CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the available literature pertaining to "Agronomic manipulation to promote yield of late sown barley (Hordeum vulgare L.) DL-88". However, necessary results on other related crops in relation to the factors have also been reviewed.

2.1 EFFECT OF ROW SPACING:

Spacing is one of the important factors of the yield. The effect of spacing on yield is due to change in radiant energy distribution. Spacing considerably affects the interruption of net solar radiation, evaporation, water use, nutrient-uptake and control of weeds. With closer and more uniform spacing of plants it could be assumed that radiant energy would be intercepted by the plants and that less will fall on the soil surface to cause moisture evaporation. Evaporation decreases with the decrease in row spacing. Light is most essential factor of photosynthesis. Narrow spacing has been found to increase the efficiency of solar energy available to the crop for photosynthesis by 15 to 20 percent.

2.1.1 Effect of row spacing on growth and yield attributes

Delhaye (1971) indicated that narrow row spacing resulted in an increase in number of shoots/m² in barley, however,
Ram et al. (1973) did not observe any perceptible variation in the number of tillers and plant height due to row spacing in wheat, similarly Upadhyaya and Chaudhary (1971) observed that in combination of lower spacing and lesser seed rates, the number of tillers were increased, but it could not bring about differential effects on height of dwarf wheat. Singh and Guliani (1983) reported that row spacing of 15 cm gave significantly more number of tillers/plant than 20 cm in wheat, however, Simmons et al. (1982) reported more tiller production in barley at row spacing of 7.5 and 15 cm but owing to higher tiller mortality there was no significant difference in surviving spike number between the treatment (7.5, 15 and 30 cm). Svihra et al. (1973) observed that the rate of above ground dry matter production was increased by increase in between row width in barley crop.

Chandrasekhariah et al. (1971) reported that more number of ear bearing tillers/unit area were obtained in case of 15 cm as compared to wide row spacing in wheat crop where as narrow spacing resulted in an increase in ears/m² in barley (Belhaye, 1971). Similarly, Finlay et al. (1971) reported that decrease in between row spacing increased the number of ears/m² area and decreased the number of grains/ear in barley. Jevtic (1971) concluded that number of ears/m² was usually higher in 12 cm row distance compared to 18 cm in barley, however, in wheat Sharma and Singh (1971) stated that the differences in yield components were not significant under row spacings of 15 and 23 cm, similarly Ram and Bhardwaj (1983) reported that row
spacings of 15 and 25 cm did not cause any notable variation in yield components in wheat. Oliveria and Bego (1981) reported highest seeds/ear of wheat in 15 cm row spacing over 25, 35 and 45 cm. Ram et al. (1973) observed that ear length was not affected by row spacing in wheat while test weight was reduced as the row width was increased and seed rate was decreased in Oats (Blackman and Snell, 1954, and Pendleton, 1957).

2.1.2 Effect on yield

Blackman and Snell (1954) and Pendleton (1957) found reduction in grain yield as the row width was increased and seed rate was decreased in oats while in Triticale, Dhiman and Kalra (1978) reported that yield at row spacings of 30 and 20 cm did not differ from each other, however, Delhaye (1971) observed high grain yield and reduced lodging due to narrower spacing in barley. Similarly, Finlay et al. (1971) observed that high yielding cultivar of barley tended to exhibit a greater response to decreased row spacing than did low yielding cultivar. Brinkman et al. (1979) observed 4 percent more grain at 7.5 cm apart than rows 15 cm apart and 12 percent more than 30 cm apart. Straw yield responses to narrow spacing were of similar magnitude as that of grain yield response in spring barley. Slade (1980) stated that row spacing of 104, 121 and 127 and 175 mm had no effect on yield of barley. Singh and Singh (1981) reported the highest grain and straw yields at 30 cm row spacing over 20 and 40 cm in barley. Bengtsson (1972) indicated that grain yield was highest for rows 10 cm apart and decreased by 0.65 percent for each cm increase in row spacing. Barley and wheat
responded similarly, but wheat responded to 13 cm row spacing in a slightly better way than barley.

However, Chantrasekhariah et al. (1971) concluded that Sonara-63 and Sonara-64 varieties of wheat gave higher grain and straw yields with 15 cm spacing while with Lerma Rojo variety of wheat with 30 cm spacing, Sharma and Singh (1971) found no significant difference in grain and straw yields under 15 and 23 cm row spacings while Upadhyay and Chauhary (1971) reported significant differences in grain yields due to various row spacings. Ram et al. (1973) reported that the maximum yield was attained due to medium row spacing of 20 cm over wider (25 cm) or closer (15 cm) row spacings in wheat. While Bhargava and Shekhawat (1981) observed that yield due to row spacing of 25 cm was higher than 15 cm row spacing in wheat. Oliveira and Bego (1981) reported significant increase in yield due to 15 cm over 25 and 35 or 45 cm row spacings. Similarly Vaishya and Singh (1981) and Ram and Bhardwaj (1983) recorded higher grain yields with 15 cm row spacing than wider row spacing. Singh and Guliani (1983) also noted that row spacing significantly affected the grain and straw yields where a row spacing of 15 cm gave 3.7 q/ha (15 percent) more grain yield than 20 cm in wheat, however, Lal and Bhardwaj (1982) did not find significant variation in yield due to 15,20 or 23 cm row spacing.

2.1.3 Nutrient uptake

Poth et al. (1964) found that, pounds of nutrients accumulated in plant tissue/acre, were closely related to the amount
of plant growth. The grains under 7 inches planting obtained 1.4 times as much nitrogen and 1.3 times as much phosphorus than under 14 inch in planted oats. Bhan (1967) summarised that amounts of nutrient accumulated in plant tissue/unit area are closely related to amount of growth (dry matter/unit area). There workers have found little differences in the percent nutrient content of the plant tissue as affected by plant spacings and population.

2.2 EFFECT OF SEED RATE:

Bhan (1967) concluded that as a rule, the yield increases with an increase in the total number of plants/unit area due to increasing seed rates. The same number of plants/unit area either by wider spacing with higher number of plants/hill or closer spacing with lesser number of plants/hill makes little difference. Due to higher plant population it could be assumed that radiant energy would be intercepted by the plants and that, less will fall on the soil surface to cause evaporation.

2.2.1 EFFECT ON GROWTH AND YIELD ATTRIBUTES

Singh and Jackobs (1971) noted that the number of plants/unit area increased with an increase in seeding rate. The number of tillers/plant declined rapidly as seeding rate was increased in oats. Kristan and Cerny (1971) observed that decrease in sowing rate increased the number of tillers/plant in spring barley. While Bimmon et al. (1982) obtained significantly increased tillers and spike numbers with the higher seed rates of barley. Verma (1977) indicated that plant height, number of shoots/m,
dry matter accumulation and number of days to blooming and maturity were not influenced significantly. Brunetti et al. (1982) reported that dry matter yield increased with increase in seeding rates up to heading only in barley.

Upadhyay and Chaudhary (1971) reported that the highest seed rate of 150 kg/ha has significantly increased the height over lower seed rates. However, increase in seed rate to 125 kg/ha produced lower number of ear bearing shoots and tillers per plant. Agarwal and Arora (1980) observed that plant height, grains/spike and 1000-grain weight were not affected significantly by seed rates but the grain weight/spike was significantly more with low (100 kg/ha) seeded crop than the higher (125 kg/ha) seed rate. Bagga and Tomar (1981) observed that at lower plant density, both the main shoot and tillers showed better growth and dry matter production/plant, grain number and grain weight were higher at the lower plant densities. Harvest index, 1000-grain weight, remained unaffected by reduction in plant population in dwarf wheat. Kirby (1969) observed that ear number/m² increased with increasing density and grain number/ear in barley. Singh et al. (1971) found no significant effect of seed rate on 1000-grain weight in wheat. Willey and Holliday (1971) observed that dry matter production from ear initiation to anthesis and the number of grains/m² increased with increasing in sowing rate to 112 kg/ha in wheat. Bengtsson (1972) reported that increasing seed rates reduced germination, tillering and 1002-grain weight but increased the number of ears/unit area in wheat and barley. Hojmark (1975) observed that number
of grains/ear and 1000-grain weight decreased with increasing sowing rate whereas number of ears/m² increased in barley, however, Warsi and Singh (1975) found no significant difference due to seed rates on yield attributes in rainfed barley. Similarly Ram and Bhariwaj (1983) observed that seed rate did not cause any notable variation in both the years in wheat. Jana et al. (1978) observed that a seed rate of 75 kg/ha increased the number of effective tillers, grains/panicle over 50 kg/ha seed rate in barley. Stiegl (1978) found that increase in seeding rates decreased 1000-grain weight, number of tillers/plant in spring barley. Gretzmacher (1979) reported that increase in seed rates resulted in a linear decrease in ears/m², ear length, number and weight of seeds/ear, 1000-grain weight in wheat and barley. Lynch et al. (1979) observed that higher sowing rates increased ear numbers/m² but decreased grain numbers/ear and grain weight in spring barley. Mcleod (1982) indicated that number of tillers/plant, grains per ear and individual grain weight and size decreased with increasing sowing rates in barley. Singh and Ram Mohan (1983) reported that the test weight is largely governed by the genetic make up and thus is least affected by varying soil rates in wheat.

2.2.2 Effect on yield

Day and Thompson (1970) observed increased yields of January sown barley with increased sowing rates, because late sown crops had less time to develop roots and tillers. Similarly, Singh and Jacobs (1971) found increase yield associated with an increase in seeding rates in oats. However, Finley et al. (1971)
reported that grain yield was not affected by seeding rate in barley, similar results were also recorded by Slade (1980), Ilieva-Staneva (1982) and White (1982) in barley and Bhargava and Shekhawat (1981) and Felicio (1982) in wheat. Singh et al. (1971) observed that seed rates did not have significant effect on the yield in first year while during second year 125 kg/ha seed rate proved significantly superior to 75 and 100 kg/ha under late sowing of wheat. Yield of straw increased with the highest seed rate in both the years. Singh et al. (1971b) concluded that a seed rate of 100 kg/ha enhanced the grain yield over 75 and 125 kg/ha seed rates in second year, while in first year, seed rates of 100 and 125 kg/ha were found statistically equal. The straw yield of barley was increased due to 125 kg seed rate in first year but 100 kg seed rate was found superior to 125 kg in second year. Singh and Prasad (1972b) reported that a seed rate of 75 kg/ha may be considered optimum for irrigated barley. Upadhyay and Chaudhary (1971) reported that the seed rate of 125 kg/ha had significantly increased in the yield over 100 kg/ha with increment being 8.33 q/ha, more or less similar quantities of straw were obtained in different seed rates i.e. 100, 125 and 150 kg/ha of wheat. Willey and Holliday (1971) reported that grain yield increased with increase in sowing rates to 112 kg/ha and then decreased with further increase in sowing rate of wheat. Bengtsson (1972) noted increased grain yield due to increasing seed rates in both barley and wheat. However, Holmes et al. (1972) noted that the result was not affected by variation in sowing rates in spring barley and winter wheat. There was no trend in the results due
to seed rates (Mehta and Mathur, 1972). According to the report of the All India Coordinated Agronomic Experiment on barley (1972-73) the seed rate for malt barley was 75 kg/ha. Khurana and Guliani (1973) found maximum grain yield with a seed rate of 100 kg/ha and addition beyond this level did not affect the yield appreciably in barley. Svihra et al. (1973) observed that decrease in the sowing rate decreased the average grain yields in spring barley. Hojmark (1975) reported that grain yield did not increase at sowing > 150 kg seed/ha in barley. Singh et al. (1975) found a seed rate of 75 kg/ha to be optimum over 100 and 125 kg in barley. However, Warsi and Singh (1975), Gupta et al. (1975), Verma (1977) and Lynch et al. (1979) found that the yield response to sowing rates was smaller. But Tola et al. (1977) reported that yield/unit area was highest at highest plant density in barley. Dhiman and Kalra (1978) reported that seed of Triticale sown at the rate of 100 and 125 kg/ha proved significantly better than a seed rate of 75 kg/ha. It is further noted that the yield increased by 3.3 percent with 100 kg over 75 kg seed/ha. Singh et al. (1978) reported that grain yield was higher with a sowing rate of 75 kg than 50 kg/ha in barley. Striegl (1978) reported decrease in grain yield due to increase in seeding rates of barley. Agarwal and Arora (1980) concluded that there was no substantial difference in grain and straw yields with seeding rates of 100 and 125 kg/ha. However, grain yield with 100 kg/ha and straw yield with 125 kg/ha were comparatively higher in barley. Kahnt and Kubler (1981) reported that the effects of late sowing were not compensated by high seeding rates in barley. Singh and Singh (1981)
observed higher grain and straw yields with a seed rate of 90 kg/ha over 70 and 110 kg/ha in rainfed barley. Vaishya and Singh (1981) reported that the highest grain yield was obtained with a seed rate of 125 kg/ha used in row spacing of 15 cm and 120 kg nitrogen/ha in wheat. Mcleod (1982) reported increase in grain yields with increasing seeding rates in barley. Simmons et al. (1982) also observed increased grain yield due to increase in seed rate. It was found 3.89, 4.11 and 4.16 t/ha due to 67, 101 and 134 kg seeds/ha, respectively in barley. Ram and Bhardwaj (1983) reported that only closer row spacing of 15 cm, higher seed rate of 125 kg/ha and covering with farm yard manure significantly increased the grain yield of late sown wheat while the above failed to show a consistent effect on the straw yield. Singh and Ram Mohan (1983) reported that higher seed rate of 150 kg/ha brought about higher grain yield than 100 kg/ha in cross sowing. Straw yield was not affected by various treatments. The higher grain yield in bi-directional sowing with higher seed rates may probably be due to efficient utilization of solar radiation and nutrients.

2.2.3 Nutrient uptake

Kirby (1969) observed that percent nitrogen content of grain and straw showed lesser response to varying densities. Nitrogen uptake/m² for both shoot and grain rose first but declined subsequently with increasing densities. Tripathi et al. (1971) stated that the effects of seed rates on grain yield nitrogen uptake are of little significance. Hojmark (1975)
reported slight decrease of grain protein due to increasing seed rates. Verma (1977) found that both the seed rates used did not differ from each other either in respect of nitrogen content in grain or in respect of removal of nitrogen through grain and straw. Jurcik (1979) concluded that the total uptake of nitrogen and its utilization in dry matter production increased with increase in seed rates. The above ground concentration and uptake of phosphorus also increased with increase in seed rates in barley. Noworolnik and Ruszkowska (1980) reported that sowing rate did not affect the chemical composition of the grain.

2.3 **EFFECT OF PHOSPHORUS**

Phosphorus is a constituent of nucleic acid, phytin and phospholipids. An adequate supply of phosphorus early in plant life is important for rapid and vigorous start by root development and cell division. It involved in the synthesis of nucleoproteins. It is also an essential constituent of many enzymes which take place in metabolic activity of plants. It stimulates flavoring, brings about early maturity and improves the quality of food grains.

2.3.1 **Effect on plant growth and yield attributes**

Sinsinwar and Singh (1980) reported that number of shoots/m and plant height of barley were beneficially influenced by 30 kg phosphorus/ha. Similar increase in barley height due to phosphorus application was reported by Das (1959), Hefni (1976) and Singh et al., (1984). Increased dry matter production due to phosphorus application over control was recorded by Misra et al.
(1982). Kaushal (1980) reported that number of tillers/m row length and dry matter accumulation increased significantly in presence of phosphorus. Singh (1981) observed that the number of shoots/m, tillers/plant and dry matter accumulation increased while shoot height and number of effective leaves were not affected and days to bloom hastened by two days due to application of 40 kg phosphorus/ha over control in barley.

Sigarkin and Kuzuetsova (1971) reported that the application of phosphorus increased tillering and number of ears per unit area. Singh et al. (1972a) showed that the number of ear heads/m row length, number of grains/ear head and 1000-grain weight increased progressively with increasing doses of phosphorus in barley crop. Agarwal and Singh (1974) observed that the number of grains/ear of barley showed quadratic response and the highest number of grains/ear was recorded at 30 kg phosphorus/ha, however, Christenson and Duley (1976) reported that the test weight was not affected by application of phosphorus. Hefni (1976) reported that increased application of phosphorus upto 40 kg phosphorus/fodden (0.42 ha) increased the 1000-grain weight of barley. Warsi et al. (1976) reported that phosphorus fertilization increased the number of tillers and 1000-grain weight over the control under late sown conditions. Kaushal (1980) reported that ear number/m row length and number of grains increased significantly due to phosphorus application while phosphorus could not influence the ear length and 1000-grain weight. Knapp and Knapp (1980) reported higher number of ears per unit area in barley due to phosphorus
fertilization, however, Misra et al. (1982) observed that phosphorus application failed to show significant effect on the yield attributes. While Singh (1981), reported increased number of effective shoots/plant, length of spike, number of grains/spike, weight of grains/spike and 1000-grain weight due to 40 kg phosphorus/ha over control. El-Latif and Salamah (1982) observed that increasing phosphorus application increased the number of tillers per plant and grains per ear. Misra et al. (1982) reported that yield attributing characters were increased due to phosphorus application over control. Further they found that the application of 50 kg nitrogen and 21.50 kg phosphorus/ha significantly increased the dry matter production, number of ear bearing shoots/m row length, ear length, number and weight of grains/ear and 1000 grain weight. Singh et al. (1984) reported increase in the ancillary characters such as effective tillers, ear length and 1000-grain weight by the application of 40 kg N + 20 kg P₂O₅/ha.

2.3.2 Effect of phosphorus on yield

Macleod (1969) observed yield response to phosphorus in plants harvested at the early vegetative, heading and mature stages of development of barley in hydroponic culture. Filipov (1970) observed increased average yield by 6 kg grain from the application of 1 kg phosphorus. Mehta and Shekhawat (1970) reported that application of 33.6 and 67.2 kg phosphorus/ha increased the average grain yields of barley by 8 and 20 percent over control, respectively. Chowdhary et al. (1971) estimated 38.5 kg and 69.4 kg as the most optimum doses of phosphorus for barley under respective rainfed and irrigated
tracts of North Eastern Plain Zones of the country. However, Finkner and Gledhill (1971), Christenson and Dudley (1976) Pandey et al. (1978) and Misra et al. (1980) indicated that barley yield was not significantly affected by added phosphorus. Rubanov and Berestov (1971) reported that application of 40 kg each of nitrogen, phosphorus and $K_2O$/ha increased the grain yield of barley. Increased grain yield due to 17.5 kg phosphorus/ha over unfertilized crop of barley was reported by Sharma and Singh (1971). Similarly Sigarkin and Kuzuetsova (1971) found increased grain yield due to phosphorus application. Singh et al. (1971a) noted that the yields of barley grain increased progressively with increasing doses of phosphorus, although the difference between 50 and 60 kg phosphorus/ha was not found significant. Singh and Parshad (1972a) observed progressive increase in grain yields of barley with increasing levels of phosphorus in irrigated condition and rainfed condition up to 60 kg phosphorus/ha. Afridi and Samiuallah (1973) reported that application of 39.9 or 53.2 kg phosphorus/ha alone or in combination with 40 kg nitrogen/ha produced the best quality of barley grain for malting. Agarwal and Singh (1974) reported that the difference in the yield of barley due to phosphorus levels was not significant. For irrigated barley, a combination of 60 kg nitrogen and 30 kg phosphorus/ha appeared reasonable under Kanpur conditions. Hefni (1976) reported higher grain yield due to 40 kg phosphorus/seedan (0.42 ha) over control. Sethi and Singh (1976) reported that a total of 30 kg nitrogen, 20 kg phosphorus and 15 kg potash is required/ha for good crop of barley. Warsi et al. (1976) noted
higher response of phosphorus largely under late sown conditions. However, 30-40 kg phosphorus/ha may be recommended for late sown conditions while under saline conditions Singh and Paliwal (1977) recorded the highest grain yield of barley with four irrigations, 120 kg nitrogen, 60 kg phosphorus and 60 kg K₂O/ha. Johnson and Zemroch (1980) found that there were economic responses to phosphorus at several sites but these were unpredictable and the overall responses were economic in barley. Kaushal (1980) found significant response up to 20 kg phosphorus/ha in grain production of barley. Similarly, Knapp and Knapp (1980) also reported that 20 kg phosphorus/ha was necessary for best winter survival and highest grain yield of barley. Malik (1980) reported that 60 kg nitrogen and 30 kg phosphorus/ha increased grain yield/ha by 11.7 and 9 percent in the first, second and third year over a dose of 40 kg nitrogen + 20 kg phosphorus/ha in late barley. Shevtsov et al. (1980) found that application of phosphorus with nitrogen and potash increased the cold resistance and yield of barley. Sin-sinvar and Singh (1980) reported that the application of 30 kg phosphorus/ha increased the grain yield of barley significantly over control. However, the increase in yield brought about by 60 kg phosphorus/ha was not significant over 30 kg phosphorus/ha. Krusser et al. (1981) observed that the optimum fertilizer rate was 60 kg nitrogen and 30 kg phosphorus. Singh (1981) indicated that grain and straw yields were increased due to 40 kg phosphorus/ha application over control. Michaelson et al. (1982) reported that in barley phosphorus application increased the yield up to the rate of 34 kg phosphorus/ha. Misra et al. (1982) observed that the application of phosphorus raised
the grain and straw yield by 9 and 20 percent over no phosphorus in 2-row barley. Further they recorded significantly increased grain and straw yields by the application of 50 kg nitrogen and 21.5 kg phosphorus/ha. Farnworth and Said (1983) reported that grain and total crop yields of barley were maximum at 80 kg phosphorus/ha. Singh et al. (1984) observed that application of 40 kg N + 20 kg P₂O₅/ha resulted in 7.8 q/ha increase in grain yield and 9.4 q/ha in straw yield of barley over control in guara areas of Bihar.

2.3.3 Nutrient uptake

Salmin (1969) stated that uptake of N and P by plants of barley were greater on soils containing high phosphorus contents. Sergeeva (1970) reported that with the application of 45 kg N + 60 kg phosphorus and 40 kg K₂O/ha increased the plant uptake of N by 19.8 to 25.0 kg/ha, phosphorus by 8.2 to 9.6 kg/ha, K₂O by 15.4 to 19.2 kg/ha over no fertilized plots of barley. Shatilov and Melik-Sarkisov (1970) observed that uptake of N, P and K was highest during the early stages and decreased gradually towards the end of the growing period. The distribution of these nutrients in barley plant depended only to a small extent of the rate of fertilizer applied, but changed considerably at different stages of plant development. N and P moved from the leaves to the ear at the milk ripe stage and from stem at wax ripe stage. At the end of the growing period, 92 percent of the total amount of N and P in the plant was concentrated in the ear. Srivastava and Pathak (1970; 71)
reported that the utilization of applied phosphorus on soils having low and medium contents of available phosphorus was 13.0 and 12.6 percent, respectively. These amounts represented 21.1 and 17.5 percent of the total uptake of phosphorus by barley crop. Rubanov and Berestov (1971) observed that the uptake of nutrient in one ton grain + associated straw obtained from fertilized plots (40 kg each N, P and K/ha) was 24.0-27.2 kg N, 11.4-11.5 kg P₂O₅ and 11.7-21.2 kg K₂O by barley. Sharma et al. (1971) reported that total uptake of phosphorus by dwarf wheat was influenced significantly by phosphorus application at 50 days and at harvest. Each increment in phosphorus application resulted in significant increase in phosphorus uptake at harvest in grain and also in whole plant. Sharma and Singh (1973) reported that the effect of levels of phosphorus (0, 17.5 and 60 kg/ha) on nitrogen and phosphorus uptake (kg/ha) in grain, straw and total produce of barley was in increasing order and the uptake (kg/ha) of N and P increased at each increment of phosphorus. Sinha (1975) observed that the fertilizer phosphorus uptake continued to increase substantially even beyond optimum dose of phosphorus in wheat. The efficiency of the utilization of the applied fertilizer, however, decreased with the increase in the dose of phosphorus. Romanova and Korobochkina (1974) reported that in barley the application of high rates of phosphorus increased mineral nitrogen contents without affecting organic phosphorus contents. Grain reserve P contents increased with an increase in phosphorus nutrition. Tiwari et al. (1978) observed that 40 kg each of phosphorus and potash in conjunction
with two irrigations enhanced the uptake of phosphorus and potassium in barley. Kaushal (1980) reported that N uptake increased up to 20 kg phosphorus/ha in barley at tillering and in grain. P uptake at tillering was significantly higher at 20 kg phosphorus/ha application, while in grain, phosphorus uptake increased at each corresponding increase in phosphorus. Singh (1981) reported that in barley crop nitrogen and phosphorus uptake per hectare was appreciably increased in grain, straw and total produce by application of 40 kg phosphorus/ha over no phosphorus. Misra et al. (1982) reported that nitrogen and phosphorus uptake increased by increasing nitrogen or phosphorus from 0 to 50 kg/ha in barley grain. Phosphorus uptake in straw was nearly 50 percent of the phosphorus uptake in grain.