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FOLIAR AND SOIL FERTILIZATION EFFECT ON SEED YIELD AND PROTEIN CONTENT OF SOYBEAN

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Abstract

A field experiment was carried out at Agronomy Farm of Patuakhali Science and Technology University, Dumki, Patuakhali, from December 2011 to March 2012, to study the effects of nutrient foliar spray on soybean growth, yield and protein content. Soybean variety Shohag was used as the test crop. N, NPK, NPKS and NPKMg were sprayed and applied in the soil at vegetative and pod filling stages. Soil fertilizations were done as recommended dose, and no soil and foliar fertilization were considered as control. Plants were sprayed at the rate of 100 mg/L of water corresponding to each nutrient. The experimental design was a split plot with three replications. Result indicated that nutrient foliar spray, either singly or in combination, enhanced the growth and yield of the soybean as well as protein content in soybean seed, at the two growth stages compared to soil fertilization. However, spraying nutrients during pod filling stage was better than vegetative spraying stage in all characters studied. The highest amount of protein content in soybean seed and grain yield were obtained by spraying NPKMg.

Introduction

Soybean (*Glycine max* (L) Merr.) belongs to leguminous family ranked as a top oilseed crop, which provides approximately 50% edible oil of the world (Akparobi, 2009). It has been recognized as an ancient crop plant since the origin of agriculture (Jandong *et al*., 2011). Due to the large amount of macro and micro nutrients, it has been considered as a nutritious food for human needs, livestock, industrial and medicinal purposes (Akparobi, 2009). Soybean seed consists of 18 to 25% oil and 30 to 50% protein. Protein of soybean seed contains amino acids required for human nutrition and livestock (Raei *et al*., 2008). Salwa *et al*. (2011) stated that soybean is a crop that compensates shortage of oil and protein of other crops. Furthermore, it is a good source for high energy, protein and essential nutrients to human and animals. A successful initiative to introduce soybean in Bangladesh was taken in the beginning of the eighties. At present soybean is not extracted in our country for oil because of lacking industrial facilities and is consumed as food products (soya-milk, soya-meat, soya-flour etc.) and ingredients of animals and poultry feed. Usually, more than 95 % of the total population of Bangladesh cannot afford protein rich food like fish, meat, egg, milk etc. due to higher price and low production. So, as supplement of low cost protein, soybean should be cultivated in more areas which can help to alleviate protein calorie malnutrition of cereal based diet in Bangladesh.

For optimum plant growth, nutrients must be balanced or in other words the soil must have nutrients that are needed for plants (Chen, 2006). Biological N_2 fixation and mineral soil or nitrogen fertilizer are the main source of meeting the nitrogen (N) requirement of high-yielding soybean (Salvagiottiet *et al.*, 2008). The mineral nutrition of crops can be supplemented with fertilizer application to soils or foliage (Mallarino *et al*., 2001). Fertilization with N, phosphorus (P), potassium (K) and other nutrients can affect yield and many physiological processes, which in turn could influence grain yield and protein concentration (Haq and Mallarino, 2005). Foliar spraying is a new method for crop feeding, which nutrients in form of liquid are used into leaves (Nasiri *et al*., 2010). Foliar application of nutrient elements is more beneficial than soil application. Since application rates are lesser as compared to soil application,

and crop reacts to nutrient application immediately (Zayed *et al*., 2011). Soybean higher yield and quality as well as its oil could be be obtained by foliar spray of nutrient elements (Vahedi, 2011). Arif *et al.* (2006) found that based on soil properties, foliar spraying could be effective 6 to 20 times as compared to soil application. Foliar application could be an advantage for crop growth (SeifiNadergholi *et al*., 2011). The objective of this study was therefore to assess the effect of foliar nutrient spray singly or in combinations before flowering and pod filling stages, on the growth, yield and seed quality of soybean.

Materials and Methods

The field experiment was carried out at Agronomy Farm of Patuakhali Science and Technology University, Dumki, Patuakhali, from December 2011 to March 2012 to determine the effects of foliar spray of nutrients on the growth, yield and protein content of soybean seed. Before planting, soil samples were collected from experimental area at 0-30 cm depth. The results of soil analysis were shown in Table 1. The soybean variety used was Shohag. The experimental design was split- plot having 4 m x 2.5 m plot size with three replications.

Table 1. Physical and chemical properties of experimental soil

Soil properties	Value
Soil texture	Clay
Silt (%)	28.2
Clay (%)	68.5
Sand (%)	3.3
Organic matter (%)	1.6
pH	6.2
Electrical conductivity (dS m^{-1})	1.45
N (%)	0.66
P (ppm)	5.60
K (ppm)	5.31
zinc (mg kg^{-1})	1.09
Iron (mg kg^{-1})	2.76
Manganese (mg kg^{-1})	2.00

Each block (replicate) was divided into main plots where growth stages (vegetative and pod filling) and six subplots to which nutrients were foliarly applied as exclusively N, NPK, NPKS and NPKMg at the rate of 100 mg $litre^{-1}$ of each nutrient were randomly assigned. Soil fertilizations were done as recommended dose and no soil and foliar fertilization in control plot. Nitrogen was derived from Urea, phosphorus from sodium dihydrogen orthophosphate ($Na_2H_2PO_4.2H_2O$), potassium from potassium chloride (KCl), Sulphur from Gypsum ($CaSO_4$) and magnesium from hydrated magnesium chloride ($MgCl_2.6H_2O$). Planting of seeds was done on 03 December, 2011 maintain spacing 30 cm x 5 cm. Weeding was done at 2 and 6 weeks after sowing (WAS). Plants were sprayed at vegetative (4 weeks after sowing) and pod filling (8 weeks after sowing) stages as per treatment. Ten selected plants were used to take the data from each plot of each replication. Data were recorded for grain yield, plant height, dry weight of different plant parts, number of pods $plant^{-1}$, number of seeds pod^{-1} and 100 grain weight. The nitrogen concentration in seeds was measured with micro-Kjeldahl method as described by Peach and Tracey (1956) and the seed protein content was determined by multiplying the nitrogen percentage and protein factor using the formula, Protein percentage = Nitrogen percentage x 5.71 (Breese, 1931). Data collected were analyzed using MSTAT- C program. The means differences among the treatments were compared by least significance difference test (LSD).

Results and Discussion

Effects of foliar spray on plant height and dry matter production

The data presented in Table 2 showed that the foliar application of essential mineral nutrients, either singly or in combinations, was consistently beneficial to soybean growth and development. Similarly, foliar spray during the vegetative and pod filling stages, also enhanced the performance of soybean. This result agreed with the work of Tayo (1981).

Table 2. Effects of foliar spray on plant height and dry matter production of soybean

Interaction of growth stages and nutrients	Plant height (cm)	Number of branches plant^{-1}	Stem dry weight (g)	Leaf dry weight (g)	Total dry weight (g)
V x Control	39.92	3.00	9.40	15.51	24.94
V x N	41.05	4.11	10.49	16.47	26.96
V x NPK	44.24	5.11	9.86	19.16	29.02
V x NPKS	44.61	5.33	11.12	20.43	31.55
V x NPKMg	46.92	7.38	11.95	21.63	33.58
V x R	43.72	4.35	9.89	16.95	26.84
P x Control	41.85	3.67	10.09	18.89	28.98
P x N	42.45	5.00	11.02	20.10	31.12
P x NPK	42.97	6.00	12.71	20.95	33.66
P x NPKS	43.51	7.67	13.59	21.79	35.38
P x NPKMg	44.85	8.68	14.97	23.47	38.44
P x R	42.26	5.86	10.51	21.54	32.05
$LSD_{(0.05)}$	8.29	1.53	2.54	15.50	16.39
CV (%)	10.24	9.49	10.17	12.35	13.37

V- Vegetative stage, P – Pod filling stage, Control (No soil and foliar fertilization), N- Foliar spray with single N, NPK- Foliar spray with NPK, NPKS - Foliar spray with NPKS, NPKMg - Foliar spray with NPKMg, R - Recommended fertilizer dose (1/2 N and full PK basal dose in soil + ½ N top dressing)

Plant sprayed with different nutrient combination generally had significantly higher plant height, higher number of branches, leaf dry weight, stem dry weight and total dry weight than control plants. Plant spraying with NPKMg produced the tallest plant with the highest total dry matter production in both the spraying stages. This could be that Mg is important in chlorophyll formation, resulting in higher photosynthesis and higher leaf growth. Stimulated photosynthetic activity and synthesis of chloroplast and protein which might have resulted in higher dry matter production as reported in soybean crop (Mishra and Agrawal, 1994). Spraying during the pod filing growth stage led to plants with higher plant height, branches plant^{-1}, stem dry weight, leaf dry weight and total dry weight than that of spraying during vegetative stage. This was probably due to the fact that all plants had reached the peak of vegetative growth before spraying was done. The fact that spraying during the pod filling growth stage would be ultimately better than spraying at vegetative stage, since the former plants had significantly higher values of all the parameter studied.

Yield attributes and protein of seed

Number of pods: Number of pods plant^{-1} is an important yield component in soybean and all the foliar spray treatments viz., N, NPK, NPKS and NPKMg increased the number of pods plant^{-1} at both growth stages (Table 3). The foliage applied nitrogen and phosphorus at the vegetative stage might have effectively absorbed and translocated to the pods resulting in more number of pods plant^{-1}. The results obtained by Solaiappan *et al.* (2002) in redgram are concomitant to the present finding. Foliar spray of these nutrients at pod filling stage of crop growth might have caused efficient translocation of

photosynthates from source to sink. However, sprayed with NPKMg during the pod filling stages of growth was higher and significantly different from those plants sprayed during at vegetative stage of growth. The foliar application of nutrients through NPKMg at pod filling stage might have reduced flower drops. This might have significantly increased the number of pods plant^{-1} as reported by Ganapaty *et al.* (2008).

Number of seed pod^{-1} and seed index: Foliar application of essential nutrients during vegetative and pod filling stages of crop growth significantly influenced the number of seed pod^{-1} and 100-seed weight (Table 3). This might be due to better absorption of nutrients applied through foliage leading to better activity of functional root nodules resulting in more dry matter production. This could have lead to more flower production and subsequently pod formation and other yield attributes. The increased 100-seed weight might be attributed to increased mobilization of metabolites to the reproductive sinks. Furthermore, plants sprayed with NPKMg during pod filling stage had significantly the highest number of pods plant^{-1} and 100-seed weight in respect of sprayed at vegetative stage.

Table 3. Effects of foliar spray on yield, yield contributing characters and protein % of soybean

Interaction of growth stages and nutrients	Pods number per plant	Seed number per pod	100-seed weight (g)	Grain yield m^{-2} (g)	Protein (%)
V x Control	83.67	2.06	4.83	155.10	21.33
V x N	85.70	2.23	6.01	164.34	25.00
V x NPK	85.38	2.50	7.92	170.09	30.00
V x NPKS	87.00	2.60	8.39	171.37	31.10
V x NPKMg	90.33	3.00	10.0	182.74	35.67
V x R	84.65	2.33	5.66	169.05	27.45
P x Control	85.09	2.30	6.85	148.40	21.00
P x N	86.00	2.56	7.63	165.07	26.00
P x NPK	87.67	2.73	8.19	173.75	29.33
P x NPKS	88.49	2.83	9.24	174.60	33.00
P x NPKMg	92.67	3.13	12.52	187.20	37.33
P x R	86.55	2.46	7.03	169.30	27.33
$LSD_{(0.05)}$	2.01	0.35	2.06	10.47	3.69
CV (%)	1.64	5.93	9.31	3.80	5.09

V- Vegetative stage, P – Pod filling stage, Control (No soil and foliar fertilization), N- Foliar spray with single N, NPK- Foliar spray with NPK, NPKS - Foliar spray with NPKS, NPKMg - Foliar spray with NPKMg, R - Recommended fertilizer dose (1/2 N and full PK basal dose in soil + ½ N top dressing)

Grain yield and protein (%) in seed:

Interaction effects of foliar application of different nutrients and growth stages had significant variations in grain yield and protein content (Table 3). Plant sprayed with NPKMg during vegetative and pod filling stages shown a better performance in grain yield and yield contributing attributes and protein % compared with other treatment combinations. Foliar spraying during the pod filling stage was more effective than during vegetative stage in all the parameters studied, probably because nutrients applied during pod filling were readily used for photosynthesis and assimilates quickly mobilized for grain filing and protein accumulation in grain. The increased yield might be due to enhanced yield attributes like number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight due to increased uptake of nutrients by soybean by effective translocation of nutrients from sink to reproductive area of crop. Spraying with NPKMg during pod filling stage enhanced yield and protein content of soybean, compared with other nutrient combinations. This agreed with the work of Ashour and Thallooth (1983). In conclusion, it appears that nutrient spraying enhanced soybean growth, development, yield and protein content and

spraying in the pod filling stage is better than spraying during vegetative stage. As for the nutrient combinations, NPKMg appear to give the highest yield and protein content of soybean.

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References

Akparobi, S. O. 2009. Evaluation of six cultivars of soybean under the soil of rainforest agro-ecological zones of Nigeria. Middle-East J. Sci. Res. 4(1): 06-09. Available online at: http://idosi.org/mejsr/mejsr4(1)/2.pdf.

Arif, M., M. A. Chohan, S. Ali, R. Gul and S. Khan. 2006. Response of wheat to foliar application of nutrients. J. Agric. Biol. Sci. 1(4). Available online at: http://www.arpnjournals.com/jabs/research_papers/jabs_1106_36.pdf.

Ashour, N. I. and A. T. Thalloth. 1983. Effects of soil and foliar application of N during pod development and yield of soybean (*Glycine max*, (L) Merill) plants. Field Crops Res. 6: 261-266.

Breese, J. 1931. Factors for converting percentage of nitrogen in foods and feeds into percentages of protein. United StatesD.partment of Agriculture Washington, p.22.

Chen, J. 2006. The combined use of chemical and organic fertilizer and/or biofertilizer for crop growth and soil fertility. Taipei Food Fert. Technol. Bull., 17: 1-9.

Ganapaty, M., G. Baradban and N. Ramesh. 2008. Effect of foliar nutrition on reproductive efficiency and grain yield of rice fallow pulses. Legume Res. 31: 142-144.

Haq, M. U. and A. P. Mallarino. 2005. Respones of soybean grain oil and protein concentrations to foliar and soil fertilization. Agron. J. 97: 910- 918.

http://www.academicjournals.org/jmpr/PDF/pdf2010/4Sept/Nasiri%20 et% 20al.pdf.

Jandong, E. A, M. I. Uguru and B. C. Oyiga. 2011. Determination of yield stability of seven soybean *(Glycine max)* genotypes across diverse soil pH levels using GGE biplot analysis. J. Appl. Biosci. 43: 2924-2941.

Mallarino, A. P., M. U. Haq, D. Wittry and M. Bermudez. 2001. Variation in Soybean Response to Early Season Foliar Fertilization among and within Fields. Agron. J. 93: 1220-1226. Available online at: https://www.soils.org/publications/aj/pdfs/93/6/1220.

Mishra, A. K. and H. P. Agarwal. 1994. Effect of sulphur on growth, yield, protein and oil content of soybean. J. Oilseeds Res. 11: 99-102.

Nasiri Y., S. Zehtab-Salmasi, S. Nasrullahzadeh, N. Najafi and K. Ghassemi- Golezani. 2010. Effects of foliar application of micronutrients (Fe and Zn) on flower yield and essential oil of chamomile (*Matricaria chamomilla* L.). J. Med. Plants Res. 4(17): 1733-1737.

Peach K. and M. V. Tracey. 1956. Modern methods of plant analysis. Springer-Verlag, Berlin.

Raei. E., M. Sedghi and R. Sayed Sharifi. 2008. Effect of *Bradirizobium* inoculation, application of nitrogen and weeding on growth and seed filling rate in soybean. J. Agric. Technol. 12(43): 91-81.

Salvagiottiet, F., K. G. Cassman, J. E. Specht, D. T. Walters, A. Wiss and A. Dobermann. 2008. Nitrogen uptake, fixation and response to fertilizer N in soybean: a review. Field Crop Res. 108: 1-13.

Salwa, A. I. E., M. B. Taha and M. A. M. Abdalla. 2011. Amendment of soil fertility and augmentation of the quantity and quality of soybean crop by using phosphorus and micronutrients. Intl. J. Acad. Res. 3(2): part 3. Available online at: http://www.ijar.lit.az/pdf/10/2011(10-127).pdf.

SeifiNadergholi, M., M. Yarnia and F. Rahimzade Khoei. 2011. Effect of zinc and manganese and their application method on yield and yield components of common bean *(Phaseolus vulgaris* L. *CV. Khomein).* Middle-East J. Sci. Res. 8(5): 859-865.

Solaiappan, D., V. K. Paulpandi and N. Chellaiah. 2002. Effect of graded levels of phosphorus and foliar fertilization on short duration redgram in rainfed vertisol. Madras Agric. J. 87: 451-454.

Tayo, T. O. 1981. Studies on the effects of foiar spray of nutrients on the performance of cowpea (*Vigna unguiculata* (L) Walp). J. Agril. Sci. Camb. Cult. Sci., Cambridge, 96: 375-388.

Vahedi, A. 2011. The effects of micronutrient application on soybean seed yield and on seed oil and protein content. J. Am. Sci. 7(6). Available online at: http://www.jofamericanscience.org/ journals/amsci/0706/110_5746am0706_672_677.pdf.

Zayed, B. A., A. K. M. Salem and H. M. El Sharkawy. 2011. Effect of different micronutrient treatments on rice *(Oryza sativa* L.*)* growth and yield under saline soil conditions. World J. Agric. Sci. 7(2): 179-184. Available online at: http://www.idosi.org/wjas/wjas7 (2)/12.pdf.