilized plots. Cultural practices such as weeding, spraying of pesticides, irrigation and drainage were done.

In all replications, the plants were harvested at the designated time. For yield determination, all the plants in the four rows per sub-plot were harvested. The yield was calculated using the following formula:

$$Y_E = \frac{Y_A\ (100 - \%\ MC_A)}{100 - \%\ MC_E}$$

where: Y_E = computed yield at 12% M.C. (moisture content)
Y_A = actual yield
MC_A = actual M.C.
MC_E = 12% M.C.

For crude protein analysis, 10 randomly selected sample plants per row, were used. Seeds were oven-dried at 43°C to constant weight. The sample was prepared for analysis by grinding the oven-dried samples until they passed through a 20-mesh sieve. The crude protein content was determined using the Kjeldajl method (Hamilton and Simpson, 1973). The total protein yield was calculated by multiplying the percent crude protein by the dry matter yield of seeds per hectare.

RESULTS AND DISCUSSION

Bean Yield (kg/ha)

Effect of Fertilizer Application

Table 1 presents the yield of soybeans harvested at different stages of maturity as affected by fertilizer application. In general, plants treated with fertilizer significantly produced higher yield than those which were not fertilized. However, fertilizer application did not significantly influence the yield of beans when harvested at 15 and 25 days after flowering but it significantly increased the yield when the beans were harvested at 35 and 45 days after flowering. This is because during the early stages of pod development, the rate of nutrient accumulation was not as much as when the pod was approaching maturity (35 and 45 days after flowering). Nutrient uptake is slower at early bloom and increases towards maturity (Caldwell, 1973). It was believed that among the three major fertilizer elements added, potassium contributed most to the increase in bean yield. This agrees with the findings of Hartwig (1962, as cited by Martin et al., 1964) that application of potassium resulted in higher bean yields and its deficiency seriously reduced crop

Table 1. Soybean yield at different stages of maturity as affected by fertilizer application.

Stage of Maturity (days after flowering)	Yield (kg/ha)		
	Fertilizer Level (kg NPK/ha)		Mean
	0-0-0	45-45-45	
15	44.43	75.63	60.03
25	240.35	403.20	321.78
35	566.07	871.03	718.55
45	918.36	1210.31	1064.34
Fertilizer Level Mean	442.02	640.04	541.17
LSD (0.05)			

Fertilizer Level Means – 175.06

Stages of Maturity Means – 127.44

Stages of Maturity at the Same Fertility Level – 180.09

Fertilizer Level at the Same Stage of Maturity – 183.76

yield. However, it should also not be overlooked that application of nitrogen and sufficient amount of phosphorus caused a significant increase in both dry matter and pod number for all tested soils (Delorit et al., 1974).

Effect of Stages of Maturity

The yield of soybean was significantly influenced by the stage at which the pods were harvested for both the fertilized and unfertilized plants (Table 1). Plants harvested at 45 days after flowering gave the highest yields. This suggests that it is advantageous to harvest the plants when they are already mature. This variation in yield was obviously due to the stage of development of the pods and the beans. When harvested immature, pods are still small and the amount of dry matter accumulated by the seed is low, but pods are already fully developed with maximum dry matter accumulation when harvested at a mature stage.

Crude Protein Content (%)

Effect of Fertilizer Application

Fertilizer application did not significantly affect the crude protein content of the beans (Table 2). This result corroborates the findings of Draper (1976) that fertilizer application does not increase the crude protein content of soybean. This could possibly be due to the ability of the plant to obtain nitrogen from the atmosphere, the elemental nitrogen being reduced to ammonia by nodulating bacteria living in the root nodules of the plant. The ammonia serves as the precursor in the synthesis of the amino acids and protein which are finally translocated to the seeds at maturity (Salisbury, 1973). Moreover, fertilizer application did not significantly influence the crude protein content of the beans at each stage of maturity. This could be probably because the rate of absorption of the available nitrogenous compounds such as nitrate and ammonia did not significantly vary at each stage

Table 2. Crude protein content of the beans (dry matter basis) at different stages of maturity as affected by fertilizer application.

Stage of Maturity (days after flowering)	Crude Protein Content (%)		
	Fertilizer Level (kg NPK/ha)		Mean
	0-0-0	45-45-45	
15	25.28	26.41	28.24
25	32.45	36.12	34.28
35	36.90	40.50	38.70
45	37.13	43.39	40.26
Fertilizer Level Mean	32.94	36.60	34.77
LSD (0.05)			

Fertility Level Means — 6.30

Stages of Maturity Means — 4.85

Stages of Maturity at the Same Fertility Level — 6.86

Fertilizer Level at the Same Stage of Maturity — 6.73

of maturity and theoretically would not cause significant variation in their crude protein contents (Salisbury, 1973).

Effect of Stage of Maturity

As the bean matured, its crude protein content generally increased (Table 2). Plants harvested at 45 days after flowering produced seeds with the highest crude protein content. This is expected because nitrogen (available form) stored in vegetative plant parts is transferred to the developing seeds upon maturation (Caldwell, 1977).

Significant differences were detected between the crude protein contents of samples harvested at 15 days after flowering and those harvested at the other three stages of maturity, with or without fertilizer application. When fertilizer was applied, significant difference was also noted between the protein content of samples harvested at 25 and 45 days after flowering.

The insignificant differences in the crude protein contents of samples with maturity differences of only 10 days (25 vs. 35 days and 35 days vs. 45 days), except between samples harvested at 15 and 25 days after flowering, suggest that the accumulation of nitrogenous compounds within a 10-day period during the later stages of maturity was not high enough to significantly increase crude protein content. Such rate of accumulation was even less when no fertilizer was applied as suggested by the insignificant difference in crude protein contents of samples harvested at 25 and 45 days after flowering.

Total Protein Yield (kg/ha)

Effect of Fertilizer Application

The total protein yield of soybean as affected by fertilizer application is presented in Table 3. Fertilizer application significantly influenced the total protein yield of soybean because it increased both dry weight accumulation and crude protein content. With or without fertilizer application, samples harvested 15 days after flowering had significantly lower total protein yield than those harvested at later stages of maturity. The values did not significantly increase when the plants were fertilized and then harvested at 15 and 25 days after flowering. However when the plants were harvested at 35 and 45 days after flowering, total protein yield was greatly increased by fertilizer application. This is expected because when the plants were harvested immature, the amount of dry matter accumulated as well as the nitrogenous compounds translocated to the seeds was not significantly increased. Rapid pod development characterized by linear accumulation of dry matter and crude protein occur only at 3 weeks after flowering or near maturity (Evans, 1975).

Effect of Stage of Maturity

Without fertilizer application, there was no significant increase in the total protein yield when the plants were harvested up to 25 days after flow-

Table 3. Total protein yield of soybeans (kg/ha) at different stages of maturity as affected by fertilizer application.

Stage of Maturity (days after flowering)	Total Protein Yield (kg/ha)		Mean
	Fertilizer Level (kg NPK/ha)		
	0-0-0	45-45-45	
15	9.83	17.58	13.70
25	70.91	127.84	99.37
35	185.67	315.45	250.56
45	299.37	461.23	380.30
Fertilizer Level Mean	141.44	230.52	185.98

LSD (0.05)

Fertility Level Means – 46.62

Stages of Maturity Means – 52.63

Stages of Maturity at the Same Fertility Level – 74.42

Fertility Level at the Same Stage of Maturity – 59.08

ering. However, delaying the harvesting for at least another 10 days (35 days after flowering) significantly increased the total protein yield.

When the plants were fertilized, there was a significant increase in total protein yield for every 10-day increment in maturity. Moreover, the increase in total protein yield during a 10-day period was significant when the plants were fertilized but not when unfertilized. In the latter, a significant increase can only be detected after at least 20 days delay in harvesting.

Significant interaction was observed between the effect of fertility levels and stages of maturity on the total protein yield of soybean. Although the total protein yield continuously increased with plant maturity, the magnitude of increase in total protein yield when no fertilizer was added did not correspond to the increase when fertilizer was applied. The total protein yield at 25 days after flowering even without fertilizer treatment (70.91 kg/ha) is higher than the yield at 15 days after flowering with ferti-

lizer treatment (17.58 kg/ha). The total protein yield at 35 days after flowering without fertilizer (185.67 kg/ha) is also higher than the yield at 25 days after flowering with fertilizer treatment (127.84 kg/ha). These results further suggest that the total protein yield of soybean is greatly affected by fertility levels at different stages of maturity.

Bean Yield vs. Crude Protein Content

The relationship between yield and crude protein content of soybean at different fertility levels and stages of maturity is shown in Figure 1. Regression analysis revealed that at different stages of maturity, yield and protein contents increased progressively. This result agrees with the findings of Aykrozd and Doughty (1977).

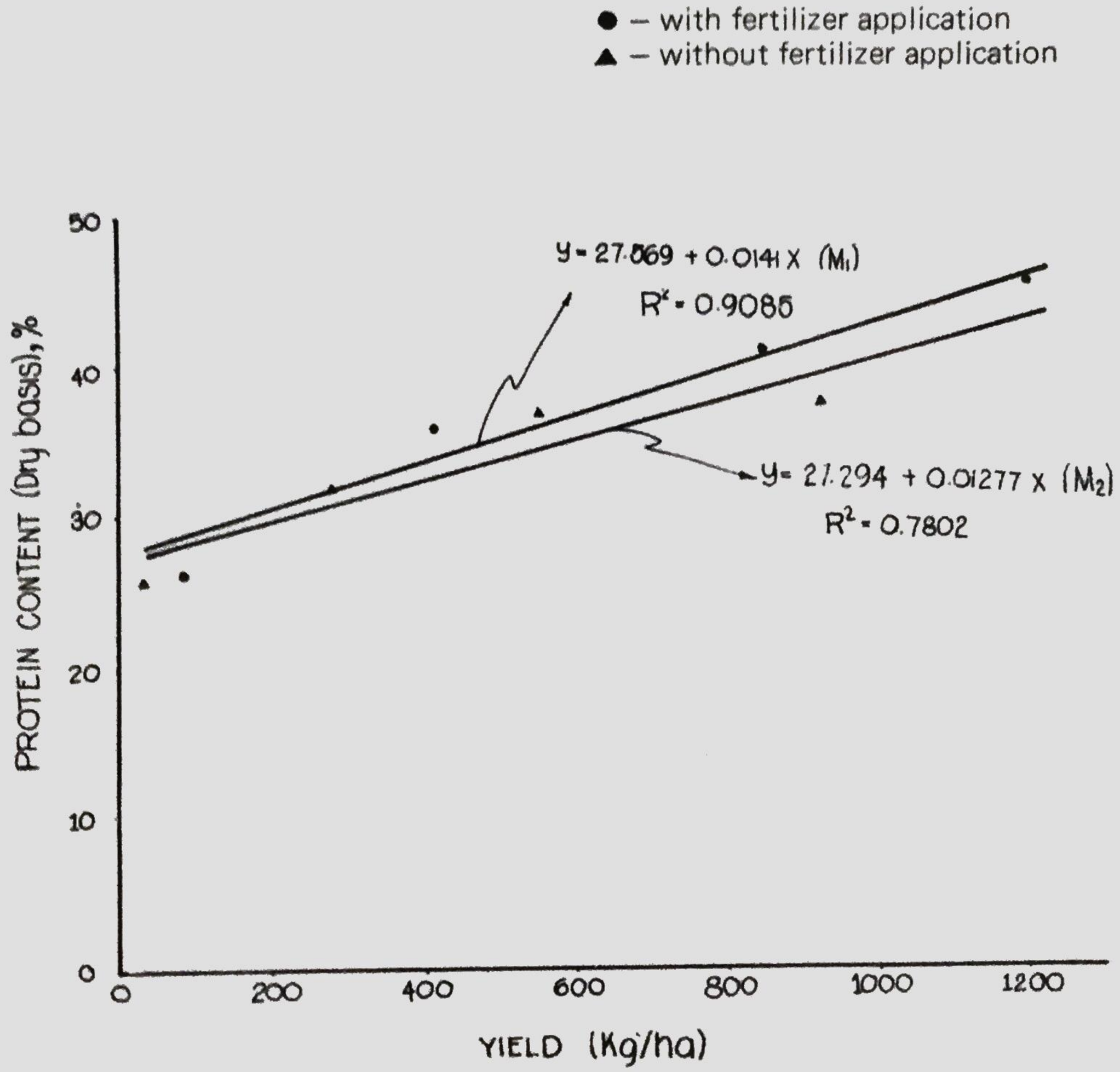

Fig. 1. Relationship between yield level and protein content of soybeans at different fertilizer levels.

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