Irrigation scheduling is commonly defined as determining when to irrigate and how much water to apply, or as deciding when to start and when to stop irrigation. However, successful irrigation actually depends upon understanding and utilizing irrigation scheduling principles to develop a management plan and implement the plan efficiently. However, the producer’s management objective must be considered first when developing an irrigation schedule strategy. Maximizing net return is a common objective, but others may be to minimize irrigation costs, maximize yield, optimally distribute a limited water supply or optimize the production from a limited irrigation system capacity. For situations where the supply of water is inadequate to achieve maximum yield on the entire field, the area irrigated or the seasonal application depth, or both, must be reduced (Martin et al., 1990).

The success of Indian Agriculture depends heavily on the use of fertilizers and other modern inputs. Among the major plant nutrients, phosphorus occupies a key place in balanced fertilizer use programmes, because crops need phosphorus in large amounts for active vegetative growth and root proliferation. Further, garden pea being a legume vegetable, phosphorus remains to be the most important nutrient, affecting its production since it increases the formation of effective root nodules and enhances the activity of *Rhizobia* for fixation of more atmospheric nitrogen in the soil (Lenka and Gautam, 1972; Kanaujia *et al.*, 1998).

The pertinent literature both from India and abroad associated with the research investigation on “Effect of irrigation and phosphorus levels on seed production of
garden pea (*Pisum sativum* L.)” has been reviewed in this chapter under the following heads:

2.1 Growth and development
2.2 Yield attributes and yield
2.3 Seed quality
2.4 Plant/soil chemical studies
2.5 Water studies

### 2.1 Growth and development

Kanwar and Thakur (1972) studied the response of phosphorus and zinc on growth and flower initiation of 4 varieties of kidney bean and reported that increment in P-application significantly reduced number of days taken to first flower. Bahadur and Singh (1990) investigated the response of N and P application on yield and growth response of garden pea variety Bonneville at ND University of Agriculture and Technology, Kumarganj, Faizabad during rabi seasons of 1987-88 and 1988-89. They reported early flowering and increased plant height with the application of the highest dose of P (80 kg P$_2$O$_5$/ha) in comparison to lower levels.

Yadav *et al.* (1993) conducted a field experiment during the winter season of 1984-85 and 1985-86 at Morena (Madhya Pradesh) to study the effect of different irrigation schedules viz., no irrigation, 1 irrigation (50DAS), 1 irrigation (70DAS) and 2 irrigations (50 and 70 DAS) and 4 phosphorus levels ( 0, 25, 50 and 75kg P$_2$O$_5$/ha) on pea. They noted significant increase in leaf area index, leaf area/plant and leaf area ratio with 2 irrigations at 50 and 70 DAS over control and other treatments when total rainfall during crop period was 69.7cm. Significant
increase in leaf area/plant, leaf area index and leaf area ratio were observed with the highest phosphorus level.

Rathi et al. (1995) studied the effect of irrigation schedule and phosphorus on yield attributes and yield of field pea during rabi seasons of 1988-89 and 1989-90 at Jabalpur in Madhya Pradesh. Treatments consisted of 8 irrigation schedules, viz., no irrigation (control); 1 irrigation at branching (B) or flowering (F) or pod development stage (P); 2 irrigations, 1 each at B+F or B+P or F+P; 3 irrigations, 1 each at B+F+P as main-plot treatments and 4 phosphorus levels (0, 20, 40 and 60 kg P$_2$O$_5$/ha) as sub-plot treatments. All the irrigation treatments led to significant increase in plant height as compared to the control treatment. However, the maximum increase in plant height was recorded with irrigation treatments B+F+P or B or B+F or B+P since all these treatments were at par with each other. This implied that irrigation at branching stage (B) was the most crucial. Phosphorus application also increased the plant height and the increase was sizable up to 40 kg P$_2$O$_5$/ha.

Tewari and Singh (2000) studied the effect of 5 levels of nitrogen (0, 40, 80, 120 and 160 kg/ha) and 4 levels of phosphorus (0, 20, 40 and 60 kg P$_2$O$_5$/ha) on French bean var. Pant Bean-2 during 1995-96 and 1996-97 at Faizabad in Uttar Pradesh. They reported that increasing the level of P up to 60 kg P$_2$O$_5$/ha significantly enhanced plant height, number of leaves and branches/plant over control (0 kg P$_2$O$_5$/ha). The phosphorus doses 40 and 60 kg P$_2$O$_5$/ha were at par. Sinha et al. (2000) conducted a field experiment during rabi season of 1997-98 at Solan (Himachal Pradesh) to study the impact of date of planting and phosphorus
levels (45, 60 and 75 kg P$_2$O$_5$/ha) on seed yield and quality of garden pea cultivars. They observed that phosphorus levels of 75 kg and 60 kg P$_2$O$_5$/ha were at par with each other but both resulted in more plant height and took less number of days to 50% flowering and seed harvest as compared to 45 kg P$_2$O$_5$/ha.

Kasturikrishna and Ahlawat (2000) conducted a field experiment during winters of 1992-93 and 1993-94 to study the effect of moisture stress, phosphorus sulphur and zinc fertilizers on growth and development of pea. Higher values of growth parameters especially leaf area index (LAI) were observed with no stress treatment (irrigation at all the three stages viz., vegetative, flowering and pod filling). They also noted higher LAI with the highest dose of P viz., 26.2 kg P/ha as compared to 13.1 kg/ha and no P during 1993-94.

Singh et al. (2001) studied the response of different irrigation schedules on vegetable pea during winter season of 1996-97 and 1997-98 at Majhera Research Station of Pantnagar University (Uttarakhand). Treatments consisted of irrigation at branching, flowering, pod filling stages and their combinations along with irrigation at 20 days interval and control (rain fed). They concluded that for the best utilization of irrigation water in vegetable pea, the water may be applied at branching stage (if only 1 irrigation is possible), may also be applied at flowering if water is available for second irrigation. Watering at branching + flowering + pod filling stages may be carried out if it is available for 3 irrigations but in any case the irrigation at branching stage must not be avoided.

Dass et al. (2005) conducted a field experiment during winter seasons of 1999-2000 and 2000-2001 to study the response of phosphorus on vegetable pea
at Kokriguda in Orissa. They reported that increasing phosphorus levels from 0 to 75 kg $P_2O_5$/ha resulted in consistent increase in plant height.

2.2 Yield attributes and yield

Tayel et al. (1990) studied the response of limited water supply on pea in a sandy loam soil located in the Western Desert of Egypt. Irrigation treatments comprised of 66.2 and 77.8% of the net irrigation requirements. The best results with respect to yield were achieved using 66.2% of the net irrigation requirement. Yadav et al. (1993) studied the effect of phosphorus levels (0, 25, 50 and 75 kg $P_2O_5$/ha) along with control on pea at Morena in Madhya Pradesh. They observed that different P levels were at par as far as grain yield was concerned.

Rathi et al. (1995) reported that the irrigation at branching and flowering stages proved promising for higher seed yields in field pea mainly due to their beneficial effects on pods/plant and seeds/pod. The highest seed yield (17.7 q/ha) was with 60 kg $P_2O_5$/ha but a dose of 41.19 kg $P_2O_5$/ha was found optimum. Phosphorus improved pods/plant, seeds/pod and pod length compared with no phosphorus, but different doses of P did not differ with each other. Phosphorus doses 40 kg and 60 kg/ha were at par with each other with respect to the traits crop biomass and pods/plant during both the years but for plant height during the second year only. Consumptive water use (mm/ha) was minimum with no irrigation and it increased due to delay in irrigation or increase in irrigation frequency. Consumptive use of water did not vary with different doses of P.

Reddy and Ahlawat (1998) conducted a field experiment to study the response of irrigation and fertilizers on chickpea genotypes under late-sown conditions during winter season of 1988-89 and 1989-90 at New Delhi on sandy loam soil. They recorded more number of pods/plant, grain and straw yields with two irrigations applied at branching and pod-initiation stages as compared to no irrigation (control).

Dubey et al. (1999) studied the influence of irrigation and phosphorus on growth, green pod yield and nutrient uptake of pea var. Arkel in Lahaul valley (Himachal Pradesh) during summer 1993 and 1994. The treatment combinations consisted of 3 regimes of irrigation viz., $M_1$ (4 days interval), $M_2$ (8 days interval) and $M_3$ (12 days interval).
interval) and 4 levels of P, viz., 0, 40, 80 and 120kg P₂O₅/ha along with recommended dose of N (25kg/ha). They observed significant response of individual as well as cumulative effect of irrigation and phosphorus. Phosphorus @ 80, 40 and 0kg P₂O₅/ha gave maximum green pod yields at 4, 8 and 12 days interval of irrigation, respectively.

Tewari and Singh (2000) obtained the highest pods/plant, number of seeds/pod and seed yield in French bean with 60kg P₂O₅/ha in comparison to lower doses of phosphorus. Uddin et al. (2001) while studying the yield performance of garden pea as affected by different row spacing and fertilization of phosphorus in Bangladesh during rabi season of 1998-99, reported that increased P-levels had significant impact on number of pods/plant, total dry matter production, pod yield and seed yield of garden pea.

Singh et al. (2001) observed that the irrigation treatmentsviz., irrigation to vegetable pea at 20 days interval and irrigation at branching + flowering + pod filling were the best and at par for number of pods/plant, number of seeds/pod and green pod yield/ha. Bhatt et al. (2002) studied the response of different sowing dates and phosphorus levels on field pea under Kashmir conditions and noted increase in the number of pods/plant, seeds/pod and seed yield with higher phosphorus level (60kg P₂O₅/ha) in comparison to control (0kg P₂O₅/ha).

Kaushik and Choubey (2003) conducted a field experiment during winter season of 1997-98 and 1998-99 on sandy loam soil at Ujhani (Uttar Pradesh, India) to determine irrigation requirement of dwarf pea cv. HFP-4. The treatments comprised of 1 irrigation at branching or flowering or pod development stage; 2 irrigations at flowering and pod development or at branching and pod development stage and 3 irrigations, at all the three stages. Pea irrigated thrice, viz., at branching, flowering and pod development proved promising for higher seed yields mainly due to beneficial effect of irrigation on pods/plant and seeds/pod. Dass et al. (2005) reported that pods/plant, seeds/pod and shelling percentage of vegetable pea were consistently and significantly enhanced by each increment in P-rates from 0 to 75kg P₂O₅/ha.

Masand et al. (2006) conducted a field experiment to study the effect of irrigation and phosphorus on pea under limited water supply in Kullu valley of Himachal Pradesh during 2002-03 and 2003-04. There were 4 irrigation levels viz., I₁ (rainfed), I₂ (1 irrigation at pre-flowering), I₃ (2 irrigations, 1 each at pre-flowering and 75% flowering) and
I₄ (4 irrigations, one each at pre-sowing, pre-flowering, 75% flowering and pod formation stage) along with 3 phosphorus levels (0, 30 and 60kg P₂O₅/ha). They reported that the I₄ irrigation treatment in combination with 60kg P₂O₅/ha significantly produced more green pod yield over 1 irrigation at the same level of P during both the years. Similarly, irrigation treatment I₃ showed significant response of pea over control.

2.3 Seed quality

Browning et al. (1983) attributed differences in seed vigour in peas to the effect of phosphorus application on the parent plants. Antuono et al. (1984) conducted an experiment to study the influence of mineral fertilizer application on quality of pea seed and showed that phosphorus application up to 100kg P₂O₅/ha increased seed vigour considerably over control (0kg P₂O₅/ha) and decreased by further increment thereafter.

Shukla and Kohli (1991) conducted a field experiment at Kalpa (Himachal Pradesh) to study the influence of 3 phosphorus levels (45, 60 and 75kg P₂O₅/ha) on seed quality attributes of 5 varieties of garden pea. They concluded that seed vigour improved with increase in P-dose from 45 to 75kg P₂O₅/ha. Germination per cent was also the maximum at the highest rate of phosphorus (75kg P₂O₅/ha).

Rathi et al. (1993) studied the response different irrigation schedules and P-levels on field pea during 1988-89 and 1989-90 at Jabalpur (Madhya Pradesh) and reported that N and P content in the seed were the highest with irrigation at branching in both the years. Protein content was the highest with irrigation at branching or flowering in 1989 and at branching in 1990. N-content in the seeds was the highest with 40 and 60kg P₂O₅/ha in 1989 and 1990,
respectively whereas P and protein content were the highest with 40kg and 60kg P₂O₅/ha, respectively.

Dhar and Singh (1995) investigated the effect of irrigation schedules on yield and yield attributes in French bean at Pantnagar (U.P.). They recorded the highest 1000-grain weight with one irrigation given at 100 days after sowing. Sinha et al. (2000) reported 100-seed weight of garden pea higher with 60kg and 75kg P₂O₅/ha as compared to a lower dose of 45kg P₂O₅/ha.

Kumar and Puri (2002) studied the response of P (0, 25 and 50 kg P₂O₅/ha) and FYM (0 and 10t/ha) rates on French bean during rainy seasons of 1996 and 1997 at Salooni in Himachal Pradesh. The seed trait 1000-seed weight was the highest with the application of 50 kg P₂O₅/ha + 10t FYM/ha. Amjad et al. (2004) investigated the influence of P on the seed quality of pea in Pakistan and noted that 1000-seed weight, seed vigour and per cent large sized seeds increased with increasing levels of P₂O₅.

Prashant et al. (2006) conducted a field experiment to study the effect of P-rates (75, 100 or 125kg P₂O₅/ha) on the seed quality of French bean (Phaseolus vulgaris cv. IIHR-909) in Dharwad (Karnataka) during Kharif season of 2003. They observed that values of seed quality parameters increased with the increase in P-rates. P @ 125kg P₂O₅/ha resulted in the highest 100-seed weight (36.89g), seed germination (92.31%), seedling vigour index (3122) and seed protein content (21.76%) over lower levels of phosphorus.
2.4 Plant/soil chemical studies

Singh and Singh (1986) studied the available NPK status of soil as influenced by irrigation and phosphorus applied to winter grain legumes (chickpea, lentil and pea) in sequential cropping with fodder sorghum at Water Technology Centre, IARI, New Delhi. They noted that irrigation given to legumes enhanced available nitrogen status of soil but not of phosphorus and potassium. Phosphorus applied to legumes improved available nitrogen, phosphorus and potassium in the soil at the end of the each sequence.

Rathi et al. (1993) recorded the highest N and P uptake in pea plants when they irrigated the crop at all the three critical stages (branching, flowering and pod development). Reddy and Ahlawat (1998) observed that dual inoculation of chickpea with Rhizobium and phosphate solubilizing bacteria (PSB) was at par with the treatments 18 kg N + 46 kg P$_2$O$_5$/ha and 18 kg N + 46 kg P$_2$O$_5$/ha + 5.25 kg Zn/ha and all the treatments recorded higher values of N and P uptake as well as soil N and P status at harvest than no fertilizer (control).

Dubey et al. (1999) recorded that N,P and K uptake were the highest with the application of 80 kg P$_2$O$_5$/ha and the lowest in the control (0 kg P$_2$O$_5$/ha). N-uptake were higher and at par in M$_1$ (irrigation at 4 day interval) and M$_2$ (irrigation at 8 days interval) irrigation treatments and both were superior to M$_3$ (irrigation at 12 days interval). There was no differential response of irrigation treatments on P-uptake. However, K-uptake was higher with M$_1$ in one year only. Parmar et al. (1999) studied the response N and P on French bean in cold desert
area of Himachal Pradesh during 1994 and 1995. They concluded that N and P-uptake increased with increasing rates of N and P during both the years.

2.5 Water studies

Tayel et al. (1990) obtained best water use efficiency (WUE) by using 66.2% instead of 77.8% of the net irrigation requirements of the pea crop. Malik and Bhandari (1994) studied the water requirement of pea var. Lincoln in inceptisol (newly formed soils) of mid-Himalayas (Solan, Himachal Pradesh) during 1989-90 and 1990-91. The highest water expense efficiency was attained when irrigation was applied at the rate of 4 cm irrigation at IW/CPE ratio of 0.8 and started decreasing with increase in frequency of irrigation.

Dhar and Singh (1995) reported increase in consumptive use of water with increase in frequency of irrigation. They also observed that lower number of irrigations resulted in more contribution of water extraction from lower or deeper layers, and vice-versa. Water use efficiency was the best with those irrigation treatments where seed yield was the highest with minimum use of water.

Nandan and Prasad (1998) conducted a field experiment at Pusa (Bihar) during rabi season of 1991-92 and 1992-93 to study the response of irrigation and nitrogen on French bean. They reported that the WUE decreased with an increase in irrigation frequency from 1 to 3. The maximum WUE was recorded with 1 irrigation scheduled at 25 days.

Das et al. (2005) reported increased WUE in vegetable pea with each increase in P-levels. Kaushal et al. (2005) studied the effect of varying irrigation schedules on WUE of sunflower at Jabalpur in Madhya Pradesh. They noted that irrigation at all the 3 critical stages had the maximum WUE followed by irrigation
only at 2 critical stages. Masand et al. (2006) recorded increased WUE with each increment in the phosphorus application from 0 to 30 and 30 to 60 kg P$_2$O$_5$/ha.