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Effect of different land slopes on plant growth and yield of intercropping of maize and soybean crop under natural rainfall conditions in Tarai region of Himalaya

Ram Kumar and PV Singh

Abstract
Intercropping is a breakthrough in land use optimization. This work objective is to study the effects of different land slopes and cropping pattern on, growth and yield of maize and soybean in the Tarai belt of the Himalayas, Uttarakhand, India. Three different land slopes (2, 5 and 8%) and four different cropping patterns (sole maize (M), intercropping of one row of maize and soybean (M1+S1), intercropping of two rows of maize and soybean (M2+S2) and with the control treatment i.e. bare). The results found to be plant height of maize and soybean at 30 DAS was observed highest (129.33 and 34.05 cm) in when cultivated intercropping (M2+S2) and lowest (125.80 and 33.02 cm) and intercropping (M1+S1) at 2% slope. Same trend has been observed for 5 and 8% slope i.e. intercropping of (M2+S2) intercropping of (M1+S1) at 60 and 90 DAS of maize and soybean. The yield of maize and soybean was observed highest (40.87 and 18.50 q/ha) in when cultivated intercropping (M2+S2) and lowest (30.57 and 15.90 q/ha) and intercropping (M1+S1) at 2% slope. Same trend has been observed for 5 and 8% slope i.e. intercropping of (M2+S2) intercropping of (M1+S1) of maize and soybean. The growth of maize and soybean was found to be decreasing with the increase in land slopes for all cropping systems. Grain yield of maize was found highest for sole maize while lowest for intercropping of two rows of maize and soybean.

Keywords: Maize, soybean, slope, intercropping

Introduction
Intercropping can provide a consistent protective cover while also protecting the soil from raindrop impact (Nyawade *et al.*, 2018) [8]. It also provides a dense canopy, reducing the impact of raindrops and soil erosion. Raindrop splashing results in aggregate peeling at the micro scale, which leads to an uneven distribution of soil granules. The finer and lighter soil components are primarily entrained and transported in the eroded sediment when flow occurs (Lal, 2001 and Quininton *et al.*, 2001) [7, 10]. Legume also serves as natural organic mulch, reducing evaporation and retaining soil moisture to help plants manage dry spells (Khola *et al.*, 1999) [5]. An environmentally sustainable approach, such as an intercropping system with soybean and maize, is needed to improve the low soil productivity in the Indian Sub-Himalayas. This technique has the potential to increase crop productivity while decreasing soil erosion and nutrient loss (Ranjan *et al.*, 2021) [9]. It is estimated that 30% of land in SSA is degraded as a consequence of erosion, nutrient mining, overexploitation, and deforestation (Bindraban *et al.*, 2016) [12]. Intercropping can raise overall yields per unit of input, prevent crop failure, especially in arid places, and improve the efficiency of land use by completely utilizing nutrients, water, and solar radiation (Li *et al.*, 2014) [13]. Intercropping can help weed growth and stop weeds from utilizing resources (Brooker *et al.*, 2014) [14].
Maize, the "Queen of Cereals" holds a distinctive place in global agriculture because of its multi-purpose use as food, feed, fodder, fuel and a range of industrial outputs. Maize is one of the most significant cereals after rice and wheat, and it can be cultivated in a variety of agro-climatic situations (Kogbe and Adediran, 2003) [6]. Soybean [*Glycine max* (L.) Merrill] is a major leguminous and oilseed crops in India. According to Vyas and Chandel, 2015, soybean is also known as the 'Wonder crop,' 'Miracle bean,' and 'Golden bean in America' (2015). In India, soybean is grown on 12.1 million hectares producing about 11.23 million tonnes with yield of 9.27 q/ha (FAOSTAT, 2020-21). Looking at the importance of the runoff-sediment-nutrient outflow from the field an attempt will be made in this study to understand the effect on maize and soybean cropping systems.

Materials and Methods

General description

The field experiment was conducted in D7 block at Norman E. Borlaug Crop Research Centre (CRC), G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. Nagar, (Uttarakhand), situated in the *Tarai* belt of of the Himalayas during the Kharif season of 2020. The latitude and longitude of the study area are 29°N and 79.38°E, respectively. The elevation of the gauging station is 243.8 m above mean sea level (MSL). The climate of the study area is humid and sub-humid in nature. The study site was characterized as soil of the *Tarai* region, has developed under the predominance of forest vegetation and moderately to well drained conditions, from calcareous medium to sandy loam texture (i.e., 52% sand, 30% silt, and 18% clay) (Michael, 2011) [15].

Experimental Treatments

The experiment, comprising of 12 treatments, having 3 different land slopes of 2%, 5%, and 8% in main plot with one control treatment and four cropping systems, was conducted using split plot design with three replications. The whole experimental area was divided into 3 plots for 3 replications of the selected treatments. Each plot consists of 4 sub plots of 3 land slopes of 2, 5, and 8%, totaling 12 subplots in one plot. The subplots will be put under 4 treatments *viz*., barren (control), sole maize, maize + soybean cropping (1:1), and maize + soybean cropping (2:2) as treatments using split plot design.

Plant growth parameters

Plant growth parameters like plant height was recorded at 30, 60, and 90 days after sowing (DAS) of maize and soybean in the year 2020. Initially, five plants were selected randomly for measuring plant growth parameters throughout the cropping season. Plant height was defined as the distance between the base of the topmost fully expanded leaf and the ground level (Myint *et al.* 2022) [11].

Yield attributes and yields

Yield characteristics and yield such as grains weight per plant, grains and grains yield. All the yield attributes and yields were taken for five randomly selected plants for yield attributes were calculated.

Result and Discussion

In the year 2020, maize plant height at 30 DAS is significantly highest at lowest slope 2% (129.33 cm) followed by 5% (127.13 cm) and 8% (124.61 cm) as evident form Fig. 1 (a). The plant height of maize found to be highest (129.33 cm) in when cultivated intercropping (M2+S2) and lowest (125.80 cm) and intercropping (M1+S1) at 2% slope shown in Fig. 1 (b). Same trend has been observed for 5% slope i.e. intercropping of (M2+S2) highest plant height (127.13 cm) and lowest intercropping of (M1+S1) (123.40 cm). Intercropping of (M2+S2) results in highest plant height (124.61 cm) and intercropping of (M1+S1) (121.32 cm) even for 8% slope. At 60 DAS is significantly highest at lowest slope 2% (256.43 cm) followed by 5% (254.68 cm) and 8% (252.36 cm) shown in Fig. 2 (a). The plant height of maize found to be highest (246.43 cm) and cultivated intercropping (M2+S2) and lowest (251.60 cm) when intercropping (M1+S1) at 2% slope shown in Fig. 2 (b). Same trend has been observed for 5% slope i.e. intercropping of (M2+S2) highest plant height (254.68 cm) and lowest intercropping of (M1+S1) (250.43 cm). Intercropping of (M2+S2) results in highest plant height (252.36 cm) and intercropping of (M1+S1) (247.75 cm) even for 8% slope. At 90 DAS is significantly highest at lowest slope 2% (290.57 cm) followed by 5% (286.33 cm) and 8% (283.13 cm) shown in Fig. 3 (a). The plant height of maize found to be highest (290.87 cm) in when cultivated intercropping (M2+S2) and lowest (287.35 cm) when intercropping (M1+S1) at 2% slope shown in Fig. 3 (b). Same trend has been observed for 5% slope i.e. intercropping of (M2+S2) highest plant height (286.33 cm) and lowest intercropping of (M1+S1) (284.45 cm). Intercropping of (M2+S2) results in highest plant height (283.13 cm) and intercropping of (M1+S1) (281.44 cm) even for 8% slope. Among different cropping patterns, intercropping of (M2+S2) is significantly superior in terms of plant height (M) and intercropping (M1+S1) at 2, 5 and 8% slopes.

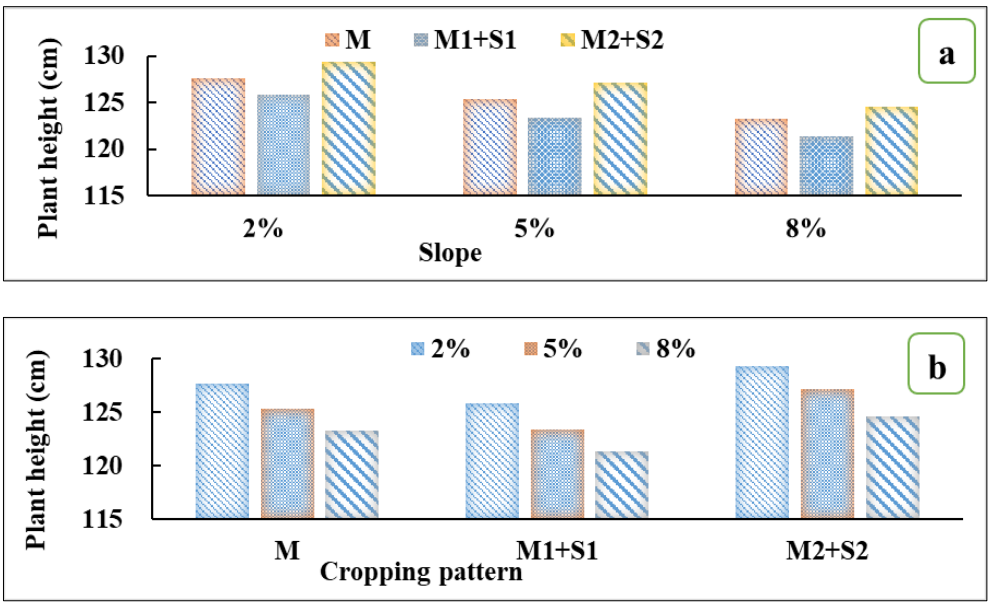

Fig 1: Effect of different land slopes and different cropping patterns on plant height at 30 DAS of maize

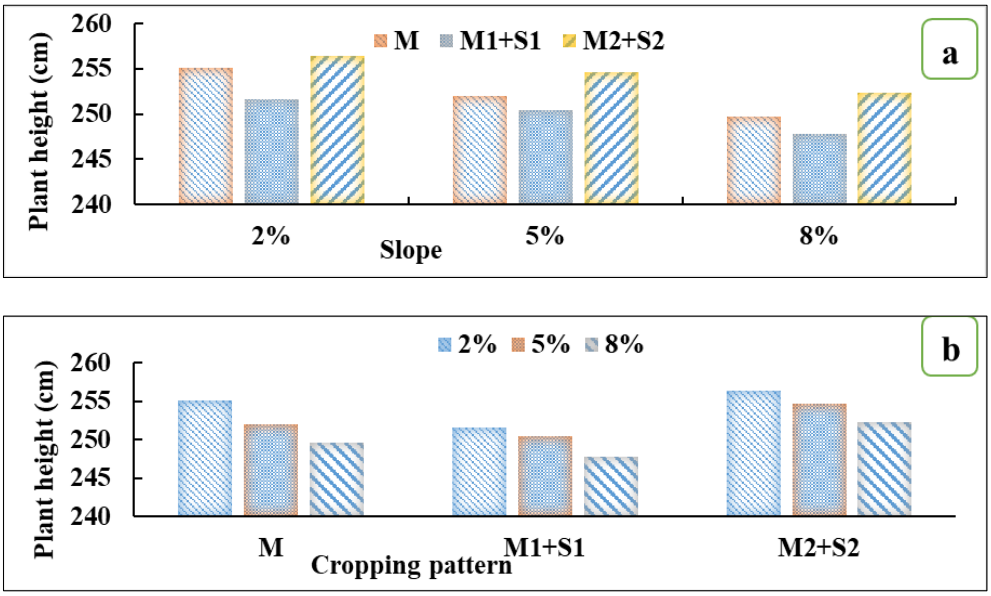

Fig 2: Effect of different land slopes and different cropping patterns on plant height at 60 DAS of maize

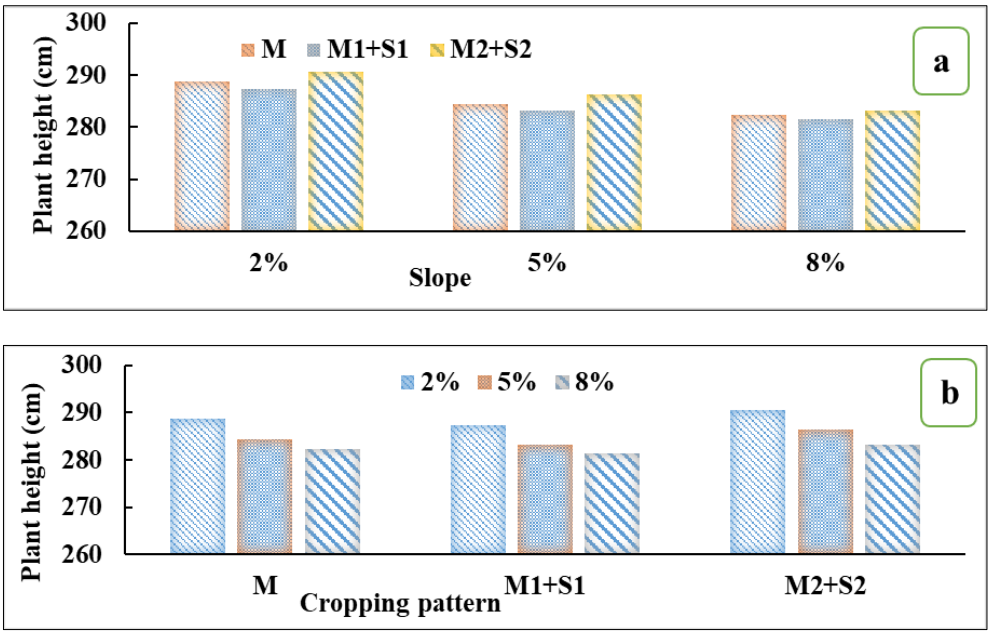

Fig 3: Effect of different land slopes and different cropping patterns on plant height at 90 DAS of maize

In the year 2020, soybean plant height at 30 DAS is significantly highest at lowest slope 2% (34.05 cm) followed by 5% (33.06 cm) and 8% (31.97 cm) shown in Fig. 4 (a). The plant height of soybean found to be highest (34.05 cm) in when cultivated intercropping (M2+S2) and lowest (33.02 cm) when intercropping (M1+S1) at 2% slope shown in Fig. 4 (b). Same trend has been observed for 5% slope i.e. intercropping of (M2+S2) highest plant height (33.06 cm) and lowest intercropping of (M1+S1) (31.67 cm). Intercropping of (M2+S2) results in highest plant height (31.97 cm) and intercropping of (M1+S1) (29.54 cm) even for 8% slope. At 60 DAS is significantly highest at lowest slope 2% (80.50 cm) followed by 5% (78.63 cm) and 8% (76.47 cm) shown in Fig. 5 (a). The plant height of maize found to be highest (80.50 cm) in when cultivated intercropping (M2+S2) and lowest (78.07 cm) when intercropping (M1+S1) at 2% slope shown in Fig. 5 (b). Same trend has been observed for 5% slope i.e. intercropping of (M2+S2) highest plant height (78.63 cm) and lowest intercropping of (M1+S1) (75.52 cm). Intercropping of (M2+S2) results in highest plant height (76.47 cm) and intercropping of (M1+S1) (73.43 cm) even for 8% slope. At 90 DAS is significantly highest at lowest slope 2% (107.33 cm) followed by 5% (103.30 cm) and 8% (100.27 cm) shown in Fig. 6 (a). Same trend has been observed for 5% slope i.e. intercropping of (M2+S2) highest plant height (103.30 cm) and lowest intercropping of (M1+S1) (101.27 cm). Intercropping of (M2+S2) results in highest plant height (100.27 cm) and intercropping of (M1+S1) (98.37 cm) even for 8% slope. Among different cropping patterns, intercropping of (M2+S2) is significantly superior in terms of plant height (M) and intercropping (M1+S1) at 2, 5 and 8% slopes.

Plant height maize and soybean after 30, 60, 90 days found to be decreasing with the increase in land slopes and also for the intercropping of two rows of maize and soybean followed by sole maize and intercropping of one row of maize and soybean for both the years i.e. 2020. The cropping pattern of intercropping of M2+S2 with 2% slope outperformed to the other treatment in terms of highest plant height at all the date of observations.

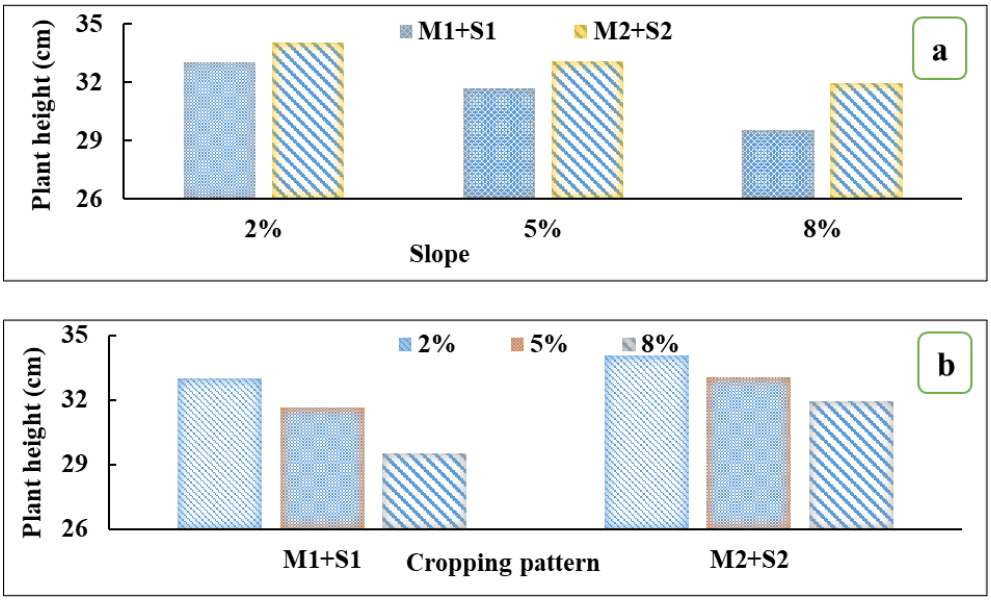

Fig 4: Effect of different land slopes and different cropping pattern on plant height at 30 DAS of soybean

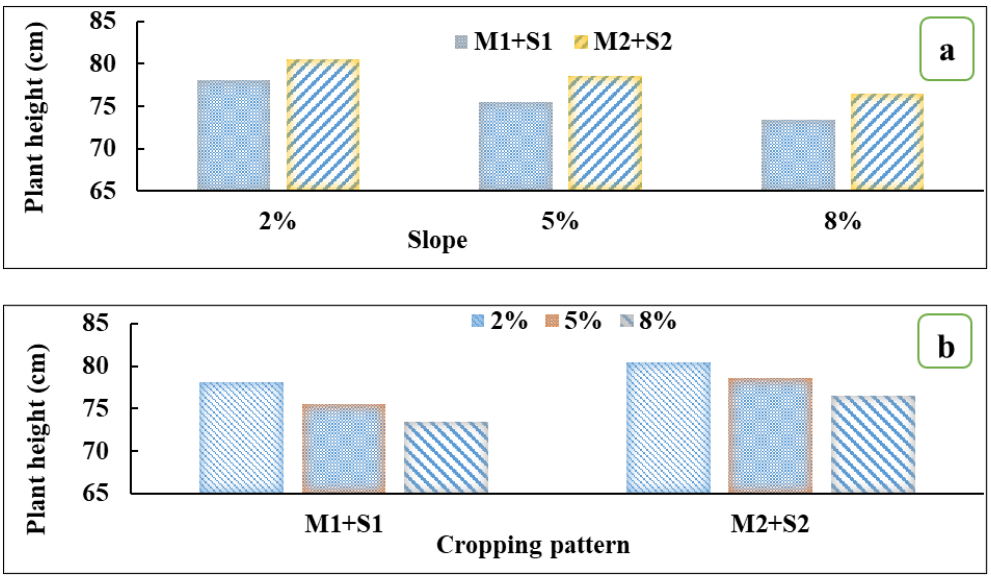

Fig 5: Effect of different land slopes and different cropping pattern on plant height at 60 DAS of soybean

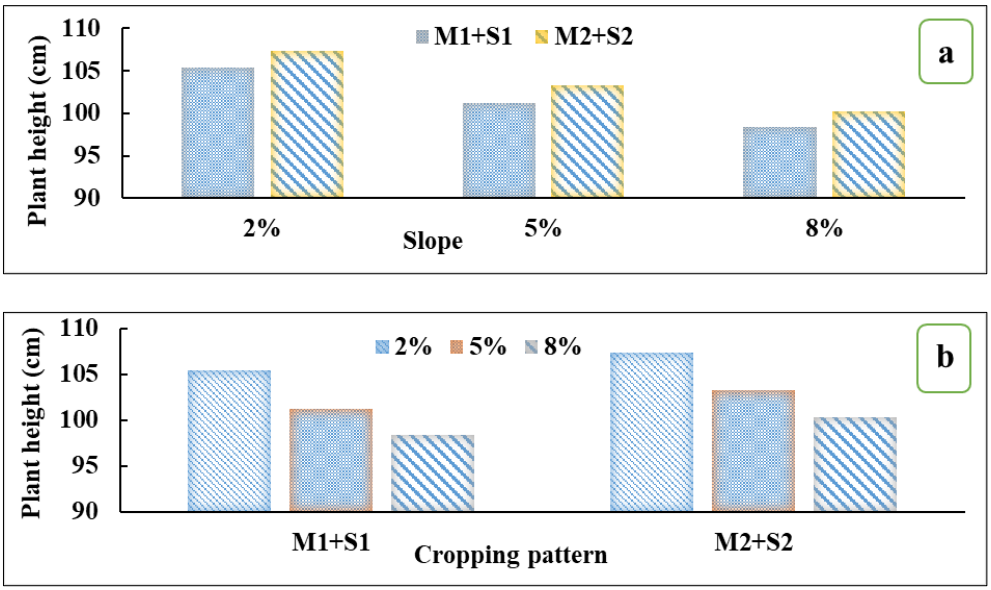

Fig 6: Effect of different land slopes and different cropping pattern on plant height at 90 DAS of soybean

Grains Yield

In the year 2020, grains yield of maize is significantly maximum at lowest slope 2% (40.87 q/ha) followed by 5% (40.37 q/ha) and 8% (40.14 q/ha) shown in Fig. 7 (a). Among different cropping patterns, sole maize is significantly superior in terms of grain yield of maize (40.87 t/ha) followed by intercropping of one row of maize and soybean (M1+S1) (30.57 q/ha) and intercropping of two rows of maize and soybean (M2+S2) (20.87 q/ha) at 2% slope shown in Fig. 7 (b). Same trend has been observed for 5% slope i.e. sole maize (M) is significantly superior in terms of grain yield of maize (4.37 q/ha) followed by intercropping of one row of maize and soybean (M1+S1) (30.47 q/ha) and intercropping of two rows of maize and soybean (M2+S2) (20.56 q/ha). Intercropping of two sole maize (M) results in highest grain yield of maize (40.14 q/ha) followed by intercropping of one row of maize and soybean (M1+S1) (20.90 q/ha) and intercropping of two rows of maize and soybean (M2+S2) (20.42 t/ha) at 8% slope.

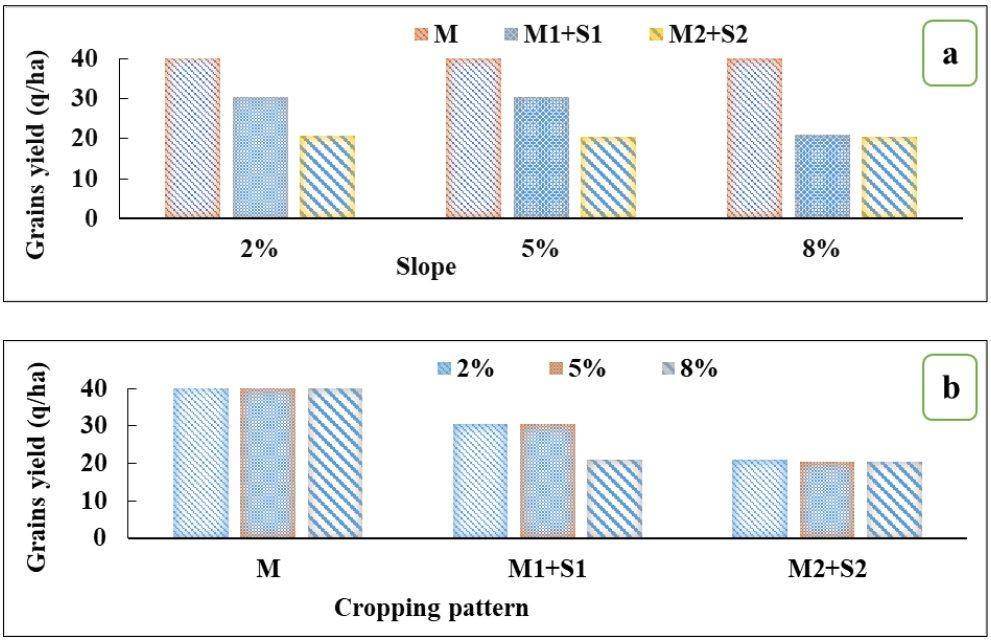

Fig 7: Effect different land slopes and of different land slopes on grain yield of maize

In the year 2020, grains yield of soybean is significantly maximum at lowest slope 2% (10.85 q/ha) followed by 5% (10.69 q/ha) and 8% (10.62 q/ha) shown in Fig. 8 (a). Among different cropping patterns, intercropping of two rows of maize and soybean is significantly superior in terms of grains yield of soybean (M2+S2) (10.85 q/ha) followed by intercropping of one row of maize and soybean (M1+S1) (10.59 q/ha) and at 2% slope shown in Fig. 8. (b). same trend has been observed for 5% slope i.e. intercropping of two rows of maize and soybean (M2+S2) is significantly superior in terms of grains yield (10.69 q/ha) followed by intercropping of one row of maize and soybean (M1+S1) (10.51 q/ha). Intercropping of two rows of maize and soybean (M2+S2) results in maximum grains yield of soybean (M2+S2) (10.62 q/ha) followed by intercropping of one row of maize and soybean (M1+S1) (10.42 q/ha) and at 8% slope.

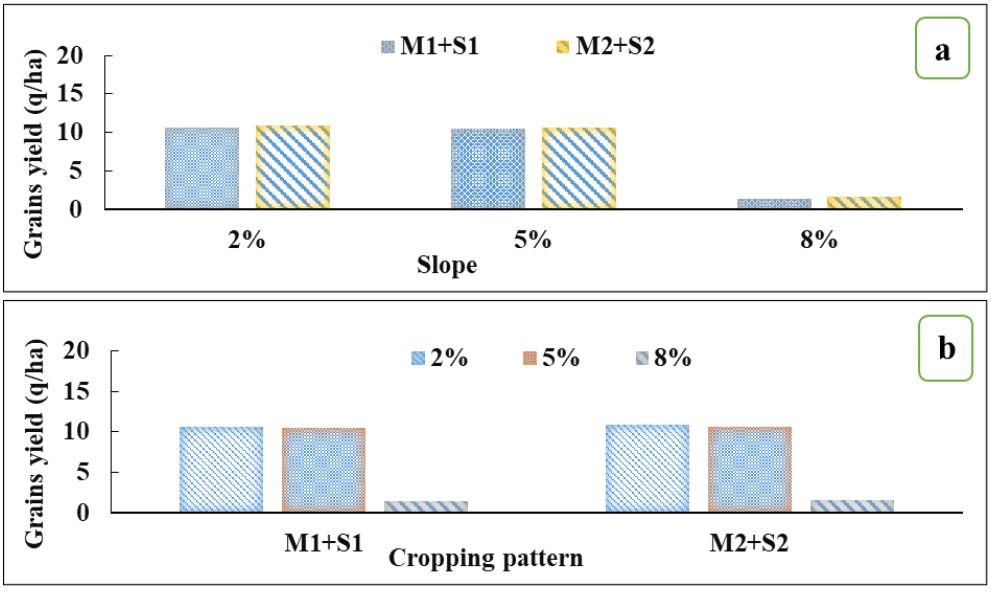

Fig 8: Effect different land slopes and of different land slopes on grain yield of soybean

Conclusions

Two rows of maize and soybean resulted in the maximum crop growth and yield attributes followed by sole maize and intercropping of one row of maize and soybean for all land slopes. The growth of the maize and soybean was found to be decreasing with the increase in land slopes for all cropping systems.

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