INFLUENCE OF SULPHUR AND BORON ON GROWTH AND YIELD OF GARDEN PEA (*Pisum sativum* L.)

SHOVAN KRISHNA DAS

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA-1207

JUNE, 2020

INFLUENCE OF SULPHUR AND BORON ON GROWTH AND YIELD OF GARDEN PEA (*Pisum sativum* L.)

BY

SHOVAN KRISHNA DAS

REG. NO. 13-05370

A Thesis
Submitted to the Department of Horticulture
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY- JUNE, 2020

APPROVED BY:

Prof. Dr. Khaleda Khatun
Department of Horticulture
Sher-e-Bangla Agricultural University
Supervisor

Prof. Dr. Tahmina Mostarin
Department of Horticulture
Sher-e-Bangla Agricultural University
Co-Supervisor

Prof. Dr. Md. Jahedur Rahman
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

Ref. No. : Date :

CERTIFICATE

*This is to certify that the thesis entitled, **"INFLUENCE OF SULPHUR AND BORON ON GROWTH AND YIELD OF GARDEN PEA Pisum sativum L.)"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **SHOVAN KRISHNA DAS,** Registration No. **13-05370** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Prof. Dr. Khaleda Khatun
Department of Horticulture
Sher-e-Bangla Agricultural University, Dhaka-1207
Supervisor

Dated: June, 2020
Dhaka, Bangladesh

Dedicated

to My

Beloved Parents

ACKNOWLEDGEMENTS

*All praises to the **"Almighty God"** Who enable the author to complete a piece of research work and prepare this thesis for the degree of Master of Science (MS) in Horticulture.*

*The author feel much pleasure to express his gratefulness, sincere appreciation and heartfelt liability to my venerable research supervisor **Prof. Dr. Khaleda Khatun**, Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh for her scholastic guidance, support, encouragement, valuable suggestions and constructive criticism throughout the study period.*

*He wants to also express his gratitude, gratefulness and thankfulness to reverend co-supervisor **Prof. Dr. Tahmina Mostarin** and Chairman, **Prof. Dr. Md. Jahedur Rahman,** Department of Horticulture, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207 for his constant inspiration, valuable suggestions, cordial help, heartiest co-operation and supports throughout the study period.*

*It is also an enormous pleasure for the author to express his cordial appreciation and thanks to all **respected teachers** of the Department of Horticulture, Sher-e-Bangla Agricultural University, for their encouragement and co-operation in various stages towards completion of this research work.*

*The author deeply acknowledges the profound dedication to his beloved **Parents and Sisters** for their moral support, steadfast encouragement and continuous prayer in all phases of academic pursuit from the beginning to the completion of study successfully.*

Finally, the author is deeply indebted to his friends and well-wishers for their kind help, constant inspiration, co- operation and moral support which can never be forgotten.

The Author

INFLUENCE OF SULPHUR AND BORON ON GROWTH AND YIELD OF GARDEN PEA (*Pisum sativum* L.)

BY

SHOVAN KRISHNA DAS

ABSTRACT

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during the period from October, 2018 to March, 2019 to study the influence of sulphur and boron on growth and yield of garden pea. The experiment comprised of two factors. Factor A: Levels of Sulphur (4 levels); S_0: 0 kg S/ha (Control), S_1: 10 kg S/ha, S_2: 20 kg S/ha, S_3: 30 kg S/ha and Factor B: Levels of Boron (4 levels); B_0: 0 kg B/ha (Control), B_1: 1 kg B/ha, B_2: 2 kg B/ha, B_3: 3 kg B/ha. This experiment was laid out in Randomized Complete Blocked Design (RCBD) with three replications. Sulphur and Boron application influenced significantly on most of the parameters. In case of sulphur, maximum plant height (50.84 cm), number of pods per plant (14.00), pod length (8.95 cm), number of seeds per pod (5.56) and green pod yield (10.76 t/ha) were recorded from S_3 treatment. In case of boron application, maximum plant height (49.17 cm), number of pods per plant (13.48), pod length (8.66 cm), number of seeds per pod (5.41) and green pod yield (10.14 t/ha) were found in B_2 treatment. Among the treatment combination, S_3B_2 treatment gave the highest green pod yield (12.19 t/ha) and the lowest (5.38 t/ha) was obtained from S_0B_0 treatment. The highest gross return (Tk. 365700), net return (Tk. 217585) and BCR (2.46) were obtained from the treatment combination of S_3B_2 where the lowest gross return (Tk. 161400), net return (Tk.17647) and lowest BCR (1.12) were obtained from S_0B_0. So, garden pea sown at 30 kg S/ha with 2 kg B/ha suitable for green pea production in Dhaka region.

CONTENTS

CONTENTS (Cont'd.)

CONTENTS (Cont'd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

ABBREVIATIONS	ELABORATIONS
AEZ	: Agro-Ecological Zone
ANOVA	: Analysis of Variance
BDT	: Bangladesh Taka
CV%	: Percentage of Coefficient of Variation
Df	: Degrees of freedom
DM	: Dry matter
et al.	: and others
FAO	: Food and Agricultural Organaization
SAU	: Sher-e-Bangla Agricultural University
BARI	: Bangladesh Agricultural Research Institute
BAU	: Bangladesh Agricultural Universiry
BBS	: Bangladesh Bureau of Statistics
DAS	: Day after Sowing
LSD	: Least Significant Difference
TDM	: Total Dry Matter

CHAPTER I

INTRODUCTION

Garden pea (*Pisum sativum* L.) belongings to the family Fabaceae (formerly Leguminosae) and subfamily Papilionoideae is one of the most important legume vegetables in Bangladesh and mostly grown for green pods and seeds. Pea is a native of Europe and Northern Asia. Ethiopia is probably the main centre of origin of garden pea (Choudhury, 2000). It is a cool season crop now grown in many parts of the world. Pea is an annual herbaceous plant. The plants are succulent erect in case of garden pea while in case of field pea, they have a tendency to climb when provided support. Plants bear tap root system with nodules on the surface. Stem is hollow, slender, succulent and ridged. It bears pinnately compound leaves with three pairs of leaf-lets and terminal one is modified into a branched tendril. At the base of the petiole (on the stem) large pair of stipules on bracts are found and they cover the petioles in such a way that leaves look like sessile.

The green pods and immature seeds are rich in vitamin and have a balanced amino acid composition. Moreover, some important mineral such as calcium, phosphorus, iron are present in abundant quantities in peas. The crop becomes popular for its high nutritive value and good taste. It contains 15-35% protein, 20-50% starch, 4-10% sugar, 0.6-1.5% fat and 2-4% minerals (Makasheva, 1983). Fresh green pea per 100 g contain about 93 calories energy, 72.0 percent moisture, 7.2 g protein, 15.8 g carbohydrates, vitamin A 139 I.u. vitamin C 9 mg (Choudhury, 2000). The importance of garden pea as a vegetables crop has sharply increases in many countries of the world. In Bangladesh people consumes 23 g vegetables per head per day but the minimum requirement is 200 g per head per day (Rashid, 1993). As the nation with an acute shortage of vegetables its production should be increased to meet the shortage. At present pea is being cultivated in an area of 17746 acres with a production of 8139 metric tons (BBS, 2018). The average yield is only 0.82 ton per hectare which is much lower as compared to other pea growing countries such as USA 3.94 ton/ha and France 2.23 ton/ha (Makasheva, 1983). The yield is mainly due to lack of modern cultural practices. Garden peas are harvested in an immature stage and are used as vegetable and are marketed fresh, canned or frozen (Prabhakara *et al.*, 2001). Besides, being rich in health building substances such as protein, carbohydrates, vitamins, minerals, sugars and starch. It is an important source of lysine, the limited amino acid in cereals. Symbiotic association of peas with nitrogen fixing bacterium (Rhizobium leguminosarium) improves soil fertility by contributing nitrogen in soil with negligible expense. Use of sulphur free and less application of boron fertilizers has created deficiencies of these nutrients while as the organic manures are used in very less amount which are the source of different macro as well as micro-nutrients including sulphur and boron, this has resulted in the deficiencies of sulphur and boron in the soils. The deficiency of these nutrients in the soils limits the growth and yield of various vegetable crops including garden pea, indicating the need of their application (Jones *et al*., 1972).

Sulphur is a plant nutrient with a crop requirement similar to that of phosphorus. Sulphur is known as the fourth major plant nutrient (Gowswamy, 1986). It is essential constituent of sulphur containing amino acids cystine, cysteine and methionine and plays vital role in regulating the metabolic and enzymatic process including photosynthesis, respiration and symbiotic N fixation, besides being responsible for the synthesis of vitamins such as biotine, thiamine, vitamin B and certain coenzymes (Chadha, 2003, Kumar and Singh, 2009). It has been observed when Sulphur is present in critical amount of soil (less than 10 ppm), the plant growth, quality and total production of crop is adversely affected (Jones *et al*., 1972). Sulphur application in vegetable crops have been found to improve quality attributes, protein content, oils and vitamins (Dhar *et al*., 1999 and Sriramchandra Sekharan, 2009). Sulphur also helps in improving the nutrient content and uptake of nutrients in legume crops (Singh and Singh, 1992).

Boron is one of the essential micronutrient required for normal growth of most of the plants. Boron is required for proper development and differentiation of tissues besides being helpful in reducing sterility and malformation in reproductive organs (Singh, 1996). Boron helps in the normal growth of plant and in absorption of nitrogen from soil, translocation of sugars, cell wall synthesis, root elongation and nucleic acid synthesis (Das, 1993 and Chadha, 2003). The boron improves the grain and straw yield, nutrient content, nutrient uptake and quality in legume crops (Singh *et al*., 2004). Sinha *et al.* (2006) indicates that variation in boron supply influence plant growth in tomato cv. DL- 3, which became apparent after 32 days of sowing. Boron deficiency symptoms included the shortening of internode, and development of thick, brittle and outward curled young leaves. Under excessive boron, toxicity symptoms appeared on the growth of plants and was markedly reduced, old leaves developed marginal necrosis, and the number of size lamina were reduced. In low and excessive boron, the concentration of reducing, non-reducing and total sugars and phenols were high in fruits. The concentration of starch, ascorbic acid and dycopene were low in low boron situation.

The combined application of sulphur and boron improves the germination, seedling growth and yield attributes of garden pea (Nasreen and Farid, 2003). Keeping in view the importance of secondary element sulphur and micronutrient boron, an investigation has been carried out to assess the effects of sulphur and boron for higher yield and quality in garden pea under Dhaka agro-climatic conditions with the following objectives:

- To find out the response of different levels of sulphur on growth and yield of garden pea.
- To determine the appropriate amount of boron for maximum yield of garden pea.
- To assess the combined effect of Sulphur and boron on growth and maximum yield of garden pea.

CHAPTER II

REVIEW OF LITERATURE

Among the pulse crops, garden pea occupies the greater position in Bangladesh. Pea being a fabaceae vegetable having high yield potential would require an ample supply of plant nutrients to ensure proper growth, development and satisfactory yield. The crop has many similarities with other fabaceae crops. Growth and yield of garden pea have been studied in various parts of the world, but a little study has been done on this crop under the agro-ecological condition of Bangladesh. However, some of the important and informative works and research findings related to the sulphur and boron so far been done at home and abroad on other related crops have been reviewed in this chapter under the following headings-

2.1 Effect of Sulphur application on the growth and yield of garden pea

Kasturikrishna and Ahlawat (1999) conducted an experiment and reported that the application of 40 kg S/ha increased plant height, dry matter, pods/plant, number of grains/pod and 1000 grain weight in pea over the control.

(Malik and Abraham, 2003) found that increased rate of sulphur application exhibited an increase in the number of pods/plant, number of seeds/pod, 1000 seed weight and grain yield in pea.

Jain *et al*. (1984) observed that sulphur application in legumes in general and pea in particular has invariably resulted in increased pod production/plant.

(Khanna and Gupta, 2005) conducted an experiment and reported that increase in plant height, number of branches, fresh and dry weight of plant, pod size, seed number per pod, fresh pod yield, pod dry weight and 100 seed weight has also been reported due to S application (30 kg/ha) in pea.

Singh *et al*. (1998) conducted an experiment and reported that application of 90 kg S ha along with 120 N +60 kg Zn significantly increased plant height, number of branches, pods/plant, pod length, number of seeds/pod, 1000-seed weight, seed and stover yield in mustard.

Patil and Sheike (1998) reported that increased dose of sulphur application enhanced yield related components in mustard. The application of sulphur increased grain, straw and total dry matter yield in black gram (Singh and Singh, 2004).

Prasad and Prasad (2003) while studying the effect of sulphur (0,10,20, 30 and 40 kg/ha) on the dwarf (Sapna) and tall (Rachna) cultivars of field pea reported that grain yield, number of pods/plant number of grains/pod, grain weight/plant exhibited an increases with increasing sulphur levels upto 30 kg/ha.

Mishra *et al*. (1995) while studying the effect of sulphur (0, 30, 40 and 60 kg/ha) through element sulphur, pyrite and gypsum on straw and grain yield of chickpea reported that application of 60 kg S/ha increased grain yield of chickpea. Sharma and Shrivastava (1993) found that application of 40 kg S/ha increased seed yield in green gram.

Ghosh *et al*. (1996) reported that application of 20 kg S/ha in black gram increased seed yield. Kumar and Singh (2009) observed that the yield and bio-chemical composition of seeds in black gram improved favourably with increasing levels of sulphur.

Budhar and Tamilselvan (2001) while studying the effect of different levels of Sulphur (10, 20, 40 and 50 kg S/ha) on yield components of rainfed green gram, reported that 40 kg S/ha markedly increased the pods/plant, number of grains/pod and test weight of grains.

Dubey *et al*. (1997) reported that sulphur application enhanced the branches/plant, capsules/plant, seeds/capsule, and 1000-grain weight of lentil. Tondon and Mersick (2001) reported that there was 5.3 percent increase in yield of chick pea by applying sulphur in sulphur deficient areas.

Vishwakarma *et al*. (1998) reported that the nodule number and weight (Fresh and dry) of nodules/plant of soybean increased significantly with 20 kg S/ha application. Singh and Kumar (1996) while found that application of 30 kg S/ha in lentil significantly increased the plant height and the nodules/plant.

Singh (1995) reported that yield and yield attributes of pea got increased with increasing rate of sulphur application. Biswas *et al.* (2004) observed that 44 percent yield improvement was reported in pea with the application of 30-45 kg S/ha.

Chaubey and Singh (2004) observed that increases in growth and yield related attributes of pea was observed with increasing levels of sulphur and highest yield was achieved at 30 kg S/ha.

Shankaralingappa *et al*. (2002) reported that the sulphur application @ 40 kg/ha increased plant height, number of pods per plant, grain yield and 1000-seed weight in pigeon pea.

Zhao et al. (1999) found that increase in number of pods per plant, seed yield and shoot dry weight in pea was reported with the sulphur application.

Ramesh et al. (2004) observed that yield and yield attributes of pea increased with increasing rates of sulphur fertilizer.

Shivran et al. (2000) conducted an experiment and reported that application of 30kg S/ha exhibited favourable response on growth and yield of pigeon pea.

Singh *et al*. (2004) found that growth attributes viz plant height, number of nodules/plant and dry weight of nodules significantly increased with the increasing levels of sulphur up to 40 kg/ha in Chick pea.

Singh *et al*. (2004) reported that number of pods/plant, 1000- grain weight, seed yield and straw yield increased significantly with the increasing levels of sulphur upto 40 kg/ha in chick pea.

The number of pods/plant, test weight, seed yield and straw yield of lentil increased significantly with the increasing levels of sulphur upto 30 kg S/ha over control (Singh and Kumar, 1996).

Zizala *et al*. (2008) reported that application of 45kg S/ha increased the yield and yield attributing characters of mustard. Khanna and Gupta (2005) reported that application of 30 kg S/ha increased protein content, carbohydrates and vitamin C content in green pea seeds.

The seed protein content was increased due to application of 45 kg S/ha in pea (Singh *et al*., 1988). Application of sulphur increased protein content in pea (Gupta and Gupta, 1972).

Kumar and Singh (2009) reported that increased rate of sulphur application markedly increased the protein, Cyctine, Cystein methionine and carbohydrate content of seeds in black gram. Dhar *et al*. (1999) observed that application of sulphur improved protein and vitamins content in various vegetable crops including pea.

Kamat *et al*. (1981) observed that application of 30 kg S/ha increased the protein content of grains in green gram. Singh and Ram (1989) found that application of 40 kg S/ha in chick-pea improved the protein content.

Singh and Yadav (1997) reported that application of 30 kg S/ha increased the protein content of green gram. Aulakh and Pasricha (1997) observed that increased protein content was observed due to sulphur application in mung bean.

Deshbhratar *et al*. (2010) reported that application of 20 kg S/ha increased protein content of pigeon pea. Improvement in protein quality of pulses due to sulphur application was observed by (Shahi *et al*., 2002).

Tiwari *et al*. (1985) conducted an experiment and reported that application of 60 kg S/ha increased yield, uptake and concentration of sulphur in lentil.

Sharma and Kamath (1991) reported that significant increase in sulphur uptake was observed due to application of 90 kg S/ha in pea. Singh and Ram (1989) found that sulphur application increased nutrient content and uptake in chick pea significantly upto 120 kg S/ha both in grain and straw.

Singh and Singh (1992) conducted an experiment and reported that increasing rate of sulphur application markedly influenced the nutrient content and uptake of N, P, K and S in pea.

Kasturikrishana and Ahlawat (1999) reported that application of 40 kg S/ha in pea markedly increased the available S in postharvest soils, N and S contents in pea grains and uptake of N, P, K, S and Zn.

Application of 120 kg S/ha as elemental sulphur in ground nut significantly increased the pod yield as well as uptake of N, P, K, Ca. and Mg. (Tathe, 2008).

Venkatesh *et al*. (2002) reported that application of 30 kg S/ha increased S uptake in groundnut. The uptake of N, K and S increased with increasing levels of sulphur application where as P uptake was decreased at highest level. (Marok and Dev, 1980).

Bharathi and Poongothai (2008) reported that application of 45 kg S/ha in maize increased the uptake of N, P, K and nutrient contents and available S in postharvest soil.

Application of sulphur increased the utilization of soil sulphur when the sulphur levels were low and at higher levels the uptake from soil sulphur was reduced and obviously more and more fertilizer sulphur was taken up. The percentage of S and P in plants varied significantly with the application of sulphur (Acharya, 1973).

Tripathi and Sharma (1993) observed that there was a slight decrease in pH with the increasing doses of sulphur. The decrease in soil pH and increased available sulphur was observed with sulphur application (Kher and Singh, 1993). (Aulakh and Chibba, 1992) observed that there is a significant negative relationship between the soil pH and the available sulphur content in the soil.

Tripathi and Sharma (1993) observed a slight decrease in EC with the increasing levels of sulphur. A highly significant and positive correlation between electrical conductivity and sulphur was observed. (Ram *et al*., 1993).

Electrical conductivity (EC) was significantly and positively correlated with sulphur (Ghai, 1980). Ram *et al*. (1993) observed significant and positive relationship of organic carbon and different forms of sulphur.

Biswas *et al*. (2004) reported that the economic returns from sulphur fertilizer use were very attractive and benefits were much more when the residual effect on succeeding crops were also taken into account.

(Prasad and Prasad, 2003) observed that application of 30 kg /ha in pea significantly increased the gross income and net profit. Crops sown in autumn took an average of 6 months to mature whereas those sown in spring took only 3 months (Aziz *et al.,* 1989).

In India, peas in mid-October gives higher pod yield compare to early October or November (Dwivedi *et al.,* 1998). The highest green pod yields are obtain from peas cv. Arkel sown on 1 November (8.19 t/ha), V.L-1 sown in 1 November (7.03 t/ha) and Bonneville sown on 15 October (6.14 t/ha) at Uttarkashi, India. Sowing on 1 December gave yields between 3.70 and 5.17 t/ha (Maurya and Lal, 1988).

The duration from sowing to germination in peas under similar conditions of the temperature and humidity does not vary. However, the moisture deficiency in the spring the vertical differences for this character is manifested more strongly (Makasheva, 1983).

The pea is a cool season crop and is genetically grown in rabi season in Bangladesh. Growth and development of this crop is sensitive to temperature and day length. Dry weather interferes in seed setting and lowers the quality of pod produced. Flowering is accelerating by long days with low temperature. Plant growth is favoured by intermediate temperature (13 °C -18 °C). Yield is reduced as average temperature increases, and plants may be dying if exposed to prolonged periods above 26 °C (Meicenheimer and Muchlbauer, 1983).

2.2 Effect of Boron application on the growth and yield of garden pea

Prasad *et al*. (1998) conducted an experiment and reported that foliar application of 2.5 kg borax/ha increased yield of pea. Highest yield of pea was observed with 1.5 kg B/ha along with 3.0 t lime stone/ha. (Dwivedi *et al*., 1992).

Singh and Singh (1984) conducted an experiment and reported that the uptake of N, Na and B by grain and straw increased significantly with the application of boron in barley.

Dutta *et al.* (1984) also observed that application of 1 Kg B/ha increased in leaf area ratio, leaf area index, number of branches/plant, number of pods/plant in mustard.

Singh *et al*. (2002) conducted an experiment and reported that increasing levels of boron application as borax upto 4 kg/ha in pea and black gram increased the grain yield.

Boron has a beneficial effect on morphological characters in different crop plants. Sinha *et al.* (1994) conducted an experiment on the effect of B, Zn and Mo on morphological characters in lentil and showed that primary branch/plant and pods/plant increased significantly due to application of B.

Srivastava (1994) reported that application of B increased the number of pods/plant and grain yield in a susceptible chickpea variety, Kalika.

Bonilla *et al*. (2004) observed that application of boron increased seed germination, root elongation, plant development and mineral composition of pea in saline soils.

Gulati (1980) reported that1.5 ppm of boron application recorded highest fruit yield of tomato. Jena *et al*. (2009) found that application of 2 kg boron ha-1 in cabbage increased the yield by 22% over control.

Singh *et al*. (1992) reported that application of 10 kg B/ha increased yield of vegetable pea. Increase in grain and straw yield of gram was observed due to 1kg B/ha application. (Singh *et al.,* 2004). (Jana and Paria, 1996) found that application of boron increased pod yield in pea.

Bolanos *et al*. (1994) reported that boron application increased the number, size and weight of nodules in pea. Hassanein *et al*. (1999) observed that application of boron in cow pea significantly increased growth parameters and yield components.

Garate *et al*. (1993) reported that the application of boron increased plant weight and number of nodules in pea. Application of boron enhanced nodule development in pea (Azevedo *et al*., 2002).

Pratima *et al.* (1999) reported that the lower levels of boron application increased the concentration of sugars, starch, and proteins in pea seeds. (Zaky *et al*., 1999) observed that application of lower concentration of boron increased the reducing sugars, Sucrose polysaccharides and total carbohydrates in cow pea.

Hassanein *et al*. (1999) reported that application of boron increased the contents of P, K, Na, Ca, Fe, Mn, Zn, Cu and B in cowpea seeds. Boron content in different parts of pea plants increased with increasing boron concentration. (Zhang *et al*., 1997).

Application of boron enhanced the N content in roots and shoots of pea plant under salinity conditions (Bonilla *et al*., 2004). Increasing levels of boron application significantly improved the protein content in lentil (Kushwaha *et al*., 2009). Increasing levels of boron application in lentil significantly increased B uptake and improved available nutrients – N, P, S and B (Kushwaha *et al*., 2009).

Sakal *et al*. (1988) reported that application of 2.0 and 2.5 kg B/ha increased grain yields of black gram and chickpea by 63% and 38%, respectively and a synergistic relationship between B and K was found in Black gram.

Saha *et al*. (1996) carried out a field trial in pre-*Kharif* seasons at Pundibari, India with given 0, 2.5 or 5.0 kg borax and 0, 1 or 2 kg/ha of sodium molybdate was applied in soil, 66% soil + 33% foliar or foliar applications and the residual effects were studied on summer green gram [*Vigna radiata*]. In both years green gram seed yield was highest with a combination of 5 kg borax + 2 kg sodium molybdate.

Banu (2003) reported that boron deficiency was established as the dominant nutritional problem causing flower and pod abortion. No pods or grains were formed in the absence of B in chickpea.

Prasad *et al*. (1998) reported that the net returns were higher with the foliar application of 2.5 kg borax/ha in pea crop. The maximum net profit was achieved with the application of 10 kg tetraborate/ha in vegetable pea. Singh *et al*. (2004) reported that application of 2.5 mg B/kg in pigeon pea significantly increased the gross income and net profit.

An experiment carried out by Moghazy *et al*. (2014) to study the influence of a foliar application with boron and five levels of combinations between compost manure and mineral nitrogen fertilizer as well as their interaction on growth, yield and chemical composition of pea. The vegetative growth traits of green pea, i.e., plant length, number of leaves, number of branches, fresh weight per plant, relative growth rate, yields and its components had high significant values by foliar spraying with boron. It could be concluded that foliar spray with boron (boric acid 17% B) at 50 ppm with application of nitrogen fertilizer in compost form at 2.5 ton/fed and inorganic N-fertilizer at 60 kg/fed in pea field were the most effective treatment for improving quality and increasing yield.

2.3 Effect of combined application of sulphur and boron on garden pea

Nasreen and Farid (2003) reported that combined application of sulphur and boron markedly improved the growth and yield related attributes of pea. Lalitha *et al*. (2008) reported that combined foliar application of potassium sulphate and boric acid at 50 DAS significantly increase the seed yield in Niger.

Application of 60 kg S/ha along with 1 kg B/ha significantly increased seed and stover yield of soyabean. (Singh *et al*., 2006). Increase in yields due to S and B application have also been reported in legume and oilseed crops by several workers (Misra 2001 and Sakal *et al*., 1988).

Kaisher *et al*. (2010) reported that combined application of 30 kg sulphur and 5 kg boron/ha significantly increased plant height, number of branches/plant, number of pods/plant, number of seeds/pod, 1000-seed weight and seed yield of mungbean.

Yang *et al*. (1998) reported that combined application of sulphur and boron markedly increased growth and yield related attributes of mungbean.

Sarker *et al*. (2002) reported that combined application of 30 kg S/ha and 1 kg B/ha significantly increased the yield and yield related attributes and straw yield in soybean.

The increase in yield and yield related attributes of french bean was reported due to combined application of NPKSZn B @ 120:120:60:20:4:1. (Moniruzzaman *et* al., 2008).

Singh *et al*. (2006) reported that application of 40kg S/ha in combination with 0.5kg B/ha significantly increased the protein content in soybean.

Kaisher *et al*. (2010) reported that application of 30kg S/ha along with 5kg B/ha significantly increased the protein content of mung bean.

Chakraborty and Das (2000) reported that the protein contents in mustard seeds was significantly influenced by the combined application of boron @ 3kg/ha and sulphur @ 60kg/ha.

Combined application of 50 kg S/ha and 1kg B/ha increased the protein perecentage in soyabean (Sarker *et al*., 2002). Combined application of sulphur and boron increased the nutrient uptake in soyabean (Singh *et al*., 2006). The highest B and S uptake was achieved by the combined application of 10 kg S/ha and 1 kg B/ha in Soyabean (Sarker *et al*., 2002).

The interaction effect of S and B on soil pH and soil extractable B was significant. The combined application of S and B in rape seed increased the nutrient content (B and S) and improved nutrient uptake at pod formation stage. A positive and significant relationship of organic carbon and sulphur and boron was observed. (Bandyopadhyay and Chattopadhyay, 2000).

CHAPTER III

MATERIALS AND METHODS

There are many information require to conducted this experiment, these includes this chapter regarding methodology that was used in execution of the experiment. This chapter contains a short description of location of the experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

3.1 Experimental period

The experiment was conducted from October 2018 to March 2019.

3.2 Location of the experimental plot

The experiment was conducted at the Horticulture Farm of the Sher-e-Bangla Agricultural University, Dhaka during the period from October 2018 to March 2019. The experimental site is situated between 23.5^0 E latitude and 90.2^0 N longitude and the altitude of 8.2 m from the sea level.

3.3 Characteristics of soil

The characteristic of the soil of the experiment site was Non- calcareous, dark gray, medium high land. The texture of soil was silty loam with a pH 5.6. The experimental plot soil samples were collected from a depth of 0 to 15 cm before conducting the experiment. Soil was analyzed in the Soil Resources Development Institute (SRDI) Farmgate, Dhaka. The experimental site was a medium high land (Appendix- IA).

3.4 Climatic condition

The experimental site was under the sub-tropical monsoon climate, which is characterized by heavy rainfall during Kharif season and scanty in the Rabi season (October, 2018 to March, 2019). There was no rainfall during the month of October, November, December and January. The average maximum temperature during the period of experiment was 26.5˚C and the average minimum temperature was 12.4˚C. Details of the meteorological data in respect of temperature, rainfall and relative humidity during the period of the experiment were collected from Weather Station of Agargoan, Dhaka (Appendix- IA).

3.5 Agro-ecological region

The experimental site belongs to the agro-ecological region of the Modhupur Tract (AEZ-28). The landscape comprises level upland, closely or broadly dissected terraces related with either shallow or broad, deep valleys.

3.6 Planting materials

The variety BARI Motorshuti-3 was used as the test variety of the crop. The seeds was collected from the Horticulture Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI Motorshuti-3 was the released variety of garden pea, which was recommended by the national seed board.

3.7 Experimental treatments

There are two factors in the experiment

Factor A: Four levels of Sulphur

1) S_0: Control (No Sulphur)
2) S_1: 10 kg S/ha
3) S_2: 20 kg S/ha
4) S_3: 30 kg S/ha

Factor B: Four levels of Boron

1) B_0: Control (No Boron)
2) B_1: 1 kg B /ha
3) B_2: 2 kg B /ha
4) B_3: 3 kg B/ha

There was (4×4) treatments combination such as

S_0B_0, S_0B_1, S_0B_2, S_0B_3, S_1B_0, S_1B_1, S_1B_2, S_1B_3, S_2B_0, S_2B_1, S_2B_2, S_2B_3, S_3B_0, S_3B_1, S_3B_2, S_3B_3

3.8 Experimental Design and layout of the experiment

The experiment was laid out with Randomized Completely Block Design

(RCBD) with 3 replications. The experimental plot was first divided into equal three blocks and each block consist of 16 units of plots. Each unit of plot was 0.8m × 0.6 m in size. All together there were 48 plots in experiment. Distance between replication was 1 m and plot to plot was 0.5 m. The treatments were assigned randomly to each block as per design of the experiment.

3.9 Cultivation procedure

3.9.1 Land preparation

The land was preparation was started at 23 October 2018 by ploughing and cross ploughing followed by laddering. The corner of the land was spaded and visible large clods were broken into small pieces. Weeds and stubbles were removed from the field. The first ploughing and the final land preparation was done on 23 October 2018 and 05 November 2018 respectively. The layout of the experiment was done in accordance with the design adopted. Finally, individual plots were prepared by using spade before organic manure (15 t/ha) application.

3.9.2 Application of manure and fertilizer

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), zinc sulphate, gypsum and boric acid were used as a source of nitrogen, phosphorous, potassium, zinc, sulphur and boron respectively. Urea, Triple super phosphate (TSP), Muriate of potash (MoP) and zinc sulphate were applied at the rate of 90, 60, 60, and 2.0 kg/hectare, respectively following the BARI recommendation but sulphur and boron and were applied as per treatment. All of the fertilizers except urea were applied during final land preparation. The fertilizers were mixed thoroughly with the soil and rest nitrogen was applied in two equal splits on 05 December and 25 December, 2018.

3.9.3 Sowing of seeds

Seeds were sown in each row at a depth of 3.0 cm. The seeds were covered with pulverized soil just after sowing and gently pressed with hands. The sowing was done on 15 November 2018 with a spacing of 20 cm ×15 cm. The seeds were covered with loose soil. For each time sowing seeds were treated with vitavex-200 @ 3g/kg seed for preventing soil borne disease.

3.9.4 Intercultural operations

3.9.5 Gap filling

During seed sowing, few seeds were sown in the border of the plots. Seedlings were transferred to fill up the gap where seeds failed to germinate. Seedlings of about 5 cm height were transplanted from border rows with roots plunged 3 cm below the soil in the hills in the evening and watering was done to protect the seedling from wilting. All gaps were filled up within two weeks after germination of seeds.

3.9.6 Weeding

The experimental plots were kept weed free by hand weeding. Weeding was done three times as and when necessary and soil surface crusts were broken. It helped to increase soil moisture conservation.

3.9.7 Irrigation

Irrigation was done whenever necessary. The young plants were irrigated by watering can. Beside this, irrigation was given five times at an interval of 7 to 10 days depending on soil moisture content.

3.9.8 Staking

After 30 days of seed sowing, staking was done with the help of bamboo split.

3.9.9 Plant protection

Protection measures were taken to protect the matured seeds against the attack of pigeon and rat.

3.9.10 Harvesting

Harvesting was done according to its maturity. Green pods were harvested at tender stage on 15 January. After harvest pods were separated from plants.

Then plants and pods were weighed.

3.10 Methods of data collection

Five plants were selected at random in such a way that the border effect could be avoided. For this reason, the outer two lines and the outer plants of the middle lines in each unit plot were avoided. Data were recorded under the following parameters at harvesting stage:

3.10.1 Plant height

The plant height was measured at harvest with a meter scale from the ground level to the top of the plants and the mean height was expressed in cm.

3.10.2 Days to first flowering

It was time duration between germination to first flowering. Date of germination of seeds to date of first flowering was recorded.

3.10.3 Number of pods per plant

Numbers of total pods of selected plants from each plot was counted and the mean numbers was expressed as per plant basis. Data was recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.10.4 Pod length (cm)

Pod length was taken of randomly selected ten pods and the mean length was expressed in cm.

3.10.5 Pod breadth (cm)

Pod breadth was taken of randomly selected ten pods and the mean length was expressed in cm.

3.10.6 Green pod yield per plant (g)

The weight of green pods per plant was recorded from randomly selected 10 plants at the time of harvest. Data was recorded as the average of 10 plants from each plot.

3.10.7 Weight of 10 green pods (g)

Ten cleaned, green pods from each treatment was counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.10.8 Number of seeds per pod

The number of seeds/pod was recorded from randomly selected 10 pods at the time of harvest. Data was recorded as the average of 10 pods from each plot.

3.10.9 Weight of 100 green seeds (g)

One hundred cleaned, green seeds from each treatment was counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.10.10 Dry matter percentage of plant (%)

A sample of 100 g of plants was collected and dried under direct sunshine for 72 hours and then dried in an oven at 70^0C for 3 days. After oven drying, plants were weighed. The dry weight was recorded in gram (g) with an electric balance. The percentage of dry matter was calculated by the following formula:

$$\text{Dry matter content (\%)} = \frac{\text{Dry weight of plants}}{\text{Fresh weight of plants}} \times 100$$

3.10.11 Green pod yield per plot (g)

The pod collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of pods was taken in gram.

3.10.12 Green pod yield per hectare (t)

The pod collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of pods was taken and converted the yield in t/ha.

3.10.13 Green seed yield per plot (g)

The seeds are collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of seeds was taken in gram (g).

3.10.14 Green seed yield per hectare (t)

The seeds are collected from 0.6 (1 m × 0.6 m) square meter of each plot was cleaned. The weight of pods was taken and converted the yield in t/ha.

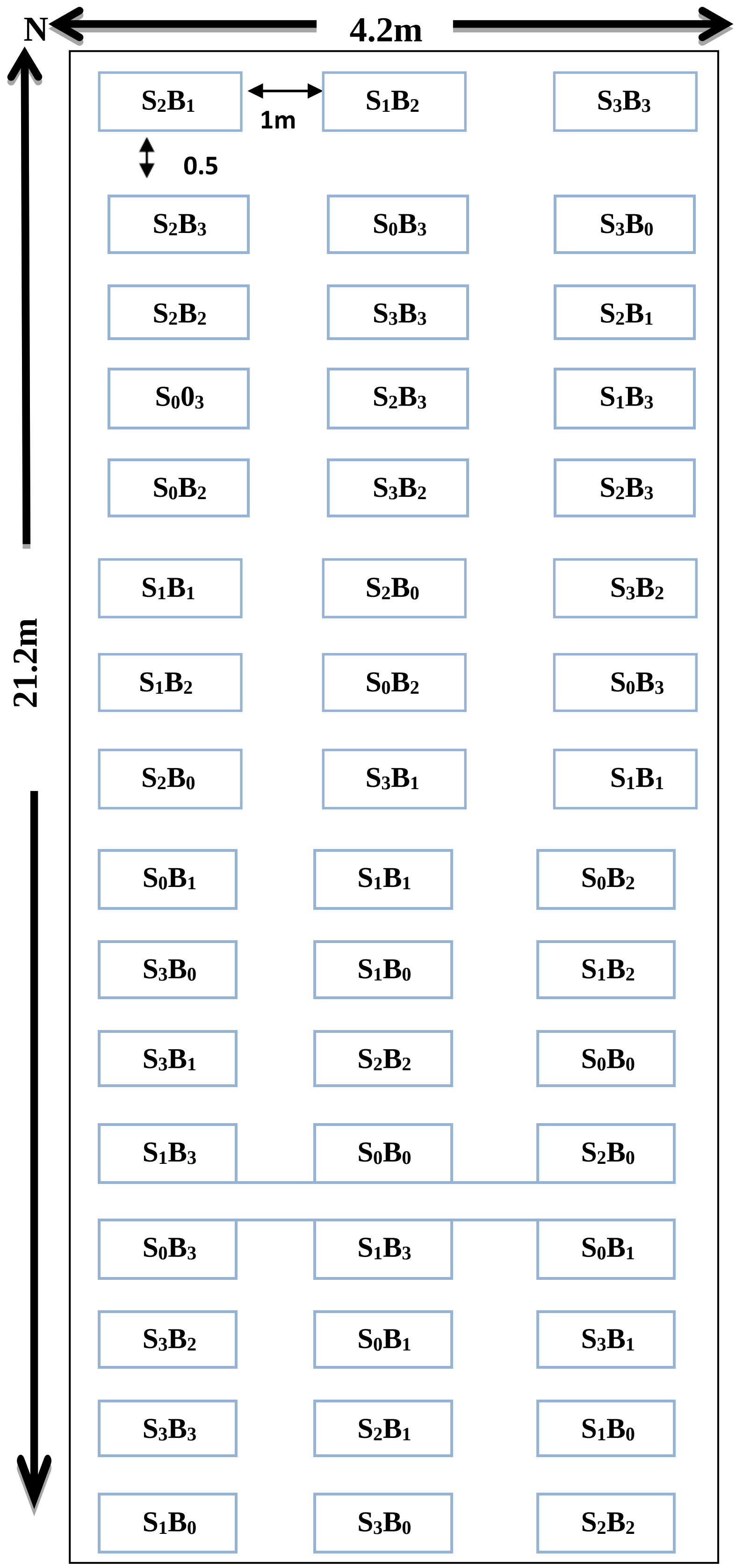
3.11 Statistical analysis

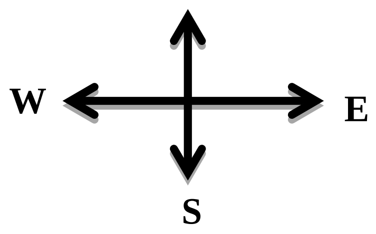
The data obtained were statistically analyzed to find out the variation resulting from experimental treatments following F-variance test. The difference between treatments was adjusted by Least Significant Difference Test (LSD) (Gomez and Gomez, 1984).

3.12 Economic analysis

The cost of production was analyzed in order to find out the most economic combination of different levels of sulphur and different levels of boron for garden pea cultivation. All input cost included the cost for lease of land and interests on running capital in computing the cost of production. The interests were calculated @ 12% in simple rate. The market price of garden pea was considered as local market for estimating the cost and return. Economic analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return (TK.)}}{\text{Cost of production (TK)}}$$





Plot size: 0.8 m × 0.6 m Spacing: 20 cm × 15 cm Spacing between plot: 50 cm Spacing between row: 1.0 m

Factor A: Four levels of Sulphur

S_0= Control (No Sulphur)
S_1= 10 kg S/ha
S_2= 20 kg S/ha
S_2= 30 kg S/ha

Factor B: four level of Boron

B_0= Control (No Boron)
B_1= 3 kg B /ha
B_2= 2 kg B /ha
B_3= 3 kg B /ha

Fig. 1. Layout of the experimental Plot

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influence of sulphur and boron dose on growth and yield of garden pea. Data on different growth characters yield and yield related characters were recorded. The findings of the experiment have been presented and discussed with the help of table and graphs and possible interpretations were given under the following headings:

4.1 Plant height

Plant height of garden pea influenced significantly by the application of different levels of sulphur dose at 30, 45 days after sowing (DAS) and at harvesting (Fig. 2, Appendix II). At 30 DAS the tallest (31.40 cm) plant was found in S_3 (30 kg S/ha) treatment and the shortest (23.10 cm) plant was found from S_0 (No sulphur application) treatment. At 45 DAS, the tallest (41.49 cm) plant height was recorded from S_3 (30 kg S/ha) treatment and the shortest plant (32.72 cm) was found in S_0 (No sulphur application) treatment. At harvesting, tallest plant height (50.84 cm) was recorded from S_3 (30 kg S/ha) treatment and shortest plant (39.49 cm) was recorded from S_0 (No sulphur application) treatment. It was observed that plant height reached its maximum stage at harvest in all the treatments. The highest plant height was obtained from S_3 (30 kg S/ha) treatment. This height was due to the Sulphur application similar results had been reported by Khanna and Gupta (2005).

Plant height of garden pea influenced significantly by the application of different levels of boron (Fig. 3, Appendix II). Plant height of pea varied with the variation of boron dose. Most of the treatments recorded significantly higher plant height over control. The highest plant height for 30 DAS was (30.29 cm) was found in B_2 (2 kg B/ha) treatment and the smallest plant height (24.10 cm) was found from B_0 (No boron application) treatment. At 45 DAS, tallest plant height (40.38 cm) was recorded from B_2 (2 kg B/ha) treatment and the shortest plant (33.95 cm) was recorded from B_0 (No boron application) treatment. At harvesting, the tallest plant (49.17 cm) was recorded from B_2 (2 kg B/ha) treatment and the shortest plant (40.72 cm) was recorded from B_0 (No boron application) treatment. Similar finding have been reported by Prasad et al. (1998).

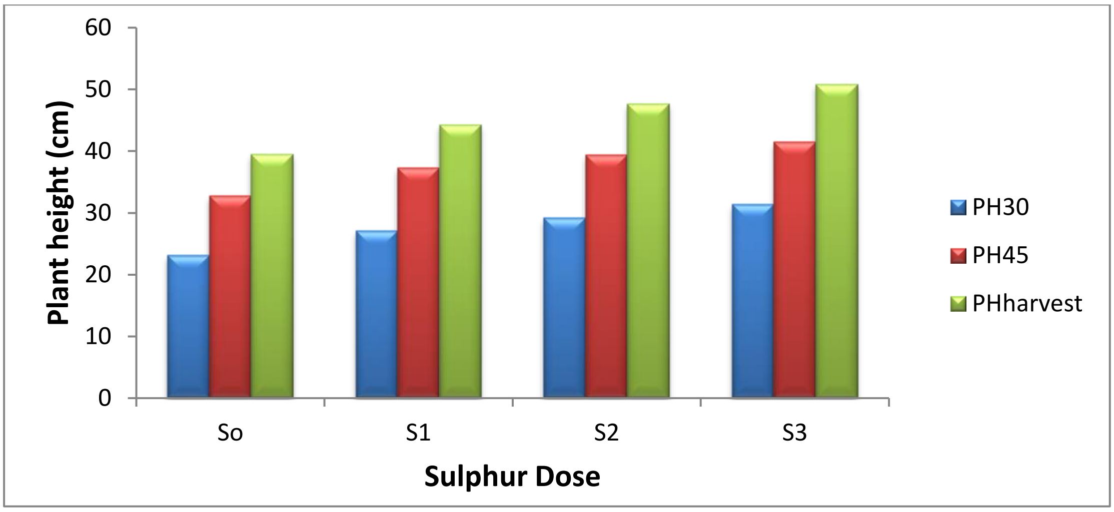


Fig. 2. Effect of different levels of sulphur on plant height of garden pea

Here, S_0= Control (No Sulphur), S_1= 10 kg S/ha, S_2= 20 kg S/ha, S_3= 30 kg S/ha, PH30= plant height at 30 days, PH45= plant height at 45 days, PHharvest= plant height at harvest

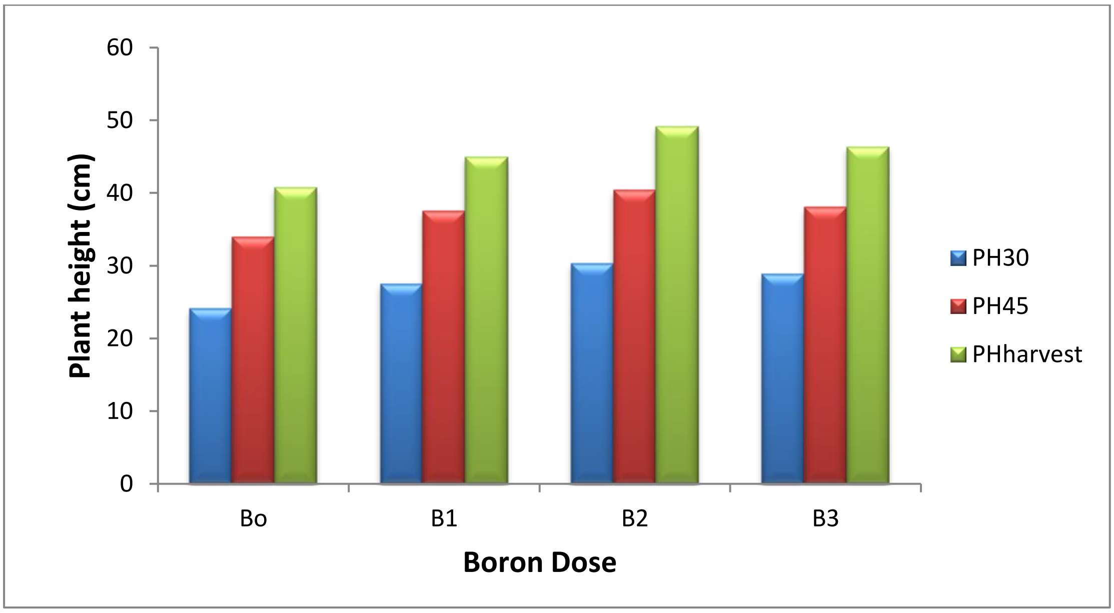


Fig. 3. Effect of different levels of boron on plant height of garden pea

Here, B_0= Control (No Boron), B_1= 1 kg B/ha, B_2= 2 kg B/ha, B_3= 3 kg B/ha; PH30= plant height at 30 days, PH45= plant height at 45 days, PHharvest= plant height at harvest

Table 1. The Combined effect of different levels of sulphur and boron on plant height of garden pea

Treatments	Plant height at 30 DAS	Plant height at 45 DAS	Plant height at Harvest
S_0B_0	21.56 l	30.80 j	37.73 l
S_0B_1	22.43 kl	31.83 j	38.40 l
S_0B_2	24.63 i-k	34.80 hi	41.43 i-l
S_0B_3	23.80 j-l	33.46 ij	40.40 j-l
S_1B_0	23.06 j-l	32.73 ij	39.30 kl
S_1B_1	27.66 f-h	37.76 e-g	44.46 f-i
S_1B_2	29.56 d-f	40.13 c-e	47.73 d-f
S_1B_3	28.16 e-g	38.60 d-f	45.50 e-h
S_2B_0	25.26 h-j	35.40 g-i	42.50 h-k
S_2B_1	28.70 e-g	39.33 c-f	46.43 e-g
S_2B_2	32.20 bc	42.03 a-c	52.43 a-c
S_2B_3	30.46 c-e	40.83 b-d	49.16 c-e
S_3B_0	26.53 g-i	36.86 f-h	43.36 g-j
S_3B_1	31.23 b-d	41.26 b-d	50.53 b-d
S_3B_2	34.76 a	44.56 a	55.10 a
S_3B_3	33.10 ab	43.26 ab	54.36 ab
CV%	7.41	8.67	8.25
LSD	2.40	2.85	3.91

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0= Control (No Sulphur), S_1= 10 kg S/ha, S_2= 20 kg S/ha, S_3= 30 kg S/ha and B_0= Control (No Boron), B_1= 1 kg B/ha, B_2= 2 kg B/ha, B_3= 3 kg B/ha; DAS= Days after sowing.

The plant height was significantly influenced by the combined effect of the sulphur and boron dose at 30, 45 DAS and at harvesting (Table 1, Appendix II). At 30 DAS, the highest plant height (34.76 cm) was measured from the S_3B_2 (30 kg sulphur with 2 kg boron), which was statistically similar with S_3B3 (33.10 cm) treatment combination and the lowest (21.56 cm) was recorded from S_0B_0 (no sulphur and no boron), which was statistically similar S_0B_1 (22.43 cm), S_1B_0 (23.06 cm) and S_0B_3 (23.80 cm) treatments, respectively. At

45 DAS, the highest plant height (44.56 cm) was measured from S_3B_2 (30 kg sulphur with 2 kg boron), which was statistically similar with S_3B_3 (43.26 cm) and S_2B_2 (42.03 cm) treatment combination and the lowest (30.80 cm) from S_0B_0 (no sulphur and no boron), which was statistically identical with S_0B_1 (31.83 cm) treatment combination and statistically similar with S_1B_0 (32.73 cm) and S_0B_3 (33.46 cm) treatments. At harvesting, the highest plant height (55.10 cm) was measured from S_3B_2 (30 kg sulphur with 2 kg boron), which was statistically similar with S_3B_3 (54.36 cm) and S_2B_2 (52.43 cm) treatment combination, respectively and the lowest (37.73 cm) from S_0B_0 (no sulphur and no boron), which was statistically identical with S_0B_1 (38.40 cm) treatment combination and statistically similar with S_1B_0 (39.30 cm), S_0B_3 (40.40 cm) and S_0B_2 (41.43 cm) treatment combination, respectively. From the results, it is inferred that the variation of plant height of garden pea depend on the sulphur and boron levels. Plant height continued to increase up to the maturity. In this study it was observed that, 30 kg sulphur with 2 kg boron gave the highest plant height. Hence it may be fact that 30 kg sulphur with 2 kg boron for better vegetative growth and balanced nutrient absorption which ultimately increases plant height of garden pea. This result is in agreement with the findings of Kaisher *et al.* (2010).

4.2 Days to first flowering

Significant variation was recorded due to different levels of sulphur on the days to first flowering (Table 2, Appendix III). The S_0 (no sulphur application) treatment took the shortest time (24.41 days) and S_3 (30 kg S/ha) treatment took maximum time (27.41 days) to first flowering. This treatment was statistically identical with S_2 (20 kg S/ha) treatment.

There existed significant variation was found on the days to first flowering due to the application of different levels of boron (Table 3, Appendix III). This might be due to the fact that optimum absorption of boron nutrients might improve physiological activities which resulted endogenous growth resulting maximum days for flowering in plants. From this experiment it showed that B_2

(2 kg B/ha) treatment took maximum days (27.41) for flower initiation which was statistically similar with B_3 (3 kg B/ha) treatment and B_0 (No boron application) treatment took minimum days (24.41) for flower initiation. Boron helps to increase first flowering days of pea.

Combined effect was found significantly influenced due to the different levels of sulphur and boron application dose on the days to first flowering (Table 4, Appendix III). The S_2B_2 (20 kg S/ha with 2 kg B/ha) treatment took maximum days (29.0) to first flower initiation. This treatment was statistically similar with S_2B_3, S_3B_2 and S_3B_3 treatment combination, respectively. On the other hand, The S_0B_0 (No sulphur with no boron) treatment combination took minimum days (23.33) to first flowering. This treatment was statistically similar with S_0B_1, S_0B_3 and S_1B_0 treatment combination, respectively. In the present study it was observed that first flowering time varied with different levels of sulphur and boron application.

4.3 Number of pods per plant

Among the yield contributing characters, number of pods per plant is one of the most important character in garden pea. Yield per unit area is the function of number of pods per plants (Table 2, Appendix III). The number of pods per plant was significantly influenced by different levels of sulphur. The number of pods per plant ranged from 14.00 to 10.00. The highest number of green pods per plant (14.00) was recorded from S_3 (30 kg S/ha) treatment and the lowest number of pods per plant (10.00) was found in S_0 (No sulphur application) treatment. Similar findings have been reported by Kasturikrishna and Ahlawat (1999).

The effect of different levels of boron on number of pods per plant was statistically significant (Table 3, Appendix III). The number of pods per plant ranged from 13.48 to 10.49. The highest number of green pods per plant (13.48) was recorded from the B_2 (2 kg B/ha) treatment and the lowest number of pods per plant (10.49) was found in the B_0 (No boron application) treatment. Jana and Paria (1996) reported that the highest number of pods per plant of garden pea was obtained with higher doses B application. Singh *et al.* (1992) also reported that boron application greatly improves the yield attributes, i.e., pods per plant and grains per pod.

Table 2. Effect of different levels of sulphur on yield and yield attributes of garden pea

Treatments	Days to first flowering	Number of pods/plant	Pod length (cm)	Pod breadth (cm)
S_0	24.41 c	10.00 d	6.72 d	1.24
S_1	25.66 b	11.90 c	7.85 c	1.33
S_2	27.41 a	12.97 b	8.42 b	1.39
S_3	27.41 a	14.00 a	8.95 a	1.43
CV%	11.46	9.98	8.16	10.97
LSD	0.68	0.74	0.16	ns

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0=control (no sulphur), S_1=10 kg S/ha, S_2=20 kg S/ha, S_3=30 kg S/ha, NS= non-significant

Combined effect of different levels of sulphur and boron showed a significant variation on the number of pods per plant (Table 4, Appendix III). Plant grown under S_3B_2 (30 kg S/ha along with 2 kg B/ha) treatment produced the highest number of pods per plant (15.50). This treatment was statistically similar with S_3B_3 and S_2B_2 treatment combinations. The lowest number of pods per plant 9.20 found in the treatment of S_0B_0 (no sulphur with no boron) which was statistically similar with S_0B_1, S_1B_0 and S_0B_3 treatment combinations. The contribution of sulphur and boron on increasing the pod number was remarkable. It was resemblance with the findings of Kaisher *et al.* (2010).

4.4 Pod length

The pod length differed significantly observed due to the effect of different levels of sulphur (Table 2, Appendix III). The length of pods ranged from 8.95 to 6.72 cm. The highest pod length (8.95 cm) was recorded in S_3 (30 kg S/ha) treatment. The lowest pod length (6.72 cm) was found in S_0 (No sulphur application) treatment. These results are in agreement to the findings obtained by Khanna and Gupta (2005).

Significant variation was observed among the boron levels in respect of pod length of garden pea (Table 3, Appendix III). The length of pods ranged from 8.66 to 7.03 cm. The highest pod length (8.66 cm) was recorded from B2 (2 kg B/ha) treatment and the lowest pod length (7.02 cm) was found in B0 (No boron application) treatment. It may be fact that optimum levels of boron play more role in vegetative growth and resulting in increasing pod length.

Table 3. Effect of different levels of boron on yield and yield attributes of garden pea

Treatments	Days to first flowering	Number of pods/plant	Pod length (cm)	Pod breadth (cm)
B_0	24.41 c	10.49 c	7.03 d	1.26
B_1	26.25 b	12.09 b	7.93 c	1.35
B_2	27.41 a	13.48 a	8.66 a	1.41
B_3	26.83 ab	12.08 b	8.33 b	1.38
CV%	11.46	9.98	8.16	10.79
LSD	0.59	0.61	0.24	NS

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, B_0=control (no Boron), B_1=1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha, NS= non-significant

The combined effect of different levels of sulphur and boron on the pod length was significant (Table 4, Appendix III). The length of pods ranged from 9.70 to 6.24 cm. The highest pod length (9.70 cm) was recorded from the treatment combination of S_3B_2 (30 kg S/ha along with 2 kg B/ha) which was statistically similar with S_2B_2 (9.43 cm) treatments, respectively. The lowest pod length (6.24 cm) was found in the S_0B_0 (No sulphur with no boron) treatment. This treatment was statistically identical with S_0B_1 treatment combination.

4.5 Pod breadth

Difference in pod breadth was observed non-significant effect as to the varied levels of sulphur application (Table 2, Appendix III). The pod breadth ranged from 1.43 to 1.24 cm. The highest pod breadth (1.43 cm) was recorded from S_3 (30 kg S/ha) treatment and the lowest pod breadth (1.24 cm) was found in S_0 (control) treatment.

There are no significant differences among the levels of boron in the pod breadth of garden pea (Table 3, Appendix III). The breadth of pods ranged from 1.41 to 1.26 cm. The highest pod breadth (1.41 cm) was recorded from B_2 (2 kg B/ha) treatment and the lowest pod breadth (1.26 cm) was found in the B_0 (control) treatment.

Table 4. The Combined effect of different levels of sulphur and boron on yield and yield attributes of garden pea

Treatments	Days to first flowering	Number of pods/plant	Pod length (cm)	Pod breadth (cm)
S_0B_0	23.33 i	9.20 m	6.24 n	1.19
S_0B_1	24.33 g-i	9.60 lm	6.42 n	1.22
S_0B_2	25.33 e-h	10.80 i-l	7.22 kl	1.28
S_0B_3	24.66 g-i	10.40 j-m	7.01 lm	1.26
S_1B_0	24.00 hi	10.03 k-m	6.77 m	1.24
S_1B_1	25.66 e-g	11.93 f-i	7.92 hi	1.34
S_1B_2	26.66 c-e	13.20 c-f	8.54 ef	1.40
S_1B_3	26.33 d-f	12.43 e-h	8.18 gh	1.36
S_2B_0	25.00 f-h	11.10 h-k	7.44 jk	1.30
S_2B_1	27.33 b-d	12.86 d-g	8.35 fg	1.38
S_2B_2	29.00 a	14.43 a-c	9.43 ab	1.46
S_2B_3	28.33 ab	13.50 b-e	8.70 de	1.42
S_3B_0	25.33 e-h	11.63 g-j	7.67 ij	1.32
S_3B_1	27.66 a-d	13.96 b-d	9.01 cd	1.44
S_3B_2	28.66 ab	15.50 a	9.70 a	1.51
S_3B_3	28.00 bc	14.90 ab	9.20 bc	1.48
CV%	11.46	9.98	8.16	10.97
LSD	1.35	1.48	0.33	NS

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Here, S_0= Control (No Sulphur), S_1=10 kg S/ha, S_2=2o kg S/ha, S_3= 30 kg S/ha and B_0= Control (No Boron), B_1=1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha, NS= non-significant

The combined effect of different levels of sulphur and boron application was also observed statistically non-significant (Table 4, Appendix III). The breadth of green pods ranged from 1.51 to 1.19 cm. The highest pod breadth (1.51 cm) was obtained from the treatment combination of S_3B_2 (30 kg S/ha with 2 kg B/ha) and the lowest pod breadth (1.19 cm) was obtained from the S_0B_0 (No sulphur with no boron) treatment.

4.6 Green pod yield per plant (g)

It was observed that the significant influence of different levels of sulphur application on green pod yield of garden pea (Table 5, Appendix IV). The highest pod weight (46.41 g) was recorded from S_3 (30 kg S/ha) treatment whereas the lowest pod yield per plant (29.83 g) was observed from S_0 (control) treatment. This result is in agreement with the findings of Malik and Abraham (2003). Jain *et al*. (1984) reported that sulphur application in legumes in general and pea in particular has invariably resulted in increased pod production/plant. Khanna and Gupta, (2005) observed that increase in plant height, number of branches, fresh and dry weight of plant, pod size, seed number per pod, fresh pod yield, pod dry weight and 100 seed weight has also been reported due to S application (30 kg/ha) in pea.

Different levels of boron showed statistically significant differences on pod weight of garden pea (Table 6, Appendix IV). The highest pod weight (44.66 g) was found from B_2 (2 kg B/ha) treatment, while the lowest pod yield per plant (31.0 g) was found from B_0 (control) treatment. Pod yield of garden pea was gradually increased with increasing level of boron up to 2 kg B per hectare then decreased. It was found that fresh pod weight of pea per plant increased with increasing boron up to 2kg/ha while the plants which were produced the lowers fresh pod without boron. The increases fresh pod weight of pea might be due to optimum level of boron improved physiological activity like photosynthesis and translocation of food materials to the seeds. These findings have the resemblance with the result of Prasad *et al.* (1998).

The difference in fresh pod weight per plant was significantly influence by combined application of sulphur and boron in garden pea (Table 7, Appendix IV). The highest pod yield/plant (54.0 g) was recorded from the treatment combination of S_3B_2 (30 kg S/ha with 2 kg B/ha) which was statistically similar with S_3B_3 treatment combination. On the other hand, the lowest pod yield/plant (26.66 g) was found from S_0B_0 (no sulphur with no boron) treatment combination which was statistically similar with S_0B_1 and S_1B_0 treatment combination. Nasreen and Farid (2003) reported that combined application of sulphur and boron markedly improved the growth and yield related attributes of pea. Misra 2001 and Sakal *et al*. (1988) observed that increase in yields due to S and B application have also been reported in legume and oilseed crops.

4.7 Number of seeds per pod

Statistically significant differences was found among the sulphur levels as to the number of seeds per pod (Table 5, Appendix IV). It was observed that the number of seeds per pod increased with the increasing sulphur levels. It varied from 5.56 to 4.26. The maximum number of seeds per pod (5.56) was found from S_3 (30 kg S/ha) treatment while the lowest number of seeds per pod (4.26) was obtained in S_0 (no sulphur application) treatment. Similar results were recorded by Kasturikrishna and Ahlawat (1999) in pea. Shankaralingappa *et al*., (2002) reported that the sulphur application @ 40 kg ha-1 increased plant height, number of pods per plant, grain yield and 1000-seed weight in pigeon pea.

Different levels of boron application had also significant effect on the number of seeds per pod (Table 6, Appendix IV). The number of seed per pod ranged from 5.41 to 4.45. The highest number of seeds per pod (5.41) was obtained when the application of boron with B2 (2 kg B/ha) treatment which was statistically identical (5.21) with B3 (3 kg B/ha) treatment and the lowest number of seeds per pod (4.45) was obtained in the B0 (no boron application) treatment. It was also observed that the numbers of seeds per pod were increased with increase of boron levels up to 2 kg B /ha and then decresed. It was also resemblance with the findings of Kaiser et al. (2010).

Table 5. Effect of different levels of sulphur on yield and yield attributes of garden pea

Treatments	Green pod yield/plant (g)	Number of seeds/pod	Weight of 100 green seeds (g)
S_0	29.83 d	4.26 d	24.65 d
S_1	36.41 c	4.95 c	30.36 c
S_2	41.83 b	5.28 b	33.75 b
S_3	46.41 a	5.56 a	36.72 a
CV%	10.68	11.58	9.62
LSD	0.21	0.20	2.30

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0=control (no sulphur), S_1=10 kg S/ha, S_2=20 kg S/ha, S_3=30 kg S/ha

Distinct difference was found due to the varied levels of combinedly sulphur and boron application in respect of number of seeds per pod (Table 7, Appendix IV). The number of seeds per pod ranged from 5.93 to 3.80. The highest number of seeds per pod (5.93) was obtained from the S_3B_2 (30 kg S/ha with 2 kg B/ha) treatment combination, which was statistically identical (5.86) with that of S_3B_3 treatment combination. The lowest number of seeds per pod (3.80) was obtained from the S_0B_0 (no sulphur with no boron) treatment combination, which was statistically similar with (4.13) S_0B_1 treatment combination. This might be due to optimum sulphur and boron improved pollen germination and pollen tube growth probably restricted fertilization. Boron in needed for the production and translocation of sugars to be used as energy source of pollen tube growth (Smit and Combrink, 2004).

4.8 Weight of 10 green pods (g)

Different levels of sulphur varied significantly in terms of weight of 10 green pods of garden pea (Fig. 4, Appendix IV). The highest weight of 10 green pods (46.16 g) was found from S_3 (30 kg S/ha) treatment, while the lowest weight of 10 green pods (29.0 g) was recorded from S_0 (control) treatment.

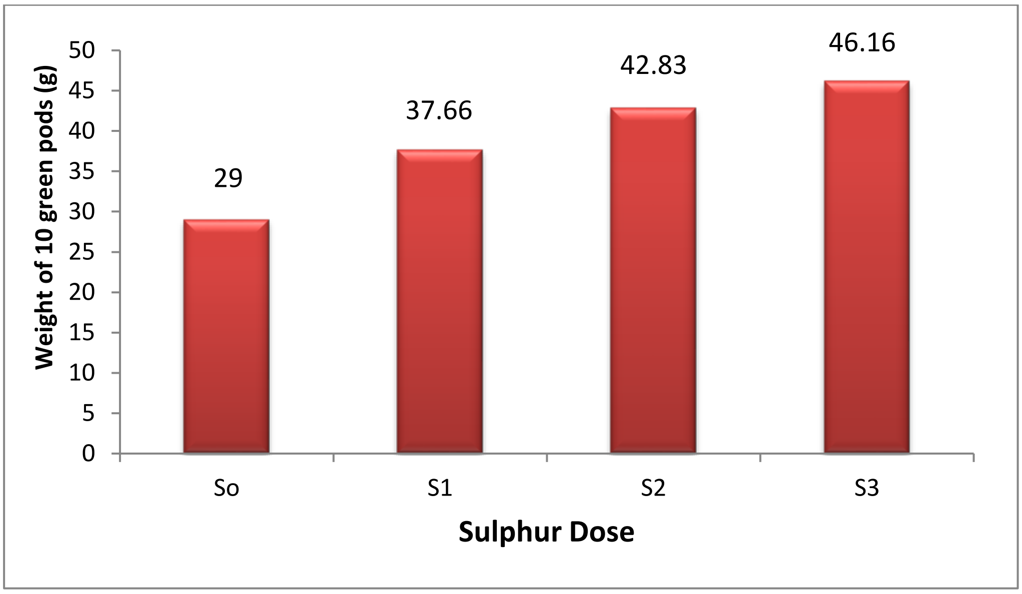


Fig. 4. Effect of different levels of sulphur on weight of 10 green pod (g) of garden pea

Here, S_0=control (no sulphur), S_1=10 kg S/ha, S_2=20 kg S/ha, S_3=30 kg S/ha

Weight of 10 green pods showed statistically significant differences due to different levels of boron (Fig. 5, Appendix IV). The highest weight of 10 green pods (44.50 g) was recorded from B_2 (2 kg B/ha) treatment, whereas the lowest weight of 10 green pods (31.0 g) was observed from B_0 (control) treatment.

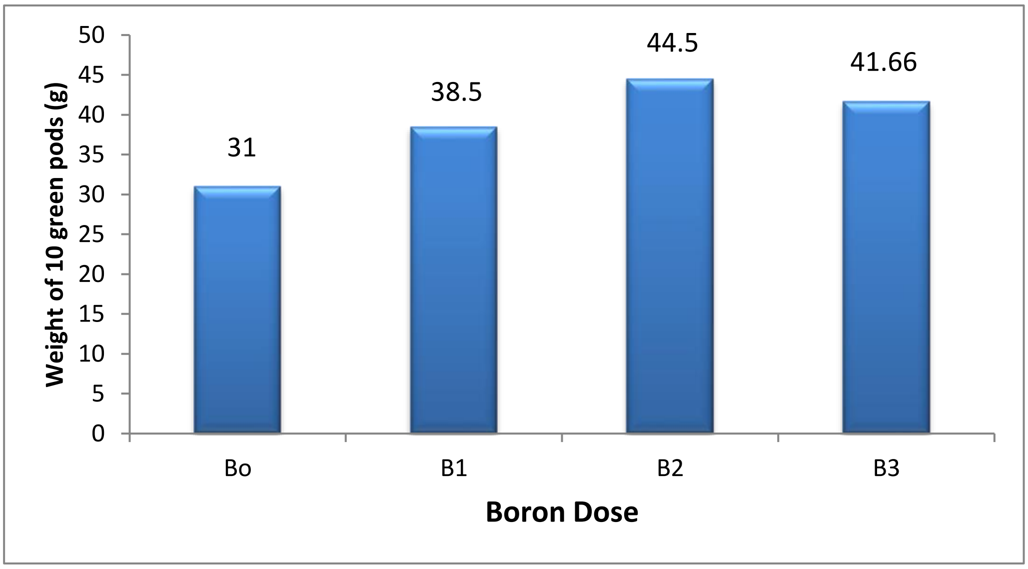


Fig. 5. Effect of different levels of boron on weight of 10 green pods (g) of garden pea

Here, B_0= Control (No Boron), B_1=1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

Statistically significant variation was recorded due to the combined effect of different levels of sulphur and boron levels in terms of weight of 10 green pods of garden pea (Table 7, Appendix IV). The highest weight of 10 green pods (51.33 g) was observed from S_3B_2 (30 kg S/ha with 2 kg B/ha) treatment which was statistically identical with (50.66 g) S_3B_3 treatment combination and statistically similar with S_2B_2 (49.33 g) and S_3B_1 (47.33 g) treatment combination. The lowest weight of 10 green pods (25.33 g) was recorded from S_0B_0 (no sulphur with no boron) treatment combination. This treatment was statistically similar with S_0B_1 (27.33 g) and S_1B_0 (29.33 g) treatment combination.

4.9 Weight of 100 green seeds

Different levels of sulphur significantly influenced 100 green seeds weight of garden pea (Table 5, Appendix V). The ranges of 100 green seeds weight of garden pea were 36.72 g to 24.65 g. The highest weight of 100 green seeds (36.72 g) found from S_3 (30 kg S/ha) treatment and lowest weight of 100 green seeds (24.65 g) were found in S_0 (no sulphur application) treatment. Similar results were recorded by Singh *et al.* (1998) in mustard, Singh and Singh (2004) in black gram.

Table 6. Effect of different levels of boron on yield and yield attributes of garden pea

Treatments	Green pod yield/plant (g)	Number of seeds/pod	Weight of 100 green seeds (g)
B_0	31.00 d	4.45 c	26.27 c
B_1	37.58 c	4.98 b	30.97 b
B_2	44.66 a	5.41 a	35.04 a
B_3	41.25 b	5.21 a	33.21 ab
CV%	10.68	11.58	9.62
LSD	0.02	0.22	2.09

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, B_0= Control (No Boron), B_1=1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

There was a significant difference on 100 green seeds weight among the different levels of boron (Table 6, Appendix V). The weight found from 35.04 g to 26.27 g. The highest weight of 100 green seeds was found (35.04 g) in B_2 (2 kg B/ha) treatment which was statistically similar with B_3 treatment and lowest weight of 100 green seeds was found (26.27 g) in the B_0 (no boron application) treatment.

Table 7. The combined effect of different levels of sulphur and boron on yield and yield attributes of garden pea

Treatments	Green Pod yield/plant (g)	Number of seeds/pod	Weight of 10 green pods (g)	Weight of 100 green seeds (g)
S_0B_0	26.66 k	3.80 k	25.33 j	21.73 k
S_0B_1	28.33 jk	4.13 jk	27.33 ij	25.53 jk
S_0B_2	32.66 h-j	4.66 g-i	32.66 f-h	27.06 g-j
S_0B_3	31.66 h-j	4.46 h-j	30.66 g-i	26.30 h-k
S_1B_0	29.66 i-k	4.26 ij	29.33 h-j	25.06 i-k
S_1B_1	36.00 f-h	5.06 d-g	36.66 ef	30.80 d-h
S_1B_2	42.66 de	5.33 b-e	44.66 b-d	34.06 c-e
S_1B_3	37.33 fg	5.13 c-f	40.00 de	31.53 d-g
S_2B_0	33.33 g-i	4.80 f-h	34.00 f-h	28.43 f-i
S_2B_1	40.00 ef	5.20 c-f	42.66 cd	32.43 d-f
S_2B_2	49.33 bc	5.73 ab	49.33 ab	38.86 ab
S_2B_3	44.66 d	5.40 b-d	45.33 bc	35.30 b-d
S_3B_0	34.33 gh	4.93 e-g	35.33 e-g	29.86 e-h
S_3B_1	46.00 cd	5.53 bc	47.33 a-c	37.13 bc
S_3B_2	54.00 a	5.93 a	51.33 a	40.16 a
S_3B_3	51.33 ab	5.86 a	50.66 a	39.73 ab
CV%	10.68	11.58	10.45	9.62
LSD	0.43	0.40	4.75	3.61

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0= Control (No Sulphur), S_1=10 kg S/ha, S_2=20 kg S/ha, S_3= 30 kg S/ha and B_0= Control (No Boron), B_1= 1 kg B/ha, B_2= 2 kg B/ha, B_3=3 kg B/ha

The combined effect of different levels of sulphur and application of different levels of boron on weight 100 green seeds was found significant (Table 7, Appendix V). Treatment combinations of S_3B_2 (30 kg S/ha combined with 2 kg B/ha) recorded higher 100 green seeds weight (40.16 g) which was statistically similar with S_3B_3 (39.73 g) and S_2B_2 (38.86 g) treatment combinations and lowest weight of 100 green seeds was found (21.73 g) in S_0B_0 (no sulphur with no boron) treatment combination. This treatment was statistically similar with S_0B_1 (23.53 g), S_1B_0 (25.06 g), S_0B_3 (26.30 g) treatment combinations. Result revealed that the combination of different levels of sulphur and boron application might have led to better vegetative growth of pea plants and ultimately produced the larger seeds.

4.10 Dry matter percentage of plant (%)

Dry matter percentage of plant differed significantly due to application of different levels of sulphur (Table 8, Appendix V). It was observed that percent dry matter increased with the increasing levels of sulphur. The highest dry matter percentage of plant (19.09) was recorded from S_3 (30 kg S/ha) treatment which was statistically identical with S_2 (18.14) treatment. The lowest dry matter percentage of plant (14.99) was recorded in S_0 (no sulphur application) treatment.

Table 8. Effect of different levels of sulphur on yield and yield attributes of garden pea

Treatments	Dry matter percentage of plant (%)	Green pod yield (kg/plot)	Green pod yield (ton/ha)
S_0	14.99 c	0.297 d	6.19 d
S_1	16.91 b	0.398 c	8.30 c
S_2	18.14 a	0.464 b	9.67 b
S_3	19.09 a	0.516 a	10.76 a
CV%	9.27	9.56	12.87
LSD	1.20	17.78	0.37

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0= Control (no sulphur), S_1= 10 kg S/ha, S_2=20 kg S/ha, S_3= 30 kg S/ha

Dry matter percentage of plant differed significantly due to application of different levels of boron (Table 9, Appendix V). It was observed that percent dry matter increased with the increasing levels of boron. The highest dry matter percentage of plant (18.55) was recorded from B_2 (2 kg B/ha) treatment which was statistically similar with B_3 (17.93) treatment. The lowest dry matter percentage of plant (15.46) was recorded in B_0 (control) treatment.

The significant difference was found on dry matter percentage of plant due to the combination of different levels of sulphur with application of different levels of boron (Table 10, Appendix V). The highest dry matter percentage of plant (20.58) was recorded in S_3B_2 (30 kg S/ha combined with 2 kg B/ha) treatment combination, which was statistically similar with S_3B_3 (20.02) treatment combination. The lowest dry matter percentage of plant (14.32) was recorded in S_0B_0 (no sulphur with no boron) treatment combination. This treatment was statistically similar with S_0B_1, S_1B_0, S_0B_3, S_0B_2, S_2B_0 and S_3B_0 treatment combination, respectively.

4.11 Green pod yield per plot (kg)

The yield of green pods per plot different markedly as to the different levels of sulphur (Table 8, Appendix V). The green pod yield ranged from 0.516 kg to 0.297 kg per plot. The highest green pod yield (0.516 kg/plot) was obtained when the crop was sown in S_3 (30 kg S/ha) treatment. The lowest green pod yield (0.297 kg/plot) was found when the crop was sown in S_0 (no sulphur application) treatment.

The green pod yield per plot was found significantly influenced by different levels of boron application (Table 9, Appendix V). Green pod yield of garden pea was gradually increased with increasing level of boron up to 2 kg B/ha and then decreased. The highest green pod yield (0.486 kg/plot) was recorded in B_2 (2 kg B/ha) treated plot. The lowest green pod yield (0.321 kg/plot) was recorded in B_0 (no boron application) treatment.

Combined effect of different levels of sulphur and boron levels found significantly influenced in producing green pod yield per plot (Table 10, Appendix V). The highest average green pod yield of 0.585 kg/plot was found in the S_3B_2 (30 kg S/ha combined with 2 kg B/ha) treatment combination. The lowest yield of 0.258 kg/plot was found in the S_0B_0 (no sulphur with no boron) treatment combination, which was statistically similar with S_0B_1 (0.276 kg) treatment combination.

Table 9. Effect of different levels of boron on yield and yield attributes of garden pea

Treatments	Dry matter percentage of plant (%)	Green pod yield (kg/plot)	Green pod yield (ton/ha)
B_0	15.46 c	0.321 d	6.69 d
B_1	17.19 b	0.413 c	8.61 c
B_2	18.55 a	0.486 a	10.14 a
B_3	17.93 ab	0.455 b	9.48 b
CV%	9.27	9.56	12.87
LSD	1.05	15.76	0.54

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, B_0= Control (No Boron), B_1=1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

4.12 Green pod yield per hectare (t)

Statistical variability was exhibited regarding per hectare yield as to the varied levels of sulphur (Table 8, Appendix VI). The green pod yield ranged from 10.76 to 6.19 t/ha. The highest green pod yield (10.76 t/ha) was obtained when the crop was sown in S_3 (30 kg S/ha) treatment. The lowest green pod yield (6.19 t/ha) was found the S_0 (no sulphur application) treatment. These findings are corroborated with those reported by Prasad and Prasad (2003).

The green pod yield per hectare was found significantly influenced by different levels of boron application (Table 9, Appendix VI). Green pod yield of garden pea was gradually increased with increasing level of boron up to 2 kg B/ha then decreased. The highest green pod yield (10.14 t/ha) was recorded in B_2 (2 kg B/ha) treated plot. The lowest green pod yield (6.69 t/ha) was recorded in B_0

(no boron application) treatment. Similar results with boron application have been report by Dwivedi *et al.* (1992).

Table 10. The combined effect of different levels of sulphur and boron on yield and yield attributes of garden pea

Treatments	Dry matter percentage of plant (%)	Green pod yield (kg/plot)	Green pod yield (ton/ha)
S_0B_0	14.32 j	0.258 n	5.38 n
S_0B_1	14.59 ij	0.276 mn	5.75 mn
S_0B_2	15.77 g-j	0.335 jk	6.98 jk
S_0B_3	15.29 h-j	0.319 kl	6.65 kl
S_1B_0	14.48 ij	0.298 lm	6.21 lm
S_1B_1	17.00 f-i	0.398 gh	8.29 gh
S_1B_2	18.34 d-f	0.473 de	9.86 de
S_1B_3	17.42 f-h	0.425 fg	8.86 fg
S_2B_0	16.11 h-j	0.355 ij	7.40 ij
S_2B_1	17.98 e-g	0.451 ef	9.40 ef
S_2B_2	19.51 bc	0.553 bc	11.52 ab
S_2B_3	18.97 b-e	0.497 cd	10.36 cd
S_3B_0	16.56 g-j	0.373 hi	7.87 hi
S_3B_1	19.20 b-d	0.538 bc	11.01 bc
S_3B_2	20.58 a	0.585 a	12.19 a
S_3B_3	20.02 ab	0.568 ab	11.61 ab
CV%	9.27	9.56	12.87
LSD	2.41	15.56	0.74

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0= Control (No Sulphur), S_1=10 kg S/ha, S_2=20 kg S/ha, S_3= 30 kg S/ha and B_0= Control (No Boron), B_1= 1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

Wide variation was found as to the combined application of different levels of sulphur and boron in respect of green pod yield per hectare (Table 10, Appendix VI). It ranged from 12.19 to 5.38 per hectare. The highest average green pod yield of 12.19 t/ha was obtained in the S_3B_2 (30 kg S/ha combined with 2 kg B/ha) treatment combination, which was statistically similar with S_3B_3 (11.61 t/ha) and S_2B_2 (11.52 t/ha) treatment combination, respectively. The lowest yield of 5.38 t/ha was recorded from the S_0B_0 (no sulphur with no boron) treatment combination, which was statistically similar with S_0B_1 (5.75

t/ha) treatment combination. Kaisher *et al.* (2010) reported that combined application of 30 kg sulphur and 5 kg boron/ha significantly increased plant height, number of branches/plant, number of pods/plant, number of seeds/pod, 1000-seed weight and seed yield of mungbean. Yang *et al*. (1998) reported that combined application of sulphur and boron markedly increased growth and yield related attributes of mungbean.

4.13 Green seed yield per plot (g)

The green seed yield per plot was found significantly influenced by different levels of sulphur (Table 11, Appendix VI). The highest seed yield (178.23 g/plot) was obtained was obtained from S_3 (30 kg S/ha) treatment and lowest (95.75 g/plot) was obtained from S_0 (no sulphur application) treatment.

Table 11. Effect of different levels of sulphur on yield and yield attributes of garden pea

Treatments	Green seed yield (g/plot)	Green seed yield (t/ha)
S_0	95.75 d	1.99 d
S_1	134.01 c	2.79 c
S_2	156.65 b	3.26 b
S_3	178.27 a	3.71 a
CV%	9.37	10.42
LSD	12.80	0.26

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, S_0= Control (no sulphur), S_1= 10 kg S/ha, S_2=20 kg S/ha, S_3= 30 kg S/ha

The seed yield per plot was significantly influenced by different levels of boron application (Table 12, Appendix VI). The highest seed yield (167.97 g/plot) was obtained in B_2 (2 kg B/ha) treated plot and the lowest (103.71 g/plot) was found in B_0 (no boron application) treated plot. The seed yield of garden pea was gradually increased with increasing level of boron up to 2 kg B/ha and then decreased.

The combined effect of different levels of sulphur and boron application on seed yield per plot of garden pea was significant (Table 13, Appendix VI).

Seed yield of pea varied significantly with the variation of different treatment combinations. All the treatment combinations produced significantly higher seed yield compared to control (no fertilizer) treatment. The highest average green seed yield of (210.50 g/plot) was found in the S_3B_2 (30 kg S/ha combined with 2 kg B/ha) treatment combination which was out yielded the other treatment combinations. The lowest yield of (79.03 g/plot) was found in the S_0B_0 (no sulphur with no boron) treatment combination. This treatment was statistically similar with S_0B_1 (87.23 g/plot) and S_1B_0 (96.43 g/plot) treatment combination, respectively.

4.14 Green seed yield per hectare (t)

The green seed yield per hectare was significantly influenced by different levels of sulphur (Table 11, Appendix VI). The highest seed yield (3.71 t/ha) was obtained was obtained when the crop was sown in S_3 (30 kg S/ha) treatment and the lowest (1.99 t/ha) was obtained when the crop was sown in S_0 (no sulphur application) treatment. The findings similar of Malik and Abraham (2003).

Table 12. Effect of different levels of boron on yield and yield attributes of garden pea

Treatments	Green seed yield (g/plot)	Green seed yield (t/ha)
B_0	103.71 d	2.16 d
B_1	138.38 c	2.88 c
B_2	167.97 a	3.49 a
B_3	154.61 b	3.22 b
CV%	9.37	10.42
LSD	11.31	0.22

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.
Here, B_0= Control (No Boron), B_1=1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

The green seed yield per hectare was significantly influenced by the application of different levels of boron (Table 12, Appendix VI). The highest seed yield (3.49 t/ha) was obtained in B2 (2 kg B/ha) treated plot and the lowest (2.16 t/ha) was found in B0 (no boron application) treated plot.

The combined effect of different levels of sulphur and boron application on green seed yield of garden pea was found significant (Table 13, Appendix VI). Seed yield of pea varied significantly with the variation of different treatment combinations. All the treatment combinations produced significantly higher seed yield compared to control. The highest average green seed yield of 4.38 t/ha was found in the S_3B_2 (30 kg S/ha combined with 2 kg B/ha) treatment combination, which was statistically similar with S_3B_3 (4.14 t/ha) and the lowest yield of 1.64 t/ha was found in the S_0B_0 (no sulphur with no boron) treatment combination, which was statistically similar with S_0B_1 (1.81 t/ha) and S_1B_0 (2.00 t/ha) treatment combination, respectively.

Table 13. The combined effect of different levels of sulphur and boron on yield and yield attributes of garden pea

Treatments	Green seed yield (g/plot)	Green seed yield (t/ha)
S_0B_0	79.03 n	1.64 m
S_0B_1	87.23 lm	1.81 lm
S_0B_2	111.40 i-l	2.32 i-l
S_0B_3	105.33 j-l	2.19 j-l
S_1B_0	96.43 k-m	2.00 k-m
S_1B_1	134.87 g-i	2.80 g-i
S_1B_2	161.60 d-f	3.36 d-f
S_1B_3	143.13 f-h	2.98 f-h
S_2B_0	115.23 i-k	2.40 i-k
S_2B_1	152.10 e-g	3.16 e-g
S_2B_2	188.40 bc	3.92 bc
S_2B_3	170.87 c-e	3.55 c-e
S_3B_0	124.13 h-j	2.58 h-j
S_3B_1	179.33 b-d	3.73 b-d
S_3B_2	210.50 a	4.38 a
S_3B_3	199.10 b	4.14 ab
CV %	9.37	10.42
LSD	10.60	0.53

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Here, S_0= Control (No Sulphur). S_1=10 kg S/ha, S_2=20 kg S/ha, S_3= 30 kg S/ha and B_0= Control (No Boron), B_1= 1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

4.15 Economic analysis of garden pea production

Input costs for land preparation, inorganic fertilizer, organic manure and manpower required for all the operations from seed sowing to harvesting of garden pea were recorded as per plot and converted into cost/hectare. Price of pod was considered as per present market rate basis. The economic analysis presented under the following headings-

4.15.1 Gross return

The combination of different levels of Sulphur and boron dose has different value in terms of gross return under the trial (Table 14). The highest gross return (BDT 3,65,700/ha) was obtained from the treatment combination S_3B_2 and the second highest gross return (BDT 3,48,300/ha) was found in S_3B_3 treatment. The lowest gross return (BDT 1,61,400/ha) was obtained from S_0B_0 treatment.

4.15.2 Net return per hectare

In case of net return, sulphur and boron dose of net return under the present trial (Table 14). The highest net return (BDT 2,17,585/ha) was found from the treatment combination S_3B_2 treatment and the second highest net return (BDT 2,00,018/ha) was obtained from the combination S_3B_3 treatment. The lowest net return (BDT 17,647/ha) was obtained from S_0B_0 treatment.

4.15.3 Benefit Cost Ratio (BCR)

In the combination of different levels of Sulphur and boron dose, the highest benefit cost ratio (2.46) was noted from the combination of S_3B_2 treatment (Table 14) and the second highest benefit cost ratio (2.35) was estimated from the combination of S_2B_2 treatment. The lowest benefit cost ratio (1.12) was obtained from S_0B_0 treatment. From economic point of view, it is apparent from the above results that the combination of S_3B_2 treatment was better than rest of the combination in garden pea cultivation.

Table 14. Economic analysis of garden pea (*Pisum sativum*) production as influenced by different levels of sulphur and boron application

Treatments	Green pod yield/ha (t)	Total cost of production (tk)	Gross return/ha (tk)	Net return/ha (tk)	Benefit Cost Ratio (BCR)
S_0B_0	5.38	143752.8	161400	17647	1.12
S_0B_1	5.75	143919.3	172500	28581	1.19
S_0B_2	6.98	144085.8	209400	65314	1.45
S_0B_3	6.65	144252.3	199500	55248	1.38
S_1B_0	6.21	145059.9	186300	41240	1.28
S_1B_1	8.29	145262.4	248700	103438	1.71
S_1B_2	9.86	145428.9	295800	150371	2.03
S_1B_3	8.86	145595.4	265800	120205	1.82
S_2B_0	7.40	146538.9	222000	75461	1.51
S_2B_1	9.40	146605.5	282000	135395	1.92
S_2B_2	11.52	146772	345600	198828	2.35
S_2B_3	10.36	146938.5	310800	162862	2.11
S_3B_0	7.78	147782.1	233400	85618	1.57
S_3B_1	11.01	147948.6	330300	182351	2.23
S_3B_2	12.19	148115.1	365700	217585	2.46
S_3B_3	11.61	148281.6	348300	200018	2.34

Here, S_0= Control (No Sulphur), S_1=10 kg S/ha, S_2=20 kg S/ha, S_3= 30 kg S/ha and B_0= Control (No Boron), B_1= 1 kg B/ha, B_2=2 kg B/ha, B_3=3 kg B/ha

Total cost of production was done in details according to the procedure of Alam *et al.* (1989).

Where,

Sale of marketable pod @ 30000 Tk per ton.

Gross return = Marketable yield × Tk/ton

Net income = Gross return – Total cost of production
Benefit Cost Ratio (BCR) = Gross return ÷ Cost of production

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out at the horticultural research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during the period from October 2018 to March 2019 to assess the response of garden pea *(Pisum sativum* L.) on different levels of sulphur and levels of boron. The seeds of BARI Motorshuti-3 were used as planting materials for this experiment. The experiment consisted of two factors: Factor A: Sulphur fertilizer (four levels) as- S_0: Control (No Sulphur), S_1: 10 kg S/ha, S_2: 20 kg S/ha, S_3: 30 kg S/ha and Factor B: Boron fertilizer (four levels) as- B_0= Control (No Boron), B_1: 1 kg B/ha, B_2: 2 kg B/ha, B_3: 3 kg B/ha. The two factor experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth yield and quality parameters were recorded and statistically significant variation was observed for different recorded parameters.

For different Sulphur dose, the tallest plant at 30, 45 DAS and at harvesting was recorded (31.40 cm, 41.49 cm and 50.84 cm respectively) for S_3 treatment, whereas the shortest plant (23.10, 32.72 and 39.49 cm, respectively) from S_0 treatment. The highest number of pods per plant (14.00) was recorded from S_3 treatment, while the lowest number of pods per plant (10.00) found from S_0 treatment. The highest pod length (8.95 cm) was recorded from S_3 treatment, while the lowest pod length (6.72 cm) found from S_0 treatment. The highest Pod breadth (1.43 cm) was found from S_3 treatment, while the lowest (1.24 cm) was recorded from S_0 treatment. The highest green pod yield per plant (46.41 g) was found from S_3 treatment, while the lowest (29.83 g) was recorded from S_0 treatment. The highest weight of 10 green pods (46.16 g) was found from S_3 treatment, while the lowest (29.00 g) was recorded from S_0 treatment. The highest number of seeds per pod (5.56) was found from S_3 treatment, while the lowest (4.26) was recorded from S_0 treatment. The highest 100 green seeds weight (36.72 g) was found from S_3 treatment, while the lowest (24.65 g) was recorded from S_0 treatment. The highest dry matter percentage of plant (19.09) was found from S_3 treatment, while the lowest (14.99) was recorded from S_0 treatment. The highest green pod yield per plot (0.516 kg) was found from S_3 treatment, while the lowest (0.297 kg) was recorded from S_0 treatment. The highest green pod yield per hectare (10.76 t) was found from S_3 treatment, while the lowest (6.19 t) was recorded from S_0 treatment. The highest green seed yield per plot (178.27 g) was found from S_3 treatment, while the lowest (95.75 g/plot) was recorded from S_0 treatment. The highest green seed yield per hectare (3.71 t) was found from S_3 treatment, while the lowest (1.99 t) was recorded from S_0 treatment.

In case of different boron dose, the tallest plant at 30, 45 DAS and at harvesting was recorded (30.29 cm, 40.38 cm and 49.17 cm respectively) for B_2 treatment, whereas the shortest plant (24.10, 33.95 and 40.72 cm, respectively) from B_0 treatment. The highest number of pods per plant (13.48) was recorded from B_2 treatment, while the lowest number of pods per plant (10.49) found from B_0 treatment. The highest pod length (8.66 cm) was recorded from B_2 treatment, while the lowest pod length (7.03 cm) found from B_0 treatment. The highest Pod breadth (1.41 cm) was found from B_2 treatment, while the lowest (1.26 cm) was recorded from B_0 treatment. The highest green pod yield per plant (44.66 g) was found from B_2 treatment, while the lowest (31.00 g) was recorded from B_0 treatment. The highest weight of 10 green pods (44.50 g) was found from B_2 treatment, while the lowest (31.00 g) was recorded from B_0 treatment. The highest number of seeds per pod (5.41) was found from B_2 treatment, while the lowest (4.45) was recorded from B_0 treatment. The highest 100 green seeds weight (35.04 g) was found from B_2 treatment, while the lowest (26.27 g) was recorded from B_0 treatment. The highest dry matter percentage of plant (18.55) was found from B_2 treatment, while the lowest (15.46) was recorded from B_0 treatment. The highest green pod yield per plot (0.486 kg) was found from B_2 treatment, while the lowest (0.321 kg) was recorded from B_0 treatment. The highest green pod yield per hectare (10.14 t) was found from B_2 treatment, while the lowest (6.69 t) was recorded from B_0 treatment. The highest green seed yield per plot (167.97 g) was found from B_2 treatment, while the lowest (103.71 g) was recorded from B_0 treatment. The highest green seed yield per hectare (3.49 t) was found from B_2 treatment, while the lowest (2.16 t) was recorded from B_0 treatment.

Due to the combined effect of different levels of sulphur and levels of boron, the tallest plant at 30, 45 DAS and at harvesting was recorded (34.76 cm, 44.56 cm and 55.10 cm, respectively) for S_3B_2 treatment, whereas the shortest plant (21.56, 30.80 and 37.73 cm, respectively) from S_0B_0. The highest number of pods per plant (15.50) was recorded from S_3B_2 treatment, while the lowest number of pods per plant (9.20) found from S_0B_0 treatment. The highest pod length (9.70 cm) was recorded from S_3B_2 treatment, while the lowest pod length (6.24 cm) found from S_0B_0 treatment. The highest Pod breadth (1.51 cm) was found from S_3B_2 treatment, while the lowest (1.19 cm) was recorded from S_0B_0 treatment. The highest green pod yield per plant (54.00 g) was found from S_3B_2 treatment, while the lowest (26.66 g) was recorded from S_0B_0 treatment. The highest weight of 10 green pods (51.33 g) was found from S_3B_2 treatment, while the lowest (25.33 g) was recorded from S_0B_0 treatment. The highest number of seeds per pod (5.93) was found from S_3B_2 treatment, while the lowest (3.80) was recorded from S_0B_0 treatment. The highest 100 green seeds weight (40.16 g) was found from S_3B_2 treatment, while the lowest (21.73 g) was recorded from S_0B_0 treatment. The highest dry matter percentage of plant (20.58) was found from S_3B_2 treatment, while the lowest (14.32) was recorded from S_0B_0 treatment. The highest green pod yield per plot (0.585 kg) was found from S_3B_2 treatment, while the lowest (0.285 kg) was recorded from S_0B_0 treatment. The highest green pod yield per hectare (12.19 t) was found from S_3B_2 treatment, while the lowest (5.38 t) was recorded from S_0B_0 treatment. The highest green seed yield per plot (210.50 g) was found from S_3B_2 treatment, while the lowest (79.03 g) was recorded from S_0B_0treatment. The highest green seed yield per hectare (4.38 t) was found from S_3B_2 treatment, while the lowest (1.64 t) was recorded from S_0B_0 treatment.

The highest gross return (BDT 3,65,700/ha) was obtained from the treatment combination S_3B_2 and the lowest (BDT 1,61,400/ha) was obtained from S_0B_0 treatment combination. The highest net return (BDT 2,17,585/ha) was found from the treatment combination S_3B_2 and the lowest net return (BDT 17,647/ha) was obtained from S_0B_0 treatment combination. The highest benefit cost ratio (2.46) was noted from the combination of S_3B_2 treatment combination and the lowest (1.12) was obtained from S_0B_0 treatment combination.

CONCLUSION

From economic point of view, it is apparent from the above results that the combination of S_3B_2 treatment combination was better than rest of the combination in garden pea cultivation.

Based on the experimental results, it may be concluded that

1. Application of 30 kg Sulphur per hectare increase the pod and seed yield of garden pea.
2. Application of 2 kg Boron per hectare was found to be the best for maximum pod and seed yield of garden pea.
3. A combination of 30 kg Sulphur with 2 kg Boron per hectare application was the most suitable combination in respect of pod and seed yield of garden pea.

Recommendations

Based on the findings of the study it can be recommended that

Further investigation may be conducted in different agro-ecological zones (AEZ) of Bangladesh for exploitation of regional adaptability and other performances. Since the experiment was conducted in one year only. So, some other levels of Sulphur and Boron dose may be included in future program for more confirmation of the results.

REFERENCES

Alam, M.S., Iqbal, T.M.T., Amin, M. and Gaffar, M.A. (1989). Krishitattic Fasaler Utpadan O Unnayan (in Bengali). Sirajgonj. pp. 231- 239.

Aulakh, M.S and Chibba, I.M. (1992). Sulphur in soils and response of crops to its application in Punjab. *Fertilizer News.* **38**(9): 33-45.

Aulakh, M.S and Pasricha, M.S. (1979). Response of gram and lentil to phosphorus as influenced by applied sulphur and its residual effects on moong. *Bulletin Indian Society of Sci.,* **12**: 433-438.

Aulakh, M.S. and Pasricha, N.S. (1997). Interaction effect of S and P on growth and nutrient content of moong (*Phaseolus aurevs* L). *Plant and soil.* **47**: 141-143.

Azevedo, W.D., Faqiun, V., Moreira, F.S., Oliveira, A. and Lisboacc, D.S. (2002). Boron effects on nodule development in pea plants cultivated in lowland soils. *Pesquisa Agropecuaria Brasileira*. **37**(8): 1137- 1143.

Aziz, F.H., Abdul, K.S. and Salih, T.J. (1989). The response of leafless pea to northern Iraqi condition and Effects of autumn and spring sowings. ZANCO. **2**(3): 31-42.

Bandyopadhyay, P.K. and Chattopadhyay, G.N. (2000). Availability of boron and sulphur and their nutrition of rape seed plants in alfisols of west Bengal. *Journal of Interacademicia*. **4**(1): 67-72.

Banu, M.A. (2003). Effects of sulphur and boron on some physiological and biochemical parameters of chickpea at different growth stages. M.S. Thesis, Dept. of April. Chem. Bangladesh Agricultural University, Mymensingh.

BBS. (2018). Year book of Agricultural statistics of Bangladesh. 2019 30th ed. Bangladesh Bureau of statistics. Statistics Division, Ministry of planning. Govt of the people Republic of Bangladesh.

Bharathi, C. and Poongothai, S. (2008). Direct and residual effect of sulphur on growth, nutrient uptake, yield and its use efficiency in maize and subsequent green gram. *Research Journal of Agriculture and Biological Sci.*, **4**(5): 368-372.

Biswas, B.C., Sarkar, M.C., Tanwar, S.P.S., Das, S. and Kalwe, S.P. (2004). Sulphur deficiency in soils and crop response to fertilizer sulphur in India. *Fertilizer News*. **49**(10): 13-18.

Bolanos, L., Esteban. E., Lorenzo, C.de., Fernandez, P.M., Felipe, MR-de., Garate, A., Bonilla, I., De-Lorenzo, C., and De-Felipe, MR. (1994). Essentiality of boron for symbiotic dinitrogen fixation in pea (*Pisum sativum*) rhizobium nodules. *Plant Physiol.,* **104**(1): 85-90.

Bonilla, I., El- Hamdaovi, A and Bolanos, L. (2004). Boron and calcium increase *Pisum sativum* seed germination and seedling development under salt stress. *Plant and soil.* **267**(1/2): 97-107.

Budhar, M.N. and Tamilselvan, N. (2001). Effect of sulphur on yield attributes and yield on rainfied green gram (*Vigna radiata* L.). *Madras Agril. J.* **88**(7): 504-505.

Chadha, K.L. (2003). Handbook of Horticulture ICAR Publication New- Delhi. pp. 52-64.

Chakraborty, A.K. and Das, D.K. (2000). Interaction between B x S on different quality parameters of rape (*B. compestris L*.). *Res. on Crops.* **1**: 326-329.

Chaubey, A.K and Singh, S.B. (2004). Growth and yield response of dwarf pea (*Pisum sativum* L.) to phosphorus and sulphur application in entisol. *Bioved.* **15**(1/2): 41-43.

Choudhury, B. (2000). Vegetables. National Book Trust, New Delhi. Pp. 133- 140.

Das, P.C. (1993). Manures and fertilizers. 1st edition. Kalyani Publishers, Ludhiana, p. 13.

Deshbhratar, P. B., Singh, P.K., Jambhulkar, A.P. and Ramteke, D.S. (2010). Effect of sulphur and phosphorus on yield, quality and nutrient status of pigeonpea. (*Cajanus Cajan*). *J. of Environ. Bio.*, **31**(6): 933-937.

Dhar, M.E., Jana, J.C. and Maity, T.K. (1999). Response of cabbage to sulphur fertilization. *Vegetable Sci.,* **26**(1): 82-84.

Dubey, S.D., shukla, P. and Tiwari, S.P. (1997). Effect of fertilizer on yield of linseed (*Linum usitatissiumum*). *Indian J. Agric. Sci.,* **67**: 539- 540.

Dutta, R.K., Uddin, M. and Rahman, L. (1984). Production of mungbean, rice and mustard in relation to boron in Brahmaputra Floodplain soils. *Bangladesh J. Soil Sci.,* **20**: 77-78.

Dwivedi, BS., Ram, M., Singh, BP., Das, M and Prasad, RN. (1992). Effect of liming on boron nutrition of pea (*Pisum sativum* L.) and corn *(Zea mays L.)* grown in sequence in an acid alfisol. *Fertilizer Res.,* **31**(3): 257-262.

Dwivedi, R.K., Sing, V.K., Choudhary, S.K., Sanger, R.B.S. and Bajpal, R.P. (1998). Response of table pea (*Pisum sativum*) cultivars to sowing dates and seed rate under northern hill zone of Chhattisgarh, M.P. *Orissa J. of Hort.,* **26**(1): 17-19.

Garate, A., Esteban, E., Lucena, J.J., Carpena, R.o., Bonilla, I and Barrow, N.J. (1993). Effect of boron on nodulated and non-nodulated pea plants. *Developments in plant and soil Sci.,* **54**: 417-420.

Ghai, V.L. (1980). "Evaluation of soil tests for available sulphur in bench mark soils of Punjab". M.Sc (Agri.) thesis, submitted to Punjab Agricultural University. Ludhiana Punjab.

Ghosh, T.K., Mitra, S., Saren, B.K., Roy, D.K and Singh, S.S. (1996). Effect of different levels of sulphur application on growth and yield of urd. *Environmental and Ecology*. **4**: 765-768.

Gomez, K. A. and Gomez A. A. (1984). Statistical Procedures for Agricultural Research. Intl. Rice Res.Inst., Jhon Wily and Sons. New York, Chickester, Brisbane, Toranto, Singapore. p. 680.

Gowswammy, N.N. (1986). In the forward to sulphur research and agricultural production in India. H.L.S. Tondon, F.D.C.O., New Delhi.

Gulati, K.L. (1980). Effect of different levels of B on the yield of tomato *plant and Soil*, **54**: 479-484.

Gupta, J.K. and Gupta, Y.P. (1972). Effect of sulphur and molybdenum on quality of pea. *Indian J. of Agron.*, **17**(3): 245-247.

Hassanein, R.A., Dowidar, A.E., Zaky, L.M and El-Mashad, A.A. (1999). Effect of foliar treatment with boron and Zinc on physiological responses of Cow Pea (*Vigna sinensis Cv. Cream* 7), I- Growth parameters, auxins, growth inhibitor content, yield their protein pattern. *Egyptian Journal of Physiological Sci.,* **23** (3): 415- 442.

Jain, G.L., Sahu, M.P. and Somani, L.L. (1984). Secondary nutrient research in Rajasthan – Retrospect and Prospect. **In**: *Proceedings of FAINR Seminar on "Balanced Fertilization Programme with Special Reference to Secondary and Micronutrients, Nutrition of Crops under Intensive Cropping*, New Delhi, The Fertilizer Association of India. pp 147-274.

Jana, S.K. and Paria, N.C. (1996). Effect of agro-chemicals on growth and yield of garden pea (*Pisum sativum* L.) cv. Arkel. *Environment and Ecology*. **14**(3): 535-537.

Jena, D, Dash, A.K., Mohanty, B., Jena, B and Mukhi, S.K. (2009). Interaction effect of lime and boron on cabbage -okra cropping system in boron deficient acidic laterite soils of Bhubaneswar. *An Asian journal of Soil sci.,* **4**(1): 74-80.

Jones, M.B., Oh, J.H. and Ruckman, J.E. (1972). *Sulphur Institute Journal*. **8**(1&2): 2-5.

Kaisher, M.S., Rahman, M.A., Amin, M.H.A., Amanullah, A.S. M., and Ashanullah, A.S. M. (2010). Effect of sulphur and boron on the seed yield and protein content of mungbean. *Bangladesh Research Publications Journal.,* **3**(4): 1181-1186.

Kamat, V.N., Kntute, V.G., Puranik, R.B., Kohadjar, W.S., and Joshi, R.P. (1981). Effect of sulphur and molybdenum application on yield and protein and S-aminoacid contents of green gram. *Journal of the Indian Society of Soil Sci.,* **29**(2): 225-227.

Kasturikrishna and Ahlawat, I.P.S. (1999). Growth and yield response of pea (*Pisum sativum*) to moisture stress, phosphorus, sulphur and zinc fertilizers. *Indian J. of Agron.,* **44**(3): 588-596.

Khanna, P.K and Gupta, A. K (2005). Changes in growth, yield and some biochemical attributes in Pea (*Pisum sativum*) with Rhizobium and Sulphur applications. *J. of Plant Bio.,* **32**(1): 25-28.

Kher, D. and Singh, N. (1993). Different forms of sulphur in mustard growing soils of North Kashmir. *Journal of the Indian society of Soil Sci.,* **41**(1): 164-165

Kumar, S and Singh, T. B. (2009). Effect of sulphur with and without rhizobium on yield and biochemical composition of black gram. *Annuals of plant Soil Res.,* **11**(1): 58-59.

Kushwaha, A.K., Singh, S. and Singh, R.N (2009). Available nutrients and response of lentil (*Lens esculenta*) to boron application in rainfed upland soils of Ranchi. *J. of the Indian Society of soil Sci.,* **57** (2): 219-222.

Lalitha, B.H., Yeledhalli, N.A. and Ravi, M.V. 2008. Effect of foliar application of potassium sulphate and boric acid on the yield, Nutrient uptake and quality of Niger (*Guizotia abyssinica L.). Karnataka J. Agric. Sci.,* **21**(20): 282-283.

Makasheva, R.K.H. (1983). The pea. Oxonion press pvt. Ltd. New Delhi. pp. 267.

Malik, R.A. and Abraham, G. (2003). Response of sulphur on the productivity of pea (*Pisum sativum*) through sulphur application. *Farm Sci.,* **12**(2): 174-175.

Marok, A.S and Dev, G (1980). Phosphorus and sulphur interrelationship in wheat. *J. of the Indian Soc. of soil Sci.,* **28**: 184-188.

Maurya, C. P and Lal, H. (1988). Effects of different sowing time on green pod yield of pea (*Pisum sativum*) varieties. *Prog. Hort.*, **20**(1-2): 17-27.

Meicenheimer, R.D. and Muchlbauer, F.J. (1983). Growth and development stages of Alaska peas. Exp. Agri., **18**: 17-27.

Misra, S.K. (2001). Effect of sulphur and zinc on yield, uptake of nutrients and quality of mustard. *Annals of Plant and soil Res.,* **3**: 203- 206.

Mishra, S.N., Josshi, R.P. and Singh, A.P. (1995). The grain yield of chick pea was increased with sulphur application. *Journal of the Indian Society of soil Sci.,* **39:** 322.

Moghazy A.M., Saed, S.M. El. and Awad, El. S.M. (2014). The Influence of Boron Foliar Spraying with Compost and Mineral Fertilizers on Growth, Green pods and Seed Yield of Pea. *Nat. Sci.,* **12**(7): 50-57.

Moniruzzaman, M., Islam, M.R. and Hasan, J. (2008). Effect of N, P, K Zn and B on yield attributes and yield of French Bean in south Eastern hilly Region of Bangladesh. *J. Agric. Rural Dev.,* **6** (1&2): 75-82.

Nasreen, S. and Farid, A.T.M. (2003). Influence of different nutrients on growth and yield of garden pea (*Pisum sativum* L.). *Indian J. of Agron.,* **48**(3): 206-209.

Patil, J.R. and Sheike, V.B. (1998). Effect of farmyard manure, phosphorus and sulphur on growth, yield and quality of Indian mustard (*Brassica juncea*). *Indian J. of Agron.,* **43**(4): 713-717.

Prabhakara, B.S., Naik, L.B., Mohan, N. and VaraLakshami, B. (2001). *Vegetables, Tubercrops and Spices*. ICAR Publication New Delhi. pp. 196-198.

Prasad, K and Prasad, R. (2003). Effect of varieties and sulphur doses on the productivity and economics of field pea. *Progressive Agriculture.* **3**(1)2: 135-136.

Prasad, K.K., Chowdhary, B.W., Amrendra, K. and Kumar, A. (1998). Effect of boron on the economic yield of Pea (*Pisum sativum* L.) in Chotanagpur region of Bihar. *Journal of Research, Birsa Agricultural University*. **10**(1): 75-77.

Pratima, S., Chatterjee, C., Sharma, C.P and Sinha, P. (1999). Changes in physiology and quality of pea by boron stress. *Annals of Agricultural Res.*, **20** (3): 304-307.

Ram, H., Dixit, V.K and Khan, T. (1993). Distribution of different forms of sulphur in rice growing soils of Uttar Pradesh. *J. of Indian Society of Soil Sci.,* **41**(3): 564-565.

Ramesh, V., Nepalia, V and Kumawat, S.K. (2004). Influence of weed control and sulphur nutrition on weed dynamics and productivity of pea (*Pisum sativum L.). Indian J. of weed Sci.*, **36**(3/4): 285-286.

Rashid, M.M. (1993). Sabji Biggan (Olericulture). Bangla Academi. 1st edition, Dhaka. pp. 515.

Saha, A., Mandal, B. K. and Mukhopadhyay, P. (1996). Residual effect of boron and molybdenum on the yield of succeeding mungbean in summer. *Indian Agriculturist*. **40**(1): 11-16.

Sakal, R., Sinha, R.B. and Singh, A.P. (1988). Effect of boron application on black gram and chick pea production in calcareous soil. *Fertilizer News.* **33**: 27-30.

Sarker, S.K., Chowdhury, M.A.H and Zakir, M.H. (2002). Sulphur and Boron Fertilization on yield, quality and nutrient uptake by Bangladesh Soybean -4 online *J. of Biological Sci.*, **2**(11): 729-733.

Shahi, D.K., Sharma, A and Singh, L. (2002). Improving protein quality of green gram (*Vigna rediata* L. Wilezek) through use of rhizobium inoculation, phosphorus and sulphur. *J.Res.,* **14**: 171-174.

Shankaralingappa, B.C., Saifulla, M and Chandra Parkash, J. (2002). Effect of levels and modes of application of sulphur on productivity of pigeon pea. *Current Research, University, Agricultural Sci. Bangalore*. **31**(9/10): 159-161.

Sharma, S.C. and Srivastava, L.C. (1993). Effect of different levels of sulphur on growth and yield of green gram. *Indian Journal of Botany*. **41**(4): 201-204.

Sharma, V. K. and Kamath, M.B. (1991). Effect of sulphur, phosphorus and calcium on sulphur utilization by mustard (*Brassica Juncea* L.) and pea (*Pisum sativum* L.) *Journal of Nuclear Agriculture and Biology*. **20**(2): 123-127.

Shivran, P.L., Ahlawat, I.P.S and Shivran, D.R. (2000). Effect of phosphorus and sulphur on pigeon pea (*Cajanus cajan*) and succeeding wheat (*Triticum sativum*) in pigeonpea – wheat cropping system. *Indian J. of Agron.*, **45**(1):

Singh, V. and Singh, S.P. (1984). Effect of applied boron on nutrient uptake by barley crop. *Curr. Agric*., **8**: 89-90.

Singh, O., Raj, B. and Singh, O. (1988). Sulphur fertilization in relation to yield and trend of production of leghoemoglobin pigment in the nodules of pea. *Annals of Agricultural Res.*, **9**(1): 13-19.

Singh, P.N and Ram, H. (1989). Effect of phosphorus and sulphur on content and uptake of phosphorus in chick pea. *Indian J. of Agric. Sci*., **59**(7): 470-471.

Singh, R.S. and Singh, R.P. (1992). Effect of sulphur fertilization and rhizobium inoculation on yield and nutrient content and uptake in pea (*Pisum sativum*) in different soils of Uttar Pradesh. *Indian J. of Agric. Res*., **26**(2): 57-64.

Singh, A., Singh, B.B. and Patel, C.S. (1992). Response of vegetable pea (*Pisum sativum*) to zinc, boron and molybdenum in an acid alfisol of Meghalaya. *Indian J. of Agron.*, **37**(3): 615- 616.

Singh, R.P. (1995). Effect of sulphur and cultivars on yield of field (*Pisum sativum* L.). *Recent Horticulture*. **2**(2):107-110.

Singh, S.S. (1996). Soil fertility and nutrient management. 1st edition. Kalyani Publishers, Ludhiana. p. 42.

Singh, B. and Kumar, V. (1996). Effect Of phosphorus and sulphur on lentil under rainfed conditions. *Indian J. of Agron*., **41**(3): 420-423.

Singh, Y.P. and Singh, R. (2004). Interaction effect of sulphur and phosphorus on growth and nutrient content of blackgram (*Phaseolus mungo* L.). *J. of the Indian Society of Soil Sci*., **52**(3): 266- 269.

Singh, V. and Yadav, D.S. (1997). Studies on sulphur and zinc nutrition on green gram (*Phaseolus radiatus* L.) in relation to growth attributes, seed protein yield and S, Zn uptake. *Legume Res*., **20**(3- 4): 224-226.

Singh, V., Trivedi, S.K., Tomar, R.A.S. and Sasode, D.S. (1998). Resposne of Indian mustard (*Brassica juncea*) to sulphur and varying fertility levels. *Indian J. of Agron.,* **43**(4): 721-724.

Singh, R., Yadav, D.S., Maurya, M.L. and Singh, R. (2002). Effect of boron application on yield of Pea (*Pisum sativum* L.) and black gram (*Vigna mungo* Hepper) in calcareous soil. *Fertilizer News*. **47**(2): 67-68.

Singh, R.N., Kumar, B. and Singh, S. (2004). Effect of lime and boron application on gram (*Cicer arietinum*) in acid soils of Jharkhand. *J. of Indian Society of Soil Sci.,* **52**(3): 283-285.

Singh, S., Saini, S.S and Singh, B.P. (2004). Effect of irrigation, sulphur and seed inoculation on growth, yield and sulphur uptake of chick pea under late sown conditions. *Indian J. of Agron.,* **49**(1): 57-59.

Singh, R.N., Singh, S. and Kumar, B. (2006). Interaction effect of sulphur and boron on yield and nutrient uptake and quality characters of soybean (*Glycine max* L. Merill) grown in acidic upland soil. *J. of Indian Society of Soil Sci*., **54**(4): 516-518.

Sinha, P, B. K. Dube, M.V. Sing and C. Chattergce. (2006). Effect on boron stress on yield, biochemical parameters and quality of tomato. *India. J. Hort*., **03**(1): 33-43.

Sinha, A.C., Mandal, B.B. and Jana, P.K. (1994). Yield and water use efficiency of rainfed lentil (Lens culinaris) as influenced by boron zinc and molybdenum. *J. Agric. Sci.,* **64**(12): 863-866.

Smit, J.N. and N.J.J. Combrink. (2004). The effect of boron levels in nutrient solutions in fruit production and quality of greenhouse tomatoes. *South Afr. J. Plant Soil.* **21**(3): 188-191.

Sriramachandrasekharan, M.V. (2009). Nutrient uptake, yield and quality of okra as influenced by sulphur in an entisol. *Annals of Plant Soil Res.,* **11**(1): 19-20.

Srivastava, S.P. (1994). Effect of soil Multiple a (Micronutrient mixture) and foliar Multiplex (boron) with or without nitrogen. Presented at the GLRP-NARC/CLAN-ICRISAT Review and Planning Meeting, Nepal.

Tathe, A.S. (2008). Response of different levels of sulphur and Zinc fertilization on yield and uptake of nutrients by groundnut. *An Asian Journal of Soil sci.,* **3**(1): 133-136.

Tiwari, K.N., Dwivedi, B.S.and Pathak, A.N. (1985). Iron pyrite as sulphur fertilizer for legumes. *Plant and Soil.* **86**(2): 295-298.

Tondon, V.R and Mersick, K.V. (2001). Increase yield of chick pea by sulphur application. *Indian J. of Agric. Sci.,* **30**(9): 61-67.

Tondon. H.L.S. (1993). Methods of Analysis of soil, plant, water and fertilizers. Fertilizer Development and consultation organization, New Delhi.

Tripathi, P.N and Sharma, N.L. (1993). Pyrite a good source of sulphur for mustard-rice cropping system. *Fertilizer News.* **38**(10): 27-30.

Venkatesh, M.S., Majumdar, B., Lal, B and Kumar, K. (2002). Relative performance of sulphur sources on sulphur nutrition of groundnut (*Arachis hypogaea*) in acid Alfisols of Meghalaya. *Indian J. of Agric. Sci.,* **72**: 216-219.

VishwaKarma, S.K., Sharma, R.S. and Khatik, S.K. (1998). Influence of varying sources and levels of sulphur on characteristics and nodulation activity in soyabean. *Journal of Soil and Crops.* **8**(20): 116-118.

Yang, Youg Hua., Zhang, Hong Yam., Y.H and Zhang, H.Y. (1998). Boron amelioration of aluminium toxicity in mung bean seedlings. *J. Plant Nutr.*, **21**(5): 1045-1054.

Zaky, L.M., Hassanein, R.A., Dowidar, A.E and El-Mashad, A.A. (1999). Effect of foliar treatment with boron and Zinc on physiological responses of cow pea (*Vigna sinensis cv. Cream* 7). II- Metabolic activities during growth and development. *Egyptian J. of Physio. Sci.*, **23** (3): 443-469.

Zhang, Y., Li, J., Zhang, F., Zhang, Y.G., Li, C.J. and Zhang, F.S. (1997). Effects of boron on pea seedling growth and the development of lateral buds of pea plant *Journal of Hebei Agricultural University*. **20**(3): 44-49.

Zhao, H.L., Puranik, R.B and Joshi, R.P. (1999). Root and nodules of gram and pea have high demand of sulphur. *Indian of Agricultural Res.*, **25**(1): 38-40.

Zizala, V.J., Jadav, N.B. and Gorfad,P.S. (2008). Effect of sulphur and zinc on yield, quality and its concentration on mustard. *An Asian J. of Soil sci.*, **3**(1): 173-177.

APPENDICES

Appendix- I. Monthly record of air temperature, relative humidity and rainfall of the experimental site during the period from October, 2018 to February 2019

Month	Air temperature (0C)		Relative humidity (%)	Rainfall (mm)
	Maximum	Minimum		
October, 2018	26.5	19.4	81	22
November, 2018	25.8	16.0	78	00
December, 2018	22.4	13.5	74	00
January, 2019	24.5	12.4	68	00
February, 2019	27.1	16.7	67	30

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka–1212

A. Morphological characteristics of the soil of experimental field

Morphological features	**Characteristics**
Location	Expeimental Field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka-1212

Appendix-II. Analysis of variance of data on plant height at different days after sowing of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Plant height at 30 DAS	Plant height at 45 DAS	Plant height at harvest
Replication	2	5.533	66.809	0.353
Factor A (Sulphur)	3	57.377**	88.242**	7.767**
Factor B (Boron)	3	46.576 **	95.986**	12.098**
A x B	9	31.049*	67.771*	4.026*
Error	30	11.566	21.538	1.152

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-III. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of			
		Days to first flowering	Number of pods/plant	Pod length (cm)	Pod breadth (cm)
Replication	2	1.453	0.486	3.021	3.787
Factor A (Sulphur)	3	20.426*	13.380**	26.481*	4.896 NS
Factor B (Boron)	3	16.634*	17.015**	29.095*	2.280 NS
A x B	9	31.755*	12.704*	22.282*	1.005 NS
Error	30	0.432	4.713	7.458	5.046

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-IV. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Pod yield/plant t (g)	Number of seeds/pod	Weight of 10 green pods
Replication	2	8.902	20.701	0.041
Factor A (Sulphur)	3	87.875**	94.121 **	1.262**
Factor B (Boron)	3	85.623**	104.005**	4.093**
A x B	9	55.516*	78.951*	1.406*
Error	30	17.932	31.059	0.643

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-V. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Weight of 100 green seeds (g)	Dry matter percentage of plant (%)	Green pod yield/plot (g)
Replication	2	5.472	2.108	10.021
Factor A (Sulphur)	3	101.372**	64.250**	86.195**
Factor B (Boron)	3	125.430**	75.811**	79.876 **
A x B	9	61.426*	35.811*	43.679*
Error	30	21.988	23.237	1.005

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-VI. Analysis of variance of data on yield contributing characters of Pea

Source of variation	Degrees of freedom (df)	Mean Square of		
		Green pod yield/hectare (t)	Green seed yield/plot (g)	Green seed yield/hectare (t)
Replication	2	19.991	443.5	0.148
Factor A (Sulphur)	3	197.014**	2409.3**	1.504**
Factor B (Boron)	3	162.570**	45510.2**	1.251 **
A x B	9	84.302*	6428.8*	1.488*
Error	30	15.549	535.4	0.196

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix VII. Cost of production of Garden pea per hectare

Input cost (A)

Treatments	Labour	Ploughing	Seed	Irrigation	Pesticides	Cowdung	Fertilizer					Subtotal input cost(A)
							Urea	TSP	MOP	Gypsum	Boric acid	
S_0B_0	25000	10000	15000	8000	6000	30000	2080	4000	2400	---	---	102480
S_0B_1	25000	10000	15000	8000	6000	30000	2080	4000	2400	---	150	102630
S_0B_2	25000	10000	15000	8000	6000	30000	2080	4000	2400	---	300	102780
S_0B_3	25000	10000	15000	8000	6000	30000	2080	4000	2400	---	450	102930
S_1B_0	25000	10000	15000	8000	6000	30000	2080	4000	2400	1210	---	103690
S_1B_1	25000	10000	15000	8000	6000	30000	2080	4000	2400	1210	150	103840
S_1B_2	25000	10000	15000	8000	6000	30000	2080	4000	2400	1210	300	103990
S_1B_3	25000	10000	15000	8000	6000	30000	2080	4000	2400	1210	450	104140
S_2B_0	25000	10000	15000	8000	6000	30000	2080	4000	2400	2420	---	104990
S_2B_1	25000	10000	15000	8000	6000	30000	2080	4000	2400	2420	150	105050
S_2B_2	25000	10000	15000	8000	6000	30000	2080	4000	2400	2420	300	105200
S_2B_3	25000	10000	15000	8000	6000	30000	2080	4000	2400	2420	450	105350
S_3B_0	25000	10000	15000	8000	6000	30000	2080	4000	2400	3630	---	106110
S_3B_1	25000	10000	15000	8000	6000	30000	2080	4000	2400	3630	150	106260
S_3B_2	25000	10000	15000	8000	6000	30000	2080	4000	2400	3630	300	106410
S_3B_3	25000	10000	15000	8000	6000	30000	2080	4000	2400	3630	450	106560

Labour cost @ Tk. 300/Man/day

Cowdung @ Tk. 2/Kg

Urea @ Tk. 16/Kg

TSP @ Tk. 20/Kg

MoP @ Tk. 18/Kg

Gypsum @ Tk. 22/Kg

Boric acid @TK.25/Kg

ii. Overhead cost (B)

Treatment Combination	Miscellaneous cost (Tk. 5% of the input cost)	Cost of lease for 6months land rent	Interest on running capital for 6 months (Tk. 12% of cost/year)	Subtotal Overhead cost(B)
S_0B_0	5124	30000	6148.8	41272.8
S_0B_1	5131.5	30000	6157.8	41289.3
S_0B_2	5139	30000	6166.8	41305.8
S_0B_3	5146.5	30000	6175.8	41322.3
S_1B_0	5184.5	30000	6221.4	41369.9
S_1B_1	5192	30000	6230.4	41422.4
S_1B_2	5199.5	30000	6239.4	41438.9
S_1B_3	5207	30000	6248.4	41455.4
S_2B_0	5249.5	30000	6299.4	41548.9
S_2B_1	5252.5	30000	6303	41555.5
S_2B_2	5260	30000	6312	41572
S_2B_3	5267.5	30000	6321	41588.5
S_3B_0	5305.5	30000	6366.6	41672.1
S_3B_1	5313	30000	6375.6	41688.6
S_3B_2	5320.5	30000	6384.6	41705.1
S_3B_3	5328	30000	6393.6	41721.6

Total Cost of production = Input Cost (A) + Overhead Cost (B)