CHAPTER 1
INTRODUCTION

Rice-wheat has been a dominant cropping system of Punjab for the last four decades where wheat (*Triticum aestivum* L.) is the premier cereal crop covering an area of 3.52 million hectares with an annual production of 15.16 million tonnes and mean yield of 4307 kg ha\(^{-1}\) during 2009-10 (PAU, 2011). In Punjab, it has been possible to achieve the near potential yield of wheat through development of high yielding varieties, standardization of primary agronomic practices and improved technology. But, adoption of monoculture of rice-wheat cropping system has led to numerous problems like deterioration and degradation of soil health due to depletion of plant nutrients and excessive tillage, declining under ground water table from 0.68 to 1.34 metres per annum (Minhas et al., 2010) in the central plains, rising underground water table in south-western districts of Punjab resulting in salinization, emergence of multiple nutrient deficiencies and appearance of new weed biotypes and resistance to applied herbicides. The rise in prices of farm inputs and reduction in size of land holding have forced the Punjab farmers to think of increasing the crop productivity for higher returns per unit area per unit time by utilizing the land in best possible ways. But under the present scenario, increasing the productivity of wheat per unit area per unit time is a challenging job. However, the possibility of increasing wheat productivity can be explored by adopting better alternative techniques/new crop establishment methods, altering the management practices and inclusion of new high value crops like mentha in combination with wheat in the intercropping system.

Methods of planting constitute an important component of physical environment of soil and therefore, could affect the crop establishment, growth and yield of crops by its impact on plant rooting, soil nutrients and moisture extraction pattern. Generally, wheat is sown as flat planted crop in Punjab. Research has shown that bed planted crop, particularly on medium to heavy textured soils and irrigation application in furrows, increased the input use efficiency with better grain yield (Dhillon et al., 2004). The bed planting system facilitates better light penetration within the crop canopy and improves the fertilizer use efficiency. A bed planted crop yields higher due to robust plant growth
and more open space available to plants on either side of the bed which allows more sunlight and aeration to the plants (Khan et al., 1987). Wheat planted on beds receives water through seepage and it is not in direct contact with flooded water, thus resulting in reduced crop lodging particularly due to upheaving. It is gaining importance also due to number of other advantages like better crop establishment, irrigation management and weed management through inter bed cultivation etc. Bed planting system could therefore, be the best resource conservation technology for rational use of land and water. According to Unger (1994), Baumhardt and Lasecano (1996) and Sayre and Moreno (1997), Furrow Irrigated Raised Bed (FIRB) system increased fertilizer uptake efficiently by reducing their losses through leaching and percolation and better control of excess water in heavy soil conditions. Another method of planting i.e. Broad Bed and Furrow (BBF) system is an effective land management practice for maximizing water infiltration, minimizing soil erosion and total runoff, facilitating drainage and improving water use efficiency of field crops.

Mint species are known as a kitchen and natural medicinal herb which yield essential oil upon distillation. Japanese mint (Mentha arvensis Linn.) oil is a source of menthol which is widely used as an ingredient in medical preparations and cosmetic industries besides a flavouring agent in tooth paste, candies, chewing gums, mouth washes, beverages, tobacco, cigarettes and pan masala. Major producers of mentha oil in the world are India, China, Brazil and USA, but India holds a unique position in mentha oil trade and export, contributing about 80 per cent towards total world production. It is mainly cultivated in the states of Punjab, Uttar Pradesh, Haryana and some parts of Tamil Nadu.

In India, Japanese mint occupied about 1,60,000 hectares with an annual production of approximately 16000 tonnes of mint oil (Singh and Khanuja, 2007) whereas it was cultivated in an area of approximately 15000 hectares in Punjab state (PAU, 2010). Hence, it offers a good scope for diversification of cereal based cropping systems. Normally, mentha is planted in the second fortnight of January after the harvest of potato, toria etc. Bed planted wheat provides an option for intercropping of mentha in the space between the raised beds on the outer side of wheat furrows. Growth of mentha picks up after the harvesting of wheat and it vacates the field by the end of June to mid of 2
July. The additional income obtained from mentha can thus be utilized to supplement the farm income and increase the per hectare profitability. Gill et al. (2000) observed that spring planted sugarcane intercropped with Japanese mint is more remunerative as compared to their sole crops. Higher gross and net returns can be obtained with intercropping systems involving *Mentha arvensis* and *Mentha spicata* with sugarcane than sole mint or sugarcane crop (Kothari and Singh, 2004). In Japanese mint, method of planting also influenced the quantity and quality of oil as in loamy sand soils, flat method of planting resulted in better herbage and oil yield over bed, trench and ridge methods of planting (Saini et al., 2002b).

Another important factor, which influences the crop productivity, is the efficient nutrient management. Nitrogen application plays a prominent role in improving crop growth and realizing production potential of crops. Application of nitrogen favourably affects the crop growth, yields attributes and yield of wheat as well as mentha. Application of excessive nitrogen to wheat leads to its luxuriant vegetative growth and may lower its grain yield due to lodging. The effect of nitrogen on crop growth, grain yield and lodging could be different under varying planting techniques and when grown in conjunction with a competing intercrop like mentha through their direct effect on microenvironment parameters, photosynthetically active radiation (PAR) interception, disease and weed competition etc. The significant response on grain yield of bed planted wheat can be obtained from 120 kg N ha\(^{-1}\) (PAU, 2004) to 180 kg N ha\(^{-1}\) (Tripathi, 1999). Application of nitrogen in mint causes the crop to grow rapidly producing many new shoots and these contribute toward higher herbage and oil yield. The response of Japanese mint to different levels of nitrogen differs remarkably from place to place because of differences in nutrient status of soil and nutrient absorption efficiency of the crop (Atal and Kapur, 1982) and N application ranged from 60 to 225 kg N ha\(^{-1}\) (Gulati and Duhan, 1975; Sarma et al., 1975; Shelke and Morey, 1978; Chandra et al., 1983; Singh, 1983).

In an intercropping situation where two or more crops are associated, their fertilizer requirement may vary widely from sole crop requirement and hence, balanced nutrition becomes more complex (Singh et al., 1996). No doubt, that lot of research work has been done on nitrogen requirement of wheat and mentha as sole crops but there is
only little information available under intercropped system. Thus, there is need to work out the nitrogen requirement of wheat and mentha in intercropping system under different planting methods for higher returns. Therefore, the present study was undertaken with the following objectives:

1. To investigate the feasibility of intercropping mentha in flat and bed planted wheat and its effect on productivity and profitability of wheat and mentha intercropping.
2. To study the effect of intercropping on wheat and mentha growth, yield attributes and quality of mentha essential oil under different planting methods.
3. To find out the optimum dose of nitrogen for wheat and mentha intercropping under different methods of crop establishment.