ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 50(2): 127-140, June 2025

RESPONSE OF GARDEN PEA TO DIFFERENT LEVEL OF IRRIGATION AND NITROGEN FERTILIZER

M. R. H. MONDOL[1], M. A. R. SARKAR[2], A. K. HASAN[3]
S. K. PAL[4] AND M. S. H. SARKER[5]

Abstract

The experiment was conducted during 2017-18 to evaluate the effect of irrigation and nitrogen for enhancing the productivity and profitability of garden pea. The experiment consisted of five irrigation treatments *viz*., no irrigation, one irrigation at vegetative stage (15 days after sowing, DAS), one irrigation at flowering stage (30 DAS), one irrigation at pod developing stage (45 DAS) and two irrigations, one irrigation at vegetative stage (15 DAS) + one irrigation at pod developing stage (45 DAS) and five levels of nitrogen *viz.,* 0, 20, 30, 40 and 50 kg N ha^{-1}. The experiment was laid out in a spilt plot design with three replications assigning nitrogen doses in main plots and irrigation treatments in sub-plots. Garden pea variety 'BARI Motorshuti-3' was used in this study. The combined effect of irrigation at flowering stage and fertilization with 30 kg N ha^{-1} gave the highest green pod yield (7.57 t ha^{-1}) and green stover yield (6.19 t ha^{-1}), which was followed by no irrigation and fertilization with 30 kg N ha^{-1} that produced green pod yield of 7.54 t ha^{-1} and green stover yield of 6.12 t ha^{-1} in garden pea. According to cost and return analysis, among all the treatment combinations, no irrigation and fertilization with 30 kg N ha^{-1} was the best combination for enhancing gross margin (Tk. 448687.58 ha^{-1}) and BCR (2.90) for maximum green pod yield. Irrigation at flowering stage coupled with 30 kg N ha^{-1} gave appreciable amount of gross margin (Tk 438363.40) and BCR (2.48) followed by the combination of irrigation at pod developing stage and 30 kg N ha-1 (gross margin: Tk 378018.40 and BCR: 2.42). Therefore, irrigation given at either at flowering stage (30 DAS) or pod developing stages (45 DAS) each in combination with 30 kg N ha^{-1} application is also a better combination for higher green pod production with better profitability under Bogura region when the crop needs to be irrigated.

Key words: Garden pea, irrigation, crop stages, nitrogen, gross margin, fresh pod yield and stover yield.

Introduction

Garden pea (*Pisum sativum* L.) is one of the most important winter minor pulse crops in Bangladesh. Garden peas are full of nutrition because its grain is rich in

[1]Senior Scientific Officer, Tuber Crops Research Sub-Centre, Bangladesh Agricultural Research Institute (BARI), Bogura, [2,3&4]Professor, Department of Agronomy, Bangladesh Agricultural University (BAU), Mymensingh, and [5]FVP & Operation Manager, United Commercial Bank PLC, Corporate Branch, Gulsan Avenue, Dhaka, Bangladesh.

protein (27.8%), complex carbohydrates (42.65%), vitamins, minerals, dietary fibers and antioxidant compounds (Dahl *et al*., 2012). Pea crop has a great impact in the rice-based cropping system to utilization of fallow land where land remains fallow about 80-90 days between *T. Aman* and *Boro* rice. In the high and medium high lands of Bangladesh, T. *Aman* – Fallow - *Boro* cropping pattern is practiced by the farmers. It was found that short duration pea variety (BARI Motorshuti-3) can be comfortably grown after harvest of short duration *T. Aman* variety in the fallow period of *T. Aman* and *Boro* cropping pattern. Further, this crop also plays a significant role in soil fertility restoration as a suitable rotation crop that fixes atmospheric nitrogen and also serves as rotational crop that plays great role in controlling disease epidemics and weeds (Hoorman *et al*., 2009). It was therefore, planned to evaluate the performance of the short duration pea variety (BARI Motorshuti-3) as sole crop after harvest of short duration *T. Aman* rice under farmer's condition. Pea production in Bangladesh depends on many factors, of which nutrition is the most important one. Worldwide the aggressive exploitation of natural resources endangers water resources, biodiversity and soil quality. Scarcity of water is the most severe constraint for development of agriculture in arid and semi-arid areas. Under these conditions, the need to use available water economically and efficiently is unquestionable. Based on the actual crop need, the irrigation management has to be improved so that the water supply to the crop can be reduced while still achieving high yield. Already more than 1.2 billion people in over 110 countries are affected by the social and environmental effects of the land degradation in dry areas (Schuster, 2003). Acute shortage of irrigation water and drought are adversely affecting crop production in general and vegetable production in particular. Pea plants do not tolerate water-logged conditions (Cannell *et al.,* 1979), and on the other side, reacts to the irrigation. However, during growth and development, especially, in the flowering and pod formation stages, drought causes aborting flowers and pods, following by decreasing yield and yield components. Also, decreasing of the quality of the product can be observed. Nitrogen increased seed protein content in peas and may be correlated with improved germination and seedling vigour (Ries, 1971). Boyd *et al*. (1971) have reported a relationship between seed size and vigour which may be increased by nitrogen application. There is general agreement that nitrogen fertilizer has the most important effect in increasing number of flowers, seed yield and quality of a wide variety of plant species. (Streeter, 1978) reported that the nitrogen contents of soybean decreased when nitrogen became limiting towards the end of the flowering season and during seed formation. Biological nitrogen fixation is an important source of nitrogen for plant growth and development requirements. Sometimes this source is enough to meet the plant requirements of nitrogen. If the factors affecting nodule activities (such as soil temperature, soil moisture, soil gaseous status, soil pH, soil salinity and soil nutrients like phosphorus and molybdenum) are inadequate or not favourable for enzymatic activities then the

amount of nitrogen fixed through this source becomes insufficient to meet the plant requirement. Nodule activity generally increases from seedling stage and during vegetative growth and reaches a maximum at reproductive growth (flowering), but then decreases rapidly during seed filling (Hardy *et al*., 1971). This means that at the time of seed filling when the crop has its greatest requirement for nitrogen it may be beneficial to provide extra nitrogen. Pea production in Bangladesh is very low due to lack of proper agronomic management practices such as sowing time and method, row spacing, seed rate as well as irrigation and nutrient management. Therefore, the present study was conducted to evaluate the effect of irrigation and nitrogen for enhancing the productivity and profitability of pea to achieve the goal of increased pea production in Bangladesh.

Materials and Methods

The experiment was conducted at the Tuber Crops Research Sub-Center, Bangladesh Agricultural Research Institute (BARI), Bogura, Bangladesh during *rabi* season 2017-18. It was located at 24.51^0 N latitude and 89.18^0 E longitudes which is 17 m above the sea level (UNDP and FAO 1988) and belongs to the Barind Level Tract "AEZ 25". The experimental site was associated with a medium high land with sandy-loam soil texture and the soil was slightly acidic in reaction. The physico-chemical properties of the soil have been presented in Table 1.

Table 1: Physical and chemical properties of soil

Physical characteristics of the soil	Chemical characteristics of the soil
1. Sand (%) (0.2-0.02 min):58	1. pH: 6.0
2. Silt (%) (0.02-0.002 min): 35	2. Organic matter (%): 1.58
3. Clay (%) (<0.002 min): 7	3. Total nitrogen (%): 0.08
4. Soil textural class: sandy loam	4. Available sulphur (ppm): 12.14
5. Particle density (g/cc): 2.60	5.Available phosphorus (ppm): 29.02
6. Bulk density (g/cc): 1.35	6. Exchangeable potassium (meq/100 g soil : 0.18
7. Porosity (%): 56.23	7. Magnesium (meq/100g soil): 0.45
	8. Boron (Micro gram/g soil): 0.29
	9. Zinc (Micro gram/g soil): 0.89

The experiment was laid out in a split-plot design with three replications. The experiment consisted of five irrigations *viz*., (i) No irrigation (rainfed condition) (I_0), (ii) One irrigation at vegetative stages (15 days after sowing, DAS) (I_1), (iii) One irrigation at flowering stages (30 DAS) (I_2), (iv) One irrigation at pod developing stages (45 DAS) (I_3), (v) Two irrigations, one at vegetative stages (15 DAS) + one at pod developing stages (45 DAS) (I_4) and five nitrogen doses *viz.,* i) 0.0 kg N ha^{-1} (N_0), (ii) 20 kg N ha^{-1} (N_1), (iii) 30 kg N ha^{-1} (N_2), (iv) 40 kg N

ha^{-1} (N_3). Irrigation treatments were allocated in main plots and nitrogen doses in sub-plots. Different levels of N through urea were applied along with recommended or blanket doses of fertilizer of P (20 kg ha^{-1}), K (20 kg ha^{-1}), Sulphur (10 kg ha^{-1}) and boron (7 kg ha^{-1}) through Triple super phosphate (TSP), Muriate of potash (MP), Gypsum and Boric acid, respectively at final land preparation. Five flood irrigations were applied at different growth stages of plant as per treatment. The unit plot size was 2.5 m x 1.8 m. The garden pea var. BARI Motorshuti-3 was used in the study. Seeds of garden pea were sown @ 200 kg ha^{-1}. Seeds were sown continuously in rows on 10 November, 2016. The distance maintained between row to row was 20 cm. Finally, approximately 5 cm plant to plant distance along with row was maintained through thinning to have uniform population in all the rows of treatments. Different intercultural operations such as weeding, thinning, gap filling, pesticide spray and irrigation were accomplished time to time for better growth and development of the crop. The crop was harvested plot-wise at green pod maturity stages from separate area of each plot. Data were collected from the sampling area of the plots excluding border plants and one m^2 middle of plot were kept for final harvest to record data on yields. Five plants were uprooted each time randomly from the sampling area of each plot. Data were recorded on plant height, number of pods $plant^{-1}$, pod length, number of seeds pod^{-1}, weight of 1000 seeds, seed yield and dry stover yield. The yield was converted into t ha^{-1}. The yield was converted into t ha^{-1}. The collected data of different parameters were statistically analyzed with the help of R Software and differences among the treatment means were adjudged by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Results and Discussion

Interaction effect of irrigation and nitrogen on plant height

Plant height of garden pea was significantly influenced by the combination of irrigation and N application at different growth stages. The highest plant height (42.54 cm) was recorded from irrigation at flowering stage with 40 kg N ha^{-1} followed by the combination of no irrigation and 30 kg N ha^{-1} (40.91 cm), irrigation at flowering stage and 0.0 kg N ha^{-1} (40.05 cm), irrigation at flowering stage and 20 kg N ha^{-1} (41.98 cm), irrigation at flowering stage and 30 kg N ha^{-1} (41.22 cm), irrigation at flowering stage and 50 kg N ha^{-1} (41.09 cm), irrigation at pod developing stage and 20 kg N ha^{-1} (39.89 cm), irrigation at pod developing stage and 30 kg N ha^{-1} (39.98 cm), irrigation at pod developing stage and 40 kg N ha^{-1} (40.47 cm) and irrigation at pod developing stage and 50 kg N ha^{-1} (40.98 cm), while the lowest plant height was observed in irrigation at vegetative stage under no N ha^{-1} (36.58 cm). This result may be attributed to intolerant of this garden pea variety to waterlogging condition at vegetative stage because flood irrigation caused a decrease in plant height or internode extension. These findings are in

consonance with the findings of Uzun and Acikgoz (2009). On the other hand, the plant height increased with the increase in nitrogen levels upto 40 kg N ha^{-1}, then decreased at 50 kg N ha^{-1}. It might be due to the role of nitrogen in cell differentiation, growth and development of plant. Similar results were reported by Uniyal and Pant (2009).

Interaction effect of irrigation and nitrogen on number of pods $plant^{-1}$

Number of pods $plant^{-1}$ of pea was significantly influenced by irrigation in combination with nitrogen at different growth stages (table 2). The highest number of pods $plant^{-1}$ (3.90) was recorded from the combination of irrigation at flowering stage and 30 kg N ha^{-1} application followed by no irrigation and 30 kg N ha^{-1} (3.88), while the lowest pods $plant^{-1}$ was found in the treatment combination of irrigation at vegetative stage and no nitrogen or control plot (2.06) followed by irrigation at vegetative stage and 20 kg N ha^{-1} (2.21), irrigation at vegetative stage + irrigation at pod developing stage and 0.0 kg N ha^{-1} (2.11), irrigation at vegetative stage + irrigation at pod developing stage and 50 kg N ha^{-1} (2.35), respectively. It might be due to intolerant of garden pea variety to waterlogging condition caused by irrigation at vegetative stage which can cause a decrease in number of pods $plant^{-1}$. These findings are in agreement with the findings of Uzun and Acikgoz (2009). The increase in the level of N was responsible for higher photosynthesis and assimilation rate and metabolic activity and cell-division, which were responsible for the significant increase in the growth characters, yield attributes and ultimately the pod yields. The results of the present investigation are in perfect agreement with the findings of Singh and Dixit (1989).

Interaction effect of irrigation and nitrogen on pod length

Pod length of garden pea was significantly influenced by irrigation and nitrogen application (Table 2). The highest pod length (6.74 cm) was recorded from the combination of irrigation at flowering stage and 30 kg Nha^{-1} application followed by no irrigation with application of 30 kg N ha^{-1} (6.58 cm), no irrigation and 40 kg N ha^{-1} (6.73 cm), no irrigation and 50 kg N ha^{-1} (6.64 cm), irrigation at flowering stage and 40 kg N ha^{-1} (6.39 cm), irrigation at flowering stage and 50 kg N ha^{-1} (6.51 cm), irrigation at pod developing stage and 30 kg N ha^{-1} (6.71 cm), irrigation at pod developing stage and 40 kg N ha^{-1} (6.52 cm) and irrigation at pod developing stage and 50 kg N ha^{-1} (6.47 cm), while the lowest in irrigation at vegetative stage + irrigation at pod developing stage and 0.0 kg N ha^{-1} (5.27 cm). It might be due to intolerant of this garden pea variety to waterlogging condition created by irrigation at vegetative stage which inhibited nitrogen uptake from the soil as a result leading to reduced nitrogen concentrations in vegetative and reproductive tissues. Similar results were reported by Jackson (1979).

Table 2. Interaction effect of (irrigation x nitrogen) on crop characters, yield contributing characters and yield of pea

Interaction (IXN)	Plant height (cm)	Number of pods plant^{-1}	Pod Length (cm)	Number of seeds pod^{-1}	Weight of 100 fresh pods (g)	Green pod yield (t ha^{-1})	Green stover yield (t ha^{-1})
$I_0 \times N_0$	38.40cdef	3.45cdef	5.98bcde	5.82bcde	338.92c	6.30bc	5.55abc
$I_0 \times N_1$	38.86cdef	3.67bcd	6.08bcde	5.95bc	342.54bc	6.69bc	5.62abc
$I_0 \times N_2$	40.91abc	3.77ab	6.58ab	5.99ab	351.96a	7.54a	6.12a
$I_0 \times N_3$	39.51bcdef	3.74bc	6.73a	5.98bc	346.29b	7.36a	6.00ab
$I_0 \times N_4$	38.99cdef	3.68bc	6.64ab	5.92bc	345.93b	7.30a	6.05b
$I_1 \times N_0$	36.58f	2.06j	5.28f	5.20i	248.78h	3.85f	3.55e
$I_1 \times N_1$	38.34cdef	2.21hij	5.35f	5.29hi	252.08fg	3.93ef	3.59e
$I_1 \times N_2$	39.41bcdef	2.31ghi	5.76def	5.32hi	253.99f	4.07ef	3.66e
$I_1 \times N_3$	38.35cdef	2.40gh	5.77def	5.42ghi	254.98f	4.33ef	3.92e
$I_1 \times N_4$	38.46cdef	2.35gh	5.57ef	5.40ghi	254.63f	4.22ef	3.74e
$I_2 \times N_0$	40.05abcde	3.44cdef	6.07bcde	5.81bcde	339.82c	6.37bc	5.95ab
$I_2 \times N_1$	41.98ab	3.63bcde	6.34abcd	5.83bcde	343.21b	6.78b	5.68abc
$I_2 \times N_2$	41.22abc	3.95a	6.74a	6.25a	349.11a	7.57a	6.19a
$I_2 \times N_3$	42.54a	3.64bcde	6.39abc	5.85bcd	345.32b	7.35a	6.03ab
$I_2 \times N_4$	41.09abc	3.65bcde	6.51ab	6.00ab	346.00b	7.49a	6.10ab
$I_3 \times N_0$	38.90cdef	3.38f	6.10bcde	5.61efg	322.84d	5.47d	5.40bcd
$I_3 \times N_1$	39.89abcde	3.42ef	6.23bcd	5.64def	324.24d	5.62d	4.80d
$I_3 \times N_2$	39.98abcde	3.51cdef	6.71ab	5.94bc	342.80bc	6.57 bc	5.96ab
$I_3 \times N_3$	40.87abcd	3.46cdef	6.52ab	5.82bcde	339.82c	6.43bc	5.55abc
$I_3 \times N_4$	40.98abc	3.45cdef	6.47ab	5.75cde	261.05e	6.14c	5.08cd
$I_4 \times N_0$	38.41cdef	2.11ij	5.27f	5.22hi	250.10g	3.87f	3.58e
$I_4 \times N_1$	37.20ef	2.29ghi	5.40f	5.34hi	253.52f	4.01ef	3.28e
$I_4 \times N_2$	36.91f	2.47g	5.79cdef	5.44fgh	255.32f	4.52e	3.62e
$I_4 \times N_3$	37.94def	2.26ghij	5.37f	5.31hi	252.14fg	3.94ef	3.60e
$I_4 \times N_4$	36.88f	2.35gh	5.59ef	5.42ghi	253.90f	4.13ef	3.49e
CV (%)	3.58	3.40	5.16	2.20	1.33	0.181	0.209

N.B.: I_0=no irrigation, I_1= One irrigation at vegetative stage (15 DAS), I_1= One irrigation at flowering stage (30 DAS), I_3 = One irrigation at podding stage (45 DAS), I_4= Two irrigations, one at vegetative stage + one at podding stage (15 & 45 DAS), N_0 = 0.0 kg ha^{-1}, N_1= 20 kg ha^{-1}, N_2= 30 kg ha^{-1}, N_3= 40 kg ha^{-1}, N_4= 50 kg ha^{-1}.

Interaction effect of irrigation and nitrogen on number of seeds pod^{-1}

Number of seeds pod^{-1} of pea was significantly influenced by irrigation and nitrogen at different growth stages (Table 2). The highest number of seeds pod^{-1} (6.25) was recorded from irrigation at flowering stage accompanied with 30 kg N ha^{-1} followed by the combination of no irrigation and 30 kg N ha^{-1} (5.99) and irrigation at flowering stage and 40 kg N ha^{-1} (6.00), while the lowest in irrigation at vegetative stage and 0.0 kg N ha^{-1} (5.20). The higher number of seeds pod^{-1} might be due to adequate supply of nitrogen. The findings of this investigation are in close conformity with the results obtained by Uniyal and Pant (2009).

Interaction effect of irrigation and nitrogen on weight of 100 fresh pods

Weight of 100 fresh pods of pea was significantly influenced by interaction of irrigation and nitrogen at different growth stages (Table 2).Interaction of no irrigation and 30 kg N ha^{-1}) gave the highest weight of 100 fresh pods (351.96g) followed by interaction of irrigation at flowering stage and 30 kg N ha^{-1} (349.11g), while the lowest100 fresh pod weight was found in irrigation at vegetative stage with 0.0 kg Nha^{-1} (248.78g). It might be due to weight of seeds is an inherent character which is directly correlated with seed yield plot^{-1} (Singh and Malik, 1994).

Main effect of irrigation on green pod yield

Green pod yield of garden was greatly influenced by irrigation at different crop stages (Fig. 1). The maximum green pod yield was obtained from irrigation given at flowering stage (30 days after sowing, DAS) (7.11 t ha-1) which was statistically similar to no irrigation (7.04 t ha-1) and then followed by irrigation provided at pod developing stage (45 DAS). The lowest green pod yield was observed at irrigation given at vegetative stage (15 DAS) being identical with two irrigations given at vegetative stage (15 DAS and pod development stage (55 DAS). Pumphrey and Schwank (1974) stated that irrigation at pod filling stage increased yield more than irrigation at any other growth stage of pea. This result is somewhat different from this experimental result where irrigation at flowering stage gave higher green pod yield than other crop growth stages. On the contrary, the highest grain yield of pea was obtained from irrigation at branching, flowering and pod development stage (Rajak *et al*., 2025).

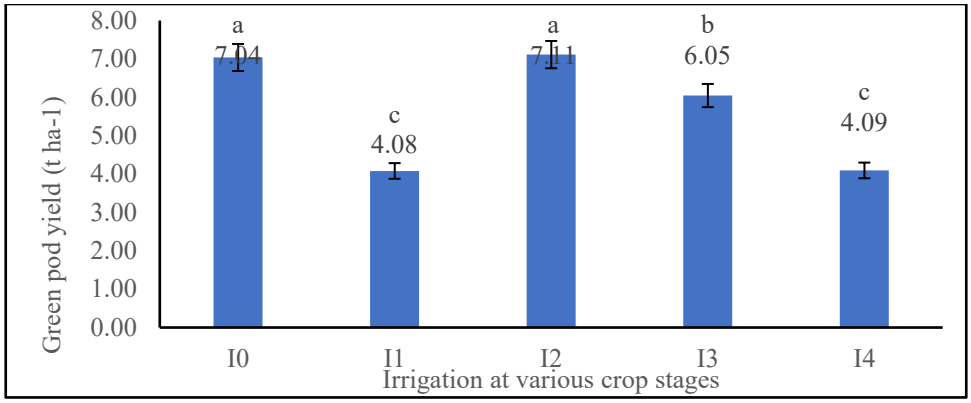

Fig 1. Effect of irrigation on green pod yield of garden pea.

I0 = No irrigation, I1 = One irrigation at vegetative stages (15 DAS), I2 = One irrigation at flowering stages (30 DAS), I3 = One irrigation at pod developing stages (45 DAS) and I4 = Two irrigations, one at vegetative stages (15 DAS) + one at pod developing stages (45 DAS).

Main effect of nitrogen on green pod yield

Green pod yield per hectare was significantly influenced by application of nitrogen (N) (Fig.2). The highest green pod yield of garden pea was recorded at 30 Kg N ha-1 (6.03 t ha-1) which was identical with 40 kg N ha-1 and 50 kg N ha^{-1} and the lowest green pod yield was obtained when N was not applied. This result corroborates the result of Uddin et al. (2014). Saini *et al*. (1996) stated that green pod yield increased with up to 30 kg N/ha. Bhopal and Singh (1990) found similar result with 40 kg N/ha.

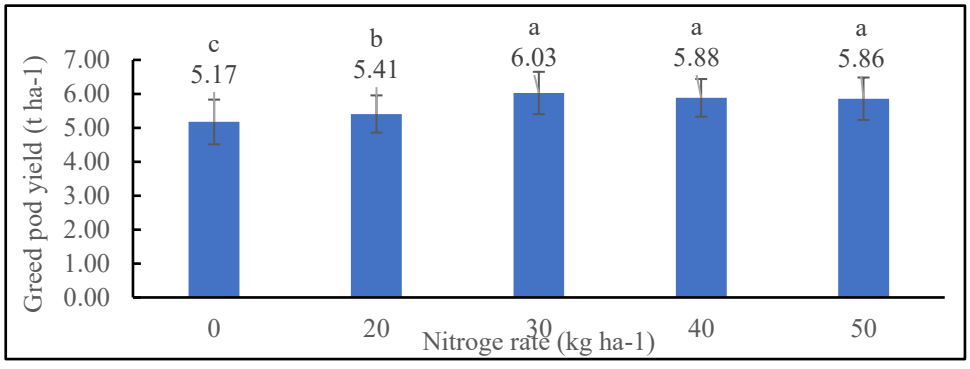

Fig 2. Effect of nitrogen on green pod yield of garden pea.

N.B.: I_0=no irrigation, I_1= One irrigation at vegetative stage (15 DAS), I_1= One irrigation at flowering stage (30 DAS), I_3 = One irrigation at podding stage (45 DAS), I_4= Two irrigations, one at vegetative stage + one at podding stage (15 & 45 DAS), N_0 = 0.0 kg ha^{-1}, N_1= 20 kg ha^{-1}, N_2= 30 kg ha^{-1}, N_3= 40 kg ha^{-1}, N_4= 50 kg ha^{-1}.

Interaction effect of irrigation and nitrogen on green pod yield

Green pod yield of pea was significantly influenced by interaction of irrigation and nitrogen (Table 2). The highest green pod yield (7.57 t ha^{-1}) was obtained from irrigation at flowering stage coupled with 30 kg N ha^{-1} followed by irrigation at flowering with application of N at 40 kg ha^{-1} (7.35 t ha^{-1}), irrigation at flowering stage and 50 kg N ha^{-1} (7.49 t ha^{-1}), no irrigation and 30 kg N ha^{-1} (7.54 t ha^{-1}), no irrigation and 40 kg N ha^{-1} (7.36 t ha^{-1}) and no irrigation and 50 kg N ha^{-1} (7.30 t ha^{-1}), while the lowest pod yield was found in irrigation at vegetative stage with 0.0 kg N ha^{-1} (3.85 t ha^{-1}). It might be due to intolerant of garden pea variety to waterlogging condition created by irrigation. Similar result have been reported by Uzun and Acikgoz (2009).

Interaction effect of irrigation and nitrogen on green stover yield

Green stover yield of pea was significantly affected by interaction of irrigation and nitrogen (Table 2). Irrigation at flowering stage coupled with 30 kg N ha^{-1} application recorded the highest green stover yield (6.19 t ha^{-1}) followed by the combination of no irrigation and 0.0 kg N ha^{-1} (5.55 t ha^{-1}), no irrigation with 20 kg N ha^{-1} application (5.62 t ha^{-1}), no irrigation with 30 kg N ha^{-1} (6.12 t ha^{-1}), no irrigation and 40 kg N ha^{-1} (6.00 t ha^{-1}), irrigation at flowering stage and 0.0 kg N ha^{-1} (5.95 t ha^{-1}), irrigation at flowering stage and 20 kg N ha^{-1} (5.68 t ha^{-1}), irrigation at flowering stage and 40 kg N ha^{-1} (6.03 t ha^{-1}), irrigation at flowering stage and 40 kg N ha^{-1} (6.10 t ha^{-1}), irrigation at pod developing stage and with 30 kg N ha^{-1} (5.96 t ha^{-1}) and irrigation at pod developing stage and 40 kg N ha^{-1} (5.55 t ha^{-1}), while the lowest green stover yield was observed in the combination of irrigation at vegetative stage + irrigation at pod developing stage and 20 kg N ha^{-1} (3.28 t ha^{-1}). It might be due to intolerant of the used variety to waterlogging condition at vegetative stage created by irrigation and lack of nitrogen in soil which can cause a decrease in root mass, root penetration depth, plant height or internode extension, leaf expansion, biomass and chlorophyll content. Similar results were reported by Przywara and Stepniewski (1999).

Economic analysis

The highest gross margin (Tk 448687.58/ha) and BCR (2.90) was obtained from the interaction of no irrigation and application of 30 kg N ha^{-1} closely followed by no irrigation coupled with application with 40 kg N ha-1 (gross margin: 442931.20 and BCR:2.86), while the lowest gross margin (Tk 157845) and BCR (1.02) was noticed in the combination of irrigation at vegetative stage and no N application (Table 3). The better gross margin and BCR were also obtained from irrigation at flowering stage or from pod developing stage in combination with 30 kg N ha^{-1}. Irrigation at flowering stage coupled with 30 kg N ha^{-1} gave appreciable amount of gross margin (Tk 438363.40) and BCR (2.48) followed by the combination of

Table 3. Comparative agro-economic performance of Pea under interaction of irrigation and nitrogen for green pod production

Interaction (IxN)	Yield (t ha^{-1})		Total variable cost (Taka ha^{-1})	Gross return (Taka ha^{-1})	Gross margin (Taka ha^{-1})	BCR
	Green pod	Green Stover				
$I_0 \times N_0$	6.30	5.55	153480.00	504000+8325 = 512325.00	358845.00	2.34
$I_0 \times N_1$	6.69	5.62	154174.40	535200+8430 = 543630.00	389455.60	2.53
$I_0 \times N_2$	7.54	6.12	154521.60	603200+9180 = 603209.18	448687.58	2.90
$I_0 \times N_3$	7.36	6.00	154868.80	588800+9000 = 597800.00	442931.20	2.86
$I_0 \times N_4$	7.30	6.05	155216.00	584000+9075 = 593075.00	437859.00	2.82
$I_1 \times N_0$	3.85	3.55	155480.00	308000+5325 = 313325.00	157845.00	1.02
$I_1 \times N_1$	3.93	3.59	156174.40	314400+5385 = 319785.00	163610.60	1.05
$I_1 \times N_2$	4.07	3.66	156521.60	325600+5490 = 331090.00	174568.40	1.12
$I_1 \times N_3$	4.33	3.92	156868.80	346400+5880 = 351335.00	194466.20	1.24
$I_1 \times N_4$	4.22	3.74	157216.00	337600+5610 = 343210.00	185994.00	1.18
$I_2 \times N_0$	6.37	5.95	175480.00	509600+8925 = 518525.00	343045.00	1.95
$I_2 \times N_1$	6.78	5.68	176174.40	542400+8520 = 550920.00	374745.60	2.13
$I_2 \times N_2$	7.57	6.19	176521.60	605600+9285 = 614885.00	438363.40	2.48
$I_2 \times N_3$	7.35	6.03	176868.80	588000+9045 = 597045.00	420176.20	2.38
$I_2 \times N_4$	7.49	6.10	177216.00	599200+9150 = 608350.00	431134.00	2.43
$I_3 \times N_0$	5.47	5.40	155480.00	437600+8100 = 445700.00	290220.00	1.87
$I_3 \times N_1$	5.62	4.80	156174.40	449600+7200 = 456800.00	300625.60	1.92
$I_3 \times N_2$	6.57	5.96	156521.60	525600+8940 = 534540.00	378018.40	2.42

Interaction (IxN)	Yield (t ha^{-1})		Total variable cost (Taka ha^{-1})	Gross return (Taka ha^{-1})	Gross margin (Taka ha^{-1})	BCR
	Green pod	Green Stover				
$I_3 \times N_3$	6.43	5.55	156868.80	514400+8325 = 522725.00	365856.20	2.33
$I_3 \times N_4$	6.14	5.08	157216.00	491200+7620 = 498820.00	341604.00	2.17
$I_4 \times N_0$	3.94	3.60	158868.80	315200+5400 = 320600.00	161731.20	1.02
$I_4 \times N_1$	4.01	3.28	158174.40	320800+4920 = 325720.00	167545.60	1.06
$I_4 \times N_2$	4.52	3.62	158521.60	361600+5430 = 367030.00	208508.40	1.32
$I_4 \times N_3$	3.87	3.58	157480.00	314985+5370 = 320355.00	162875.00	1.03
$I_4 \times N_4$	4.13	3.49	159216.00	330400+5235 = 335635.00	176419.00	1.11

N.B.: I_0=no irrigation, I_1= One irrigation at vegetative stage (15 DAS), I_1= One irrigation at flowering stage (30 DAS), I_3 = One irrigation at podding stage (45 DAS), I_4= Two irrigations, one at vegetative stage + one at podding stage (15 & 45 DAS), N_0 = 0.0 kg ha^{-1}, N_1= 20 kg ha^{-1}, N_2= 30 kg ha^{-1}, N_3= 40 kg ha^{-1}, N_4= 50 kg ha^{-1}.

N.B.: Urea = Tk 16.00 /kg, TSP = Tk 22.00 /kg, MOP = Tk 15.00 /kg, Boric acid =Tk 190 /Kg, Gypsum = Tk 10.00 /kg, Manures=Tk 1.50 /kg, Labour = Tk 400.00/ 8 hr /head, Irrigation = Tk 2000 /ha, ploughing= Tk 1500/plough/ha, Green pod sale price= TK.80 /kg, Dry stover = TK. 0.75 /kg, Seed= Tk 150 /kg, Non-seed= Tk 130 /kg, Seed treatment= TK 1500 /ha, Fungicide spray (two times) = TK 6000 /ha, Harvesting/pod picking = Tk 5.00 /kg, Bird man= Tk 3000/15 days/ha.

irrigation at pod developing stage (Tk 378018.40) and BCR (2.42). This result revealed that the treatment of no irrigation and application of 30 kg N ha^{-1} was the best combination for enhancing pod yield, gross margin and BCR for fresh pod production of garden pea var. BARI Motorshuti-3 under the climatic condition of Bogura. Irrigation given at either fat lowering stage or pod developing stages each in combination with 30 kg N ha^{-1} application was also a better combination for higher green pod production with better profitability under Bogura region when the crop needs to be irrigated.

Relationship between green pod yield and number of irrigations

The relationship between green pod yield and number of irrigations at different crop stages has been presented in Fig. 1. The regression analysis indicated that that the green pod yield of garden pea was linearly and negatively correlated to the number of irrigations. The linear regression line was y = 7.146 -1.472x, R^2 = 0.476, r = 0.69*). From the estimated relationship, it can be expected that the green pod yield decreased with the increase of number of irrigations. The coefficient of determination (R^2) indicates that irrigation levels accounted for 47.6% of the variation in green pod yield. It is also evident that from the regression equation that a decrease of 1.47 t/ha green pod yield can be expected for per unit increase of irrigation.

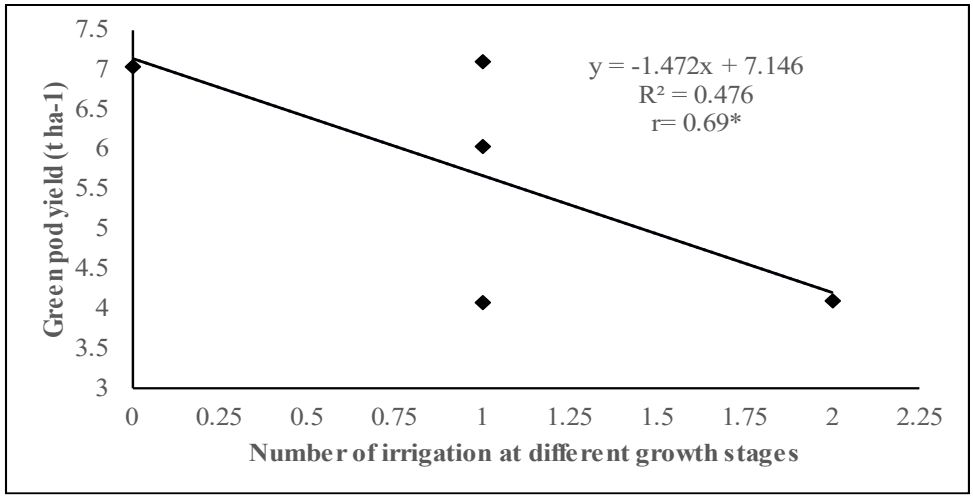

Fig. 1 Relationship between number of irrigations and green pod yield of garden pea.

Relationship between green pod yield and nitrogen fertilization

Regression analysis was done to quantify the relationship of applied nitrogen (N) with green pod yield (t ha^{-1}). Applied N showed a linear positive relationship with green pod yield of garden pea (Fig. 2). From the estimated relationship, it can be

expected that the green pod yield increased with the increase of N application. The coefficient of determination indicates that N fertilization accounted for 84% of the variation in green pod yield. It also revealed that by increasing per kg of N, green pod yield of garden pea was increased by 15.8 kgha^{-1}.

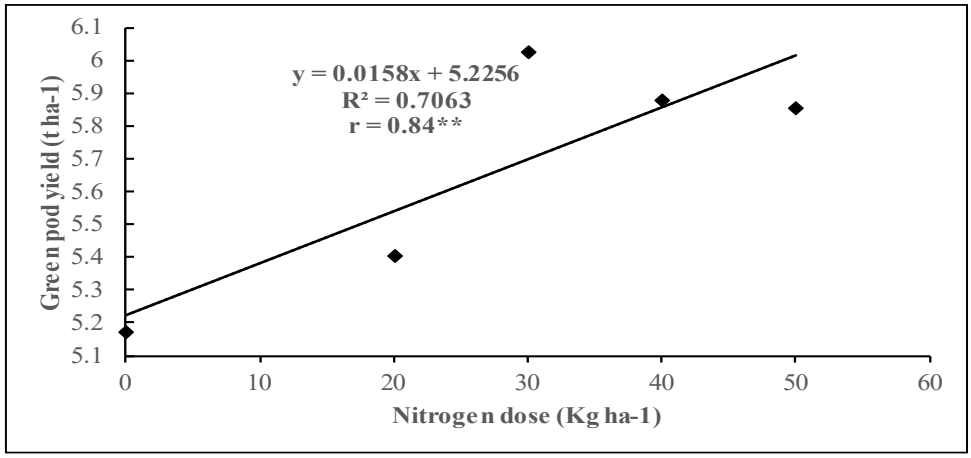

Fig. 2 Relationship between nitrogen rate and green pod yield of garden pea.

Conclusion

From the above study, it may be concluded that irrigation at either flowering stage or pod developing stage and in combination with fertilization of 30 kg N ha^{-1} was the most suitable combination to give the highest green pod yield and fresh stover yield of the garden pea var. BARI Motorshuti-3. Economic analysis showed that no irrigation i.e. rainfed condition in combination with fertilization of 30 kg N ha^{-1} was found to be the best combination for enhancing gross margin and BCR. Irrigation given at either flowering stage or pod developing stages each in combination with application of 30 kg N ha^{-1} was also better combinations for higher and profitable green pod production with better profitability under Bogura region when the crop needs to be irrigated.

References

Bhopal, S. and B. Singh B. 1990. Note on response of garden pea to N and P application in North Hills. *Ind. J. of Hort.* **47 (1):** 107-108.

Boyd, W. J. R, A. G. Gordon and L. J. Lacroix, 1971. Seed size, germination resistance and seedling vigour in barley. *Canadian Journal of plant Science* **51**: 93-99.

Cannell, R.Q, K., Gakes, R. W. Snaydon and B.A. Suhail. 1979. Effects of short-term waterlogging on the growth and yield of peas (*Pisum sativum*). *Annals of Applied Biology* **93:** 327-335.

Dahl, W.J., L. M. Foster and R.T. Tyler. 2012. Review of the health benefits of peas (*Pisum sativum* L.). *British Journal of Nutrition* 1**08:** S3-S10.

Hardy, R. W. F., R. C. Burns, R. R. Hebert, R. D. Holsten and E.K. Jackson. 1971. Biological Nitrogen fixation a key to world protein. *Plant soil,* **Special.** 561-590.

Hoorman, J. J., R. Islam and A. Sundermeier. 2009. Sustainable crop otations with cover Crops. OSU, *Agriculture and Natural Resources. Fact Sheet*.

Jackson, M.B. 1979. Rapid injury to peas by soil waterlogging. *Journal of the Science of Food and Agriculture* **30**: 143-152.

pea. *Indian Journal of Pulses Research* **16**: 34-35.

Przywara, G. and W. Stepniewski. 1999. The influence of waterlogging at different temperatures on penetration depth and porosity of roots and on stomatal diffusive resistance of pea and maize seedlings. *Acta Physiologiae Plantarum* **21**: 405-411.

Pumphrey, F. V. and R. K. Schwank. 1974. Effects of Irrigation on Growth, Yield, and Quality of Peas for Processing. *J. Ame. Soc. Hort. Sci*. **99** (2): 104-106.

Rajak, P, A. S. Rajput, P. R. Mirjha, C. Verma, D. S. Khusro, M. Karwar and A. Sahu. 2025. Effect of water and nutrient management practices on the yield attributes and yield of field pea (Pisum sativum L.). *Int. J. Rese. Agron*. **8**(10): 865-869. https :// www. doi. Org /10.33545 /2618060X.2025.v8.i10l.4079

Ries, S.K. 1971. The relationship of size and protein content of bean seed with growth and yield. *Journal of American Society and Horticultural Science* 96 557-560.

Saini J P and Thakur S R .1996. Effect of nitrogen and phosphorus on vegetable pea (Pisum sativum) in cold desert area. *Ind. J. of Agric. Sci*. *66* (9): 514-517.

Schuster, M. A. 2003. Causes of desertification. *Annals of Arid Zone* **42**: 417-423.

Singh, R.C. and B.P.S, Malik. 1994. Correlation and path coefficient analysis for yield and its attributes in peas. *Indian Journal of Pulses Research* **7**(2): 168- 171.

Singh, S.S. and R.S. Dixit. 1989. Response of mustard to various levels of irrigation and nitrogen. *Indian Journal of Agronomy* **34**(3) *307-311.*

Streeter, J.G. 1978. Effect of nitrogen starvation of soybean plants at various yield and rust in dwarf

Uddin, B, A. K. Paul, A. S. M. Fazle Bari, S. Sultana and M S. Jahan. 2014. Effect of different levels of nitrogen and phosphorus on the growth and yield of garden pea (Pisum sativum L.). *Eco-friendly Agril. J.* **7**(09): 93-99.

UNDP AND FAO (United Nations Development program and food and agriculture Organizatio. 1988. *Land Resources Appraisal of Bangladesh for Agricultural Development Rep 2.* Agroecological Regions of Bangladesh. BARC/UNDP, New Airport Road, Farmgate, Dhaka-1207. pp. 212-221.

Uniyal, S.P. and G.B. Pant. 2009. Effect of different levels of nitrogen and phosphorus on performance of vegetable pea in rainfed hills. Pantnagar *Journal of Research* **7**(2) 184-186.

Uzun, A and E. Acikgoz. 2009. The response of pea genotypes differing in testa color to waterlogging during early germination stages. *Journal of Food, Agriculture & Environment* **7:** 347-351.