

## YIELD IRRIGATION PRODUCTION EFFICIENCY AND ECONOMIC RETURN OF GREEN PEA UNDER VARIABLE IRRIGATION AND FERTIGATION

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**Abstract:** Field study was carried out at the irrigation Research Farm of Sam Higginbottom Institute of Agriculture and Sciences (Deemed to be University) Allahabad, U. P., India, During winter crop growing season of December 2011 to March 2012, on clay loam soil in order to evaluate the yield of green pea under different irrigation scheduling with fertigation under semi arid climate. The crop was subjected to variable irrigated level (IW/CPE ratio of 50, 75, 100, 125, 150) and fertigation level (100, 200, 300). The crop was irrigated when daily mean of USWB class. A pan evaporation reached to predetermined value of 16.3 mm. irrigated by drip irrigation method with 41/h non compensated on line dripper's Irrigation at 125% of pan evaporation replenishment and fertigation level 300kg/ha resulted in higher green pea yield, whereas irrigation production efficiency was higher with irrigation at 50% of pan evaporation replenishment with fertigation level 300kg/ha. The irrigation at 125% with fertigation level of 300kg/ha, of Pan –evaporation replenishment resulted in higher gross return, net return and benefit cost ratio. Seasonal water applied irrigation schedules and bulb yield, gross return, net return and benefit cost ratio exhibited strong quadratic relationship which can use for optimizing green pea production in this region.

**Keywords:** Drip irrigation, Irrigation scheduling, Fertigation, Economic analysis marketable yield, Pea

### INTRODUCTION

Water resource is the major constraint for crop diversification and production in India. India has the second largest net irrigated area in the word, after china. The irrigation efficiency under canal irrigation is not more the 40% and for ground water schemes, it is 69%. The net irrigated area in the country is 53.5Mha, which is about 38% of the total sown area. Although considerable area has been brought under irrigation since independence; There are several causes that limit water availability for agriculture an increasing demand by the civil users a greater requirement by the industrial sector; climate changes that cause a rise in the air temperature and an irregular distribution of rainfall, producing more intense precipitations and runoffs and limiting water infiltration in the soil as well as the refill of the aquifers; a scarce maintenance of the water distribution network. Therefore, it is necessary to develop irrigation management strategies in order to use scarce water resources efficiently and effectively for vegetable production.

Scheduling the irrigation is all about deciding by amount and frequency of irrigation. The amount of water to be applied during each irrigation was determined by IW/Epan, the ratio between a fixed amount of irrigation water (IW) and cumulative open evaporation (Epan) minus rainfall. Therefore, it is important to develop a proper and effective scheduling of irrigation under prevailing climatic condition to obtained maximum benefit from the available limited water resources. Numerous studies

have been carried out in the past on the development and evaluation of irrigation scheduling techniques under a wide range of irrigation system and management, soil, crop and climatic conditions (Stewart, 1975). Drip irrigation has gained widespread acceptance as an efficient and economically viable method due to its highly localized application of water and nutrient to crop. Pea (*Pisum sativum* L.) is an important frost hardy cool-season leguminous vegetables crop that is widely cultivated throughout the world.

### MATERIAL AND METHOD

The experimental was conducted at the Irrigation Research Farm of the Department of Soil water land Engineering and management in the Vaugh school of Agriculture Engineering and Technology SHIATS, Allahabad (UP). The irrigation research station is situated at an elevation of 98 meter above sea level at 25.87°N latitude and 81.15°E longitude and has a tropical to sub tropical climate with extremes of summer and winter. During the winter months average temperature range from 5°C to 1°C while in the summer season the temperature varies from 3°C to 45°C. The soil of the experimental field was fertile clay loam. (35.5% sand, 25.8% silt and 38.6% clay) with average bulk density of 1.31 gm/cm. The moisture content at field capacity (-1/3 bar) and wilting point (-1/5 bar) was 19.5% and 9.1% on an oven dry weight loss basic respectively. The experiment was laid out in a three factor complete randomized block design. It comprises of 15

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treatments with five irrigation levels and three fertigation levels. The area of each experimental plot was 5.4sqm (3x1.8m). Total number of plot was 45. A buffer zone spacing of 1.0 m was provided between the plots. Each plot was irrigated and fertigated independently, improved variety of pea was sown directly on 14<sup>th</sup> December 2012 at a spacing of row to row 30 cm and plant to plant 10 cm. Before planting, experimental field of pea was well irrigated. After 15 days of sowing, irrigation treatments were started. Drip irrigation crop receive first nutrient dose as booster dose after 15 days of sowing, whole recommended dose of P and K and half of N fertilizer was applied in before sowing. In case of fertigation, fertilizer was applied in six doses at regular interval of 10 days.

The irrigation treatment comprised of five level of pan evaporation replenishment (50, 75, 100, 125, and 150%). And three fertigation level (100, 200, 300 kg/ha). Crop were irrigated when sum of the daily USWB class-A open pan evaporation data for a period of 6 years (2005-2010) were collected from meteorological station, SHIATS. The crop was irrigated when the sum of daily mean (6years) of pan evaporation reached to a predetermined value of 16.3 mm (rooting depth in m × plant available water soil

moisture in mm /m × permissible soil moisture depletion in fraction). The crop was irrigated by drip irrigation method. The irrigation water was pumped directly from the tank into the main line, sub-main and then into the plot through the laterals. PVC pipe of 50 mm diameter and low density polyethylene pipes (LDPE) of 12 mm diameter were use for main and lateral lines respectively. A control valve and water meter was connected to the sub- main line in order to monitor the amount of water application in respective treatment. Screen filter was installed on main line to minimize clogging of dipper and a control valve was connected to each experimental plot in order to deliver the desired amount of water. In drip irrigation system, lateral lines were laid to crop row system. The discharge of non pressure compensated online dripper was 4 l/ hr. The standard cultural practices were performed during the crop growing season. Green pea was harvested from 10<sup>th</sup> - 24<sup>th</sup> March 2012, respectively.

In order to assess the economic viability of different system under variable irrigation, both fixed and operating costs were included. The total cost of production, gross return and net return under different irrigation level were estimated under following assumption

Salvage value of the components	=	0
Useful life of tube-well, pump motor & pump house	=	25 years
Useful life of drip irrigation system	=	8 years
Useful life of weeding and spraying equipments	=	7 years
Interest rate	=	11.5%
Repair and maintenance	=	7.5%
Number of crops/year	=	2

The fixed costs which include tube well, pump, motor pump house and irrigation systems, PVC pipe for main and sub main and LDPE pipes for lateral, fertilizer tank, pressure gauges, water meter, drippers, spraying and weeding equipments for different methods and schedules which were calculated by the approach (James and Lee, 1971):

$$\text{CRF} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

Where,

CRF	=	Capital recovery factor
I	=	Interest rate (fraction)
N	=	Useful life of the components (years)
Annual Fixed cost/ha	=	CRF X fixed cost/ha
Annual cost /ha/season	=	<u>Annual fixed cost/ha</u> / 2

The operating cost which includes labor (system installation, fertilizer, chemical application and harvesting etc.); land preparation, seeds, fertilizer, chemicals (insecticides and pesticides) and water pumping (electricity) and repair and maintenance (tube well pump, motor, pump house, irrigation systems and pipe conveyance system etc.) was estimated. The gross return for different irrigation methods and schedules was calculated taking into consideration of marketable yield and wholesome price of green pea. Subsequently, the net return for green pea was calculated considering total cost of production (fixed and operating) and grosses return.

Total cost of production (Rs)	= Fixed cost (Rs) + Operating cost (Rs)
Gross return (Rs/ha)	= Marketable yield (t/ha) x wholesale price of green pea (Rs/t)
Net return (Rs/ha)	= Gross return (Rs/ha) - Total cost of production (Rs/ha)
Benefit cost ratio (B/C)	= Gross return (Rs/ha) / Total cost of production (Rs/ha)

## RESULT AND DISCUSSION

### i. *Marketable Yield and irrigation production efficiency*

The marketable pod yield and irrigation production efficiency of green pea as influenced by different irrigation and fertigation levels are presented in Table 1. The irrigation levels and fertigation

significantly influenced the marketable pod yield of green pea. The pod yield for different irrigation level ranged from 6.31 to 11.27 t/ha. The highest mean pod yield (11.27 t/ha) was recorded when irrigation during the crop growing season was applied at IW/CPE ratio of 125% ( $I_4$ ) with fertigation level  $F_1$  (200kg/ha). A further increase in irrigation level resulting from 150% of pan evaporation replenishment reduced the marketable pod yield (10.21 t/ha) due to poor aeration caused by excessive soil moisture. The fertigation level has significantly effect on marketable pod yield of green pea Table 1. Significantly higher marketable pod yield (10.26 t/ha) was recorded with fertigation levels  $F_3$  (300 kg/ha) of nutrient was applied, compared with 200 kg/ha ( $F_2$ ) and 100 kg/ha ( $F_1$ ) fertigation levels. The irrigation production efficiency of green pea was significantly influenced by irrigation levels and fertigation levels (Table1). The irrigation production efficiency for different irrigation levels range for 2.83 to 5.25 kg/m<sup>3</sup> the highest irrigation production

efficiency (5.25 kg /m<sup>3</sup>) was observed when irrigation was applied at 50% at pan evaporation replenishment because reduction in marketable yield was less as compared with seasonal water applied. Irrigation at 150% of pan evaporation replenishment resulted is significantly minimum irrigation production efficiency (2.83 kg/m<sup>3</sup>) because it increased seasonal water applied considerably but decreased the marketable pod yield (Table1). The overall results clearly revealed that both irrigation levels and fertigation levels in green pea influenced the marketable pod yield and irrigation production efficiency. The highest marketable pod yield was recorded at 125% of pan evaporation replenishment gave the higher irrigation production when fertigation walls provide at  $F_3$  300kg/ha levels. Imtiyaz et al. (2000a); reported the higher yield and irrigation production efficiency of vegetable crop at 80% of pan evaporation replenishment under the agro-climatic condition of northwestern Botswana.

**Table 1.** Effect of irrigation schedules and fertigation on marketable yield and irrigation production efficiency of green pea.

Treatment	Mean marketable green pod yield (t/ha)	Mean irrigation production efficiency (kg/m <sup>3</sup> )
<b>Irrigation level</b>		
50	6.31	5.25
75	7.29	4.05
100	9.35	3.89
125	11.27	3.75
150	10.21	2.83
LSD-0.717		
<b>Fertigation level</b>		
$F_1$	7.22	3.01
$F_2$	9.17	4.09
$F_3$	10.26	4.57
LSD-0.414		

## 2. Water applied and marketable pod yield

The relationship between seasonal water applied and marketable pod yield of green pea for three fertigation levels are presented in Fig. 4.1. The seasonal water applied ranged from 120 to 360mm, where as marketable pod yield for  $F_1$  (100kg/ha),  $F_2$  (200kg/ha) and  $F_3$  (300kg/ha) fertigation levels ranged from 5.00 to 9.10 t/ha, 6.62 to 11.65 t/ha and 7.33 to 13.06 t/ha respectively. The seasonal water and fertigation applied and marketable pod yield at green pea for 100kg ( $R^2= 0.9291$ ), 200kg ( $R^2= 0.8871$ ) and 300kg ( $R^2= 0.8893$ ) fertigation levels exhibited strong quadratic relationship. Green pea attained a maximum marketable pod yield at the seasonal water applied of 240 to 300 mm for  $F_1$  (100kg/ha),  $F_2$  (200kg/ha) and  $F_3$  (300kg/ha) fertigation levels respectively and their after it tended to decline. The relationship between pan evaporation replenishment are marketable pod yield at green pea 100kg/ha, 200kg/ha and 300kg/ha fertigation levels are presented in Fig. (4.2). The marketable pod yield

at green pea ranged from 5.00 to 9.10, 6.62 to 11.65 for and 7.33 to 13.06 t/ha for 100kg/ha, 200kg/ha and 300kg/ha fertigation levels respectively. The marketable yield and pan evaporation replenishment for 100kg/ha ( $R^2= 0.9291$ ), 200kg/ha ( $R^2= 0.8871$ ) and 300kg/ha ( $R^2= 0.8893$ ) fertigation levels exhibited strong quadratic relationship. Marketable pod yield at green pea increased with increase in pan evaporation replenishment approximately upto 125% for  $F_1$  (100kg/ha),  $F_2$  (200kg/ha) and  $F_3$  (300kg/ha) fertigation levels and their after it tended to decline. Inspite of some variation the overall result show quadratic relationship between market able yield and seasonal water applied / pan evaporation replenishment under variable fertigation level. Imtiyaz et al.,(2000a) reported the quadratic relationships between marketable yield and seasonal water applied for cabbage, carrot, onion, tomato, broccoli spinach, green pepper, hot pepper, okra, egg plant and green maelies under both sprinkler and drip irrigation system. Many researchers have reported a

quadratic relationship between seasonal irrigation and yield of vegetable and field crop under a wide range of irrigation system and regimes, soil and climate (Tiwari and reddy, 1997; Zhang and Oweis, 1999).

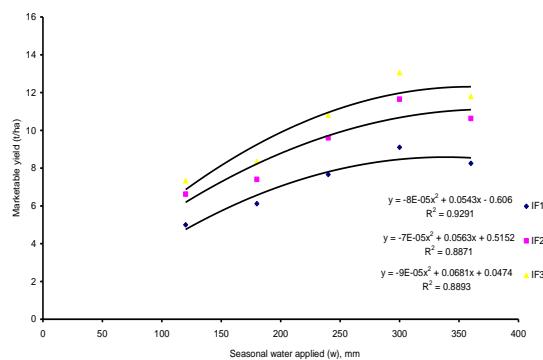
### *ii Economic return*

The total cost of production, gross return, net return and benefit cost ratio of green pea as influenced by variable irrigation and fertigation level are presented in Table 2. The total cost of production increased slightly with an increase in irrigation and fertigation levels due to increase in water development with increase in amount of fertilizer applied. The highest gross return was obtained the irrigation levels with fertigation level  $I_4F_3$ , due to significantly higher marketable yield as compared with irrigation and fertigation levels. The net return increase significantly with increase in irrigation levels with increase in amount of fertilizer applied. The benefit cost ratio also increased considerably with increase in irrigation and fertigation levels. The highest benefit cost ratio was recorded when irrigation was applied at IW/ CPE ratio of 1.25  $I_4$  with fertigation level  $F_1$  (300kg/ha). Imtiyaz et al., (2000a) reported the similar results for cabbage, broccoli, onion, rape, tomato, carrot, spinach and green melies under drip and sprinkler irrigation.

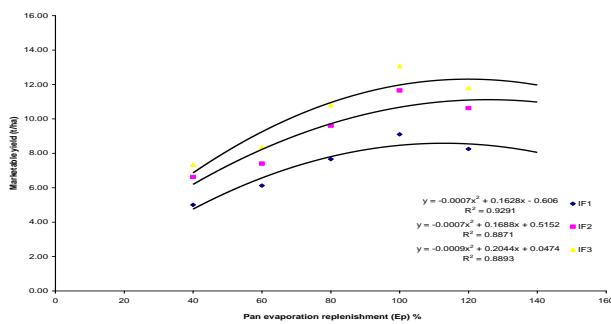
### *iii Relationship between Economic Return and Irrigation levels under fertigation levels*

The Relationship between the seasonal water applied and gross return of green pea under variable fertigation levels are presented in (Fig. 4.3). Gross return ranged from 200000.00 to 330000.00 Rs/ha, 264800.00 to 424800.00 Rs/ha and 293200.00 to 471200.00 Rs/ha for 100kg/ha fertigation levels, 200kg/ha and 300kg/ha fertigation levels respectively. The gross return and seasonal water applied for 100kg/ha ( $R^2 = 0.9278$ ), 200kg/ha ( $R^2 = 0.8865$ ), and 300kg/ha ( $R^2 = 0.8844$ ) fertigation applied showed strong quadratic relationship. The

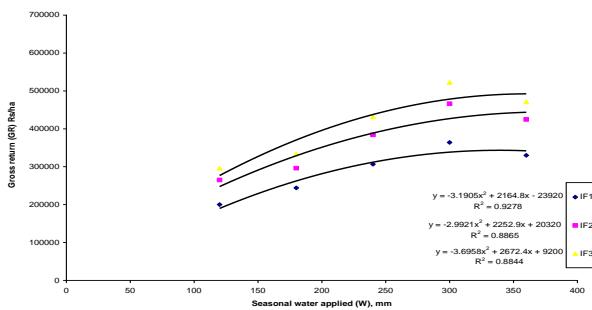
gross return of green pea increased with increase in seasonal water application upto 300 mm and thereafter it tended to decline. The green pea attained the maximum gross return at an IW/CPE ratio of 125%  $I_4$  with fertigation level  $F_3$  (300kg/ha) and thereafter the gross return tended to decline (Fig 4.4) The Relationship between the net return and seasonal water applied of green pea under variable fertigation levels are presented in Fig. (4.5) The seasonal water applied and net return for 100kg/ha200kg/ha and 300kg/ha fertigation levels exhibited strong quadratic relationship ( $R^2 = 0.9255$ ,  $R^2 = 0.886$ ,  $R^2 = 0.8867$ ).The green pea attained the maximum net return at 300 mm seasonal water applied application for all the three fertigation levels. The green pea attained the maximum net return at an IW/CPE ratio of 125%  $I_4$  with fertigation level  $F_3$  (300kg/ha) and thereafter the net return tended to decline (Fig 4.6) The Relationship between the seasonal water applied and benefit cost ratio of green pea under variable fertigation levels are presented in Fig (4.7). The seasonal water applied and benefit cost ratio for 100kg/ha200kg/ha and 300kg/ha fertigation levels exhibited strong quadratic relationship ( $R^2 = 0.9264$ ,  $R^2 = 0.8779$ ,  $R^2 = 0.87$ ). The green pea attained the maximum benefit cost ratio at 300 mm seasonal water applied application for all the three fertigation levels and thereafter benefit cost ratio tended to decline (Fig. 4.7). Similar trend were observed for irrigation level. The green pea attained the maximum benefit cost ratio at an IW/CPE ratio of 125%  $I_4$  with fertigation level  $F_3$  (300kg/ha) and thereafter the benefit cost ratio tended to decline (4.8). Inspite of some variation, the overall result showed the strong quadratic relationship between seasonal water applied/ irrigation levels and gross return, net return and benefit cost ratio under variable fertigation levels which in turn can be use for optimizing the economic return of green pea with limited water resource condition. Similar results were reported by imtiyaz et al. (2000e, and 2004a) for different vegetable crop under varying soil, crop and climatic condition.



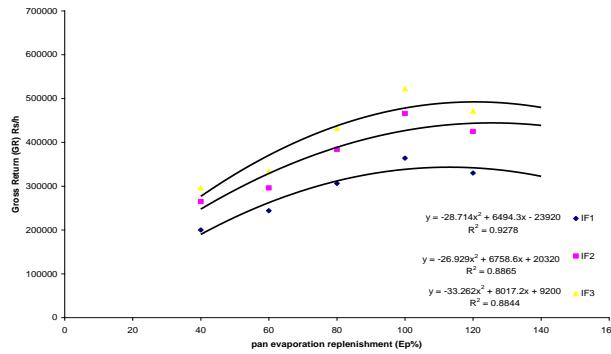
**Fig. 4.1.** Relationship between seasonal water applied and marketable yield of green pea for difference fertigation levels



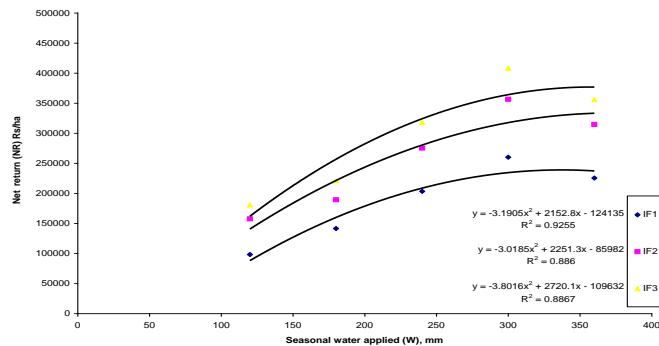
**Fig. 4.2** Relationship between pan evaporation replenishment and marketable yield of green pea for difference fertigation levels



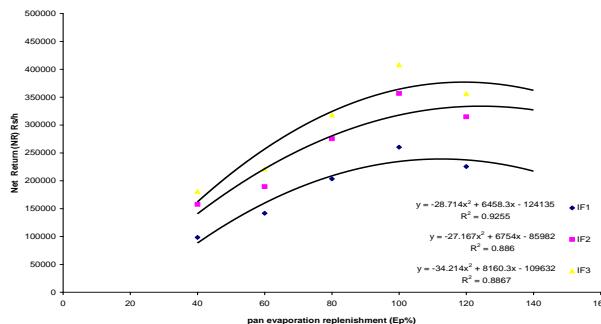
**Fig. 4.3.** Relationship between seasonal water applied and gross return of green pea for different fertigation levels



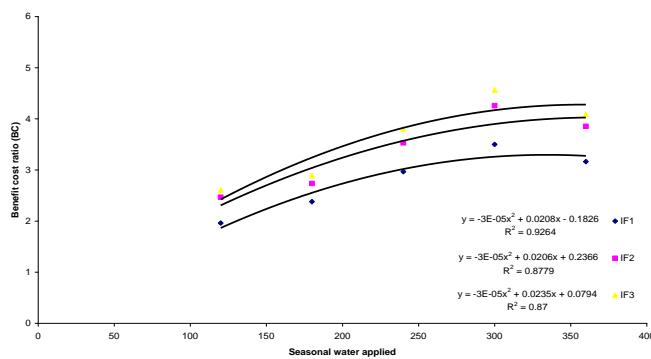
**Fig. 4.4** Relationship between pan evaporation replenishment and gross return green pea for different fertigation levels



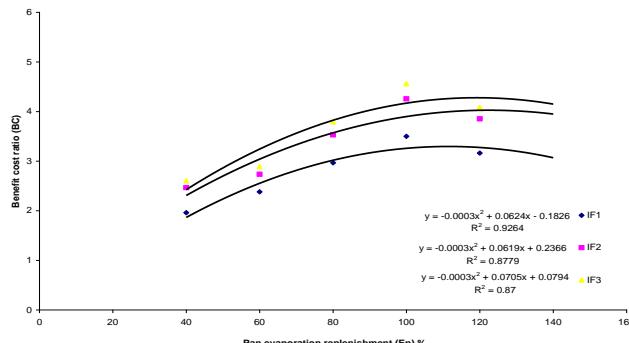
**Fig.4.5** Relationship between seasonal water applied and net return of green pea for different fertigation levels



**Fig.4.6.** Relationship between pan evaporation replenishment and net return of green pea for different fertigation levels



**Fig. 4.7.** Relationship between seasonal water applied and benefit cost ratio of green pea for different fertigation levels



**Fig. 4.8** Relationship between pan evaporation replenishment and benefit cost ratio of green pea for different fertigation levels

## CONCLUSION

Irrigation at 125 % of pan evaporation replenishment resulted in significantly higher green pod yield whereas irrigation production was higher with irrigation at 50% of pan evaporation replenishment. The fertigation levels of 300kg gave the higher marketable yield and irrigation production efficiency as compared with 100kg and 200kg fertigation levels. Irrigation at 125% of pan evaporation replenishment resulted in higher gross return, net return and benefit cost ratio. The fertigation level of  $F_3$  300kg gave higher net return as compared to 100kg and 200kg fertigation levels. The seasonal water applied / irrigation schedule and yield of green pea showed strong quadratic relationship for fertigation levels of 100, 200 and 300 kg fertigation levels exhibited a strong quadratic relationship. The seasonal water

applied / irrigation schedule and yield, gross return net return and benefit cost ratio under variable irrigation and fertigation levels exhibited a strong quadratic relationship which in turn can be under for allocation limited water resources for maximum return.

Finally the overall result clearly reveled that in order to obtain optimum yield and economic return, green pea should be irrigation at 125% of pan evaporation replenishment either with 100, 200 and 300kg/ha fertigation levels.

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