1. INTRODUCTION

Sorghum [Sorghum bicolor (L.) Moench] is widely distributed in semi arid tropics endowed with large variability in cultivated types represented by durras, guineas, caudatums, bicolor and their combinations (Harlen, 1970 and Murthy, 1970). It is the third important cereal crop next to rice and wheat in the country as well as in the world is a major dryland areas for its utility as food, feed, forage and alternative uses. The demand for sorghum grain and fodder for feed purposes is increasing in Asia, particularly in India. Total sorghum production in the world is over 60 m.t. but nearly a quarter of it is from USA which is the largest producer, followed by India (9.3 m.t.) (FAO/ICRISAT, 1996). It is grown over 44.7 million hectares in the world. Of it 26 per cent is presently grown in India. Of the 10.4 million hectares total grain sorghum area, rabi sorghum area has been fairly consistent around 5.64 million hectares and competitive with other crop (Anonymous, 2001).

In India, sorghum is grown in an area over 10.4 million hectares with a production of 6.9 million tonnes in the season 1999-2000, wherein yield was 852 kg/hectares. In this season kharif area was 4.76 million hectares with a production of 4.82 million tones and rabi area was 5.64 million hectares with a production of 4.03 million tones (Anonymous, 2001), since the grain provides the staple food for a large section of the population and the fodder/straw serves as the principal feed for cattle. The crop is primarily (96%) cultivated under
rainfed conditions in the areas receiving 500 to 1000 mm annual precipitation and the temperature profile ranging from 26 to 35°C. The principal states cultivating sorghum in India are Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Gujrat and Rajasthan. *Kharif* sorghum accounts for more than 60 per cent of the area sown and the rest is sown in *rabi* season.

Sorghum for forage, dual purpose is popularly grown over 2.6 million hectares area in Western Uttar Pradesh, Punjab, Haryana, Delhi, Gujrat, Rajasthan and is fast becoming popular with farmers in other states. Almost 60-70 per cent of total forage demand in *kharif* is met from sorghum (Rana et al., 1999). In Uttar Pradesh total production was 0.31 million tonnes with the total area of 0.35 million hectares in the season of 1999-2000, whereas yield was 872 kg/hectare (Anonymous, 2001).

In developing countries, sorghum is grown primarily for its grain used for human consumption and fodder for cattle. It is an important staple food crops in Africa, South Asia and Central America. Sorghum is grown in USA, Australia and other developed countries for animal feed. The high nutritive value of grain and fodder, better tolerance to drought, high yield potential and ability to grow under varied climatic conditions are the important characteristics of the crop which enable expansion of its area in tropics as well as temperate regions.

The discovery and development of cytoplasmic genetic male sterile lines has made hybrid sorghum commercially possible and viable (Quinby and Martin 1954; Quinby, 1963). In India, a major break through resulting in green revolution in sorghum has altered with the release of the first commercial hybrid, Coordinated Sorghum Hybrid 1 (CSH 1) and CSH 2 hybrids during 1964 and 1965 and CSH 3, CSH 4 during 1970 as a result of sustained research
carried out by Rao and his Co-Workers (1968, 1970 a,b). Many new hybrids/varieties were subsequently added to the existing list. Commercial hybrids are currently grown in Australia, China, Thailand, South Africa, Central and Latin America and South Eastern Europe, and were recently introduced into Sudan and Egypt (ICRISAT, 1994).

The sorghum is important for food and fodder security in large drought prone area. One of the important reason is the consistent area, high demand of both grain and fodder with higher competitiveness with other crops. In spite of this fact, the productivity changed over the last 25 years between 1968-70 to 1992-94 has been low in *rabi* season (146%) and (201%) compared to *kharif* season sorghum. The improved cultivars particularly the *Kharif* season hybrids rapidly become the primary components of production system and made commendable impact over productivity. The productivity in *kharif* increased by 3.22 per cent per annum between 1967 to 1980 and 1.9 per cent per annum between 1980 to 1994 (Rana *et al.*, 1996). While several high yielding hybrids and varieties have been developed for *kharif* cultivation, the yield improvement in *rabi* is limited and the local land races are still grown (Rana *et al.*, 1998). Since *rabi* productivity in the last 25 years could increase slowly from 436 kg/ha to 637 kg/ha, there is an urgent need to develop productive *rabi* sorghum hybrids and varieties on the pattern of *kharif* hybrids to replace the wild grown land races/local cultivars. Therefore, recombination of these traits and developing *rabi* sorghum hybrids on the pattern of *kharif* have been the major approach in the national programme.

The heterosis in *kharif* hybrids has been reported 9.66-50 per cent by several workers (Kirby and Atkins, 1968; Vasudeva Rao, 1973; Patil *et al.*, 1982 and Francea *et al.*, 1986). Subsequently, Rana and Kaul, (1997) reported the extent of heterosis exploited in *kharif* hybrids i.e., 53.4 per cent in CSH 5, 52.6 per cent in CSH 9, 35 per cent in CSH 13 and 39 per cent in CSH 14. They
reported the genetic gain 7 to 14 per cent in early hybrids and 9 to 26 per cent in medium maturity hybrids over the first commercial hybrid CSII 1.

However, in rabi sorghum F1 hybrid involving GS or KxK derivatives as R lines, Kaul and Rana (1997) reported the range of high per cent heterosis. They reported 6.5 to 81.1 per cent heterosis in grain yield, -16.7 to 16 per cent for panicle length, -32.8 to 39.5 per cent for grains per panicle branch and -26.3 to 8.5 per cent for days to 50 per cent flowering which is more relevant to present studies. In restorer line improvement in rabi season the heterosis over better parent was 27.6 to 117.6 per cent for grain yield and 22.7 to 46.4 per cent for seeds per panicle. The average inbreeding depression involving restorer line was 12.9 to 52 per cent in F1, which was double than that occurred in F2. In this breeding programme, 36.1 per cent genetic improvement was realised in F1 over F2 generation. F1 yields may also be predicted based on the per se performance of B and Restorer lines for grain yield (Rana and Kaul, 1997). These observations lead to choose high yielding parents for improving rabi hybrids in the present studies.

The improved rabi cultivars including some of the hybrids have marginal superiority over local varieties. Therefore level of heterosis need to be enhanced on the pattern of kharif hybrids so that stability of production under variable environments can be ensured.

As earlier rabi hybrids were based on kharif CMS lines, the level of heterosis and range of adaptability has been narrow. It is therefore necessary to identify type of cross, involving recently developed rabi based CMS lines, an improved restorer lines.

Rao et al. (1998) found that hybrids were superior by 12 per cent in harvest index for grain yield than their parental lines and that grain number was positively correlated with grain yield. Subsequently Rao and Rana (1998)
observed a significant negative relationship between 1000-seed weight and grains per panicle, in kharif hybrids and varieties, respectively. While, Lata Chaudhary et al. (2001) reported high heritability for ear head length and days to maturity range varied from 56.04 to 97.8 per cent. Subsequently they recorded high GCV and PCV for ear head width, grain yield per plant, days to maturity, number of primaries per panicle, plant height and ear length.

The information on yield component and different genetic parameters in rabi type sorghum genotypes is limited which is important for the improvement for grain yield, plant type and selection of suitable parental lines so that higher level of heterosis may be realised in rabi sorghum.

In view of higher importance of rabi sorghum both for food and fodder security and yield pleasuring over several years and limited genetic information. The present investigation includes estimation of heterosis and inbreeding depression in different crosses and comparison with their parents. The study has been taken with the following objectives:

1. To estimate the magnitude of heterosis.
2. To determine the degree of inbreeding depression.
3. To identify the type of crosses which may result in higher heterosis.
4. To analyse yield components in segregating and non-segregating genotypes.
5. To co-relate degree of genetic divergence among parents with their magnitude of heterosis.
6. To relate yield heterosis with degree of heterosis in yield components.