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Influence of Maize-Legume Intercropping System on Growth and Productivity of Crops

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ABSTRACT

Intercropping has multifaceted benefits such as yield enhancement, more efficient use of resource, resource conservation, soil health improvement, crop diversification and superior ecosystem services and agricultural sustainability. Maize (*Zea mays* L.), the queen of cereals, is planted with wide row spacing and so it offers the scope of intercropping. Considering the benefits of cereal-legume association, an experiment on maize-legume intercropping system was conducted during summer season of 2018 at Bagusala Farm Centurion University of Technology and Management, Gajapati district, Odisha. The experiment was laid out in randomized complete block design and the treatments were comprised of ten cropping systems. Paired row sowing of hybrid maize was done with a spacing of 80 cm/30 cm × 25 cm in sole maize. Pure stand of legumes, i.e., green gram, groundnut and black gram were sown with 30 cm × 10 cm spacing. As per the treatments, legumes were sown in between two pairs of maize. The data revealed that sole maize produced taller plants than intercropped maize in sole of the treatments. Similarly, more dry matter accumulation was noted with sole maize compared to intercropped maize, but from a unit area maize + groundnut (2:2) produced significantly more dry matter than pure stand of maize. Sole maize yielded more than intercropped maize, however, extra yield obtained in intercropping black gram and groundnut (2:2) was quite satisfactory that indicated advantage of intercropping system.

Keywords: Maize, legumes, intercropping, plant height, dry matter accumulation, yield

The present-day global agriculture is facing a tremendous pressure to continuous population growth, threat of climate change, shrinkage of farmland, depletion and pollution of water resource, changed consumer demand (Hossain *et al.* 2021; Zaman *et al.* 2017; Maitra *et al.* 2018). In the countries like India where a major portion of the farmers belong to the small and marginal groups, engagement of family workforce throughout the year, production of enough foods with nutritional quality and enhancement of livelihood are further great challenges to them. Under these consequences, there is a felt need for maximization of productivity from unit area and greater utilization of resources. In this regard intercropping has enough potential to increase crop yield and farm income from a unit area with superior land use efficiency (Maitra *et al.* 1999, 2000; Gitari *et al.* 2020). Intercropping is actually an age-old cropping system where two or more crops are grown simultaneously in the same filed (Willey, 1979; Maitra, 2020). Moreover, intercropping is recognized for using less inputs, namely, chemical fertilizer and pesticides and thus produces environmentally safe food in a sustainable manner (Maitra and Gitari, 2020; Duvvada and Maitra, 2020). In intercropping, the component crops use the same resource differently, they show

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complementarity and, in this way, collectively they produce more than the yield generally obtained when they are grown individually in a unit area. Further, intercropping results in various benefits such as yield enhancement, more efficient use of resource, resource conservation, soil health improvement, crop diversification and superior ecosystem services and agricultural sustainability. In other words, it may be stated that intercropping potentially facilitate poverty alleviation, hunger reduction and provision of healthy foods to small farmers and biodiversity enhancement covering some Sustainable Development Goals (SDGs) such as SDG 1, SDG 2, SDG 3 and SDG 15, respectively (UN, 2021).

For adoption of intercropping system that too with additive series of arrangement, it is better to choose widely row-spaced crops (Maitra *et al.* 2020; Manasa *et al.* 2020) and maize (*Zea mays* L.) is considered as a suitable crop in this regard (Panda *et al.* 2021). In India, maize occupied 9.2 million hectares with an average productivity of 2965 kg/ha and production of 27.8 million t (IIMR, 2021). In Odisha, expansion of maize area is observed, particularly in southern part of the state (Maitra *et al.* 2019). Presently, maize is grown 2.5 lakh ha with a productivity of 2886 kg/ha (Odisha Agricultural Statistics, 2020). Considering the above, an experiment was conducted to obtain the growth performance and productivity of maize in south Odisha conditions.

MATERIALS AND METHODS

Experimental site

A field trial was carried out at Bagusala farm (23°39′ N latitude, 87°42′ E longitude) of Centurion University of Technology and Management, Paralakhemundi, Odisha under tropical climatic conditions during the summer season of 2018.

Soil type

Soil samples from experimental site were collected at randomly (0-30 cm depth) before starting the preparatory cultivation. The composite samples were analysed for physical and chemical properties by standard methods and the results are furnished below in Table 1. The results revealed that the soil was clay loamy in texture, slightly acidic, low in organic carbon and available nitrogen, medium in available phosphorus and available potassium.

Agro-meteorological conditions

The agro-meteorological conditions such as weekly mean maximum and minimum temperatures, relative humidity and rainfall recorded at meteorological station of Centurion University of Technology and Management, Paralakhemundi were presented in Fig. 1. The weekly mean maximum and mean minimum temperatures during the crop period ranged from 28.4° to 45.8°C and 14.4° to 26.5°C,

Table 1: Physico-chemical properties of experimental soil

Particulars	Value	Method of analysis
		Physical analysis
Sand (%)	71.50	Bouyoucos Hydrometer method (Piper, 1950)
Silt (%)	16.20	
Clay (%)	12.30	
Textural class	Clay loam	
		Chemical analysis
Soil reaction (pH)	6.2	Determined by pH meter in 1:2.5 ratio of soil–water suspension (Jackson, 1973)
Organic carbon (%)	0.45	Walkley and Black's modified method (Jackson, 1973)
Available N (kg/ha)	78.4	Alkaline permanganate method (Subbaiah and Asija, 1956)
Available P (kg/ha)	20.6	Bray's method (Bray and Kurtz, 1945)
Available K (kg/ha)	128.4	Neutral ammonium acetate method using flame photometer (Jackson, 1973)

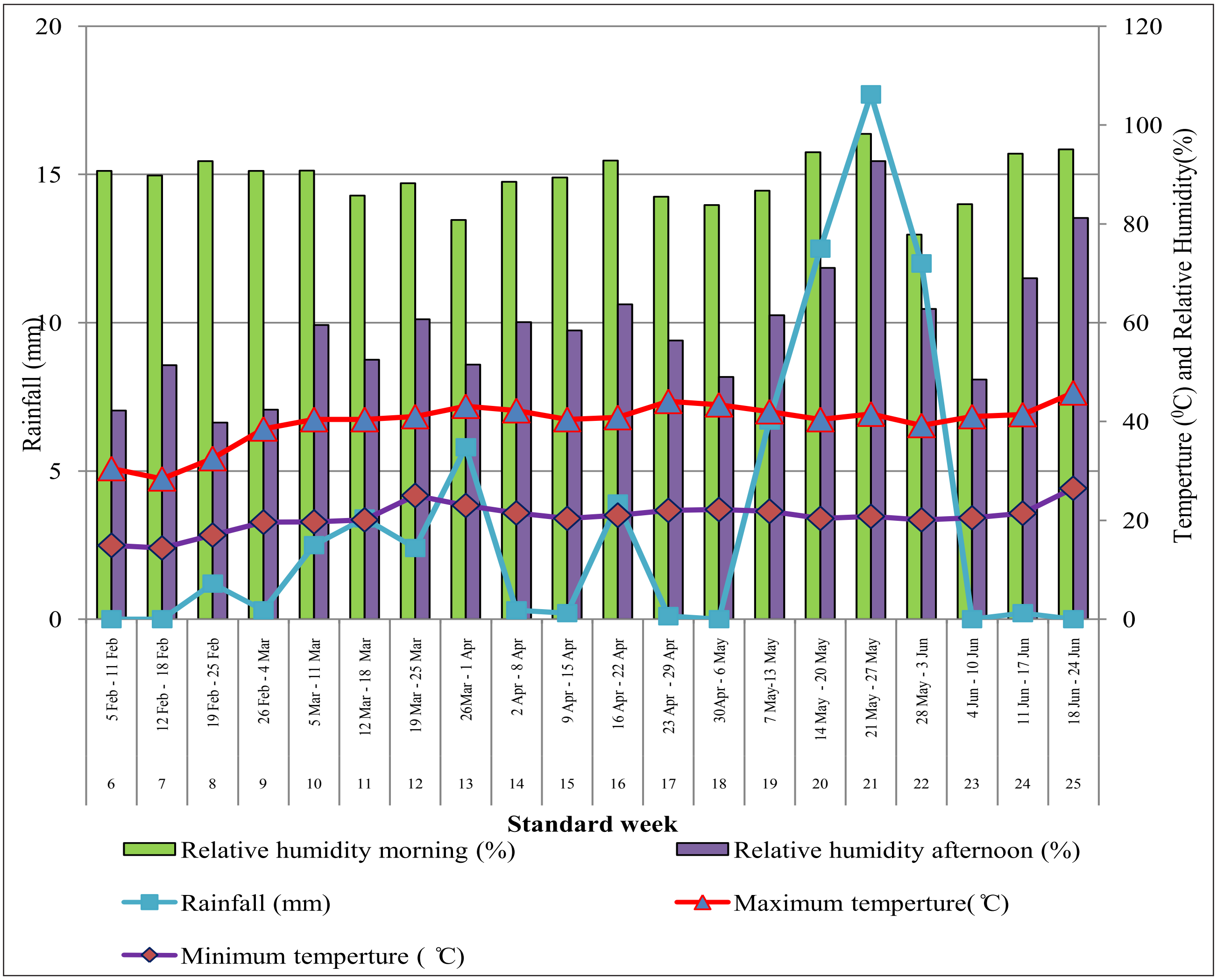

Fig. 1: Agro-meteorological parameters of the location during the crop period

respectively. The weekly mean relative humidity during crop period ranged from 88.36 percent to 56.9 percent. The crops received 69.2 mm of rain during their cycle.

Experimental details

The field trial was laid out in a Randomized Complete Block Design (RCBD) comprised of 10 treatments and replicated thrice. The net plot size was of 5.0 m × 4.0 m size. The treatments were T_1 : sole maize, T_2 : sole green gram, T_3 : sole groundnut, T_4 : sole black gram, T_5: maize + green gram (2:1), T_6 : maize + groundnut (2:1), T_7 : maize + black gram (2:1), T_8 : maize + green gram (2:2), T_9 : maize + groundnut (2:2) and T_{10} : maize + black gram (2:2).

Crop management

A recommended fertilizer of @ 120:60:60 kg $N:P_2O_5:K_2O$ ha^{-1} was applied to maize and 20:40:20 kg $N:P_2O_5:K_2O$ ha^{-1} was given to legumes in sole cropping. However in mixed stands, the recommended dose of fertilizer for maize (i.e., 120:60:60 kg $N:P_2O_5:K_2O$ ha^{-1}) was provided. In case of sole maize and maize + legume treatments, half dose of nitrogen and full quantity of phosphorus and potassium were applied in basal dose in every treatment, but all fertilizers were applied as basal in pure stands of legumes, namely, green gram, black gram and groundnut. The remaining portion of N fertilizer was top-dressed to sole maize and maize + legume treatments at knee height stage of maize. Maize hybrid 'Kaveri 50' was considered and for legume varieties, green gram 'IPM 02-03', groundnut 'K6' and black gram, 'PU 31' were selected. Spacing adopted for paired row hybrid maize (under both of sole and intercropping) was

30 cm/ 80 cm × 25 cm, however, pure stand of legumes, i.e., green gram, groundnut and black gram were sown with 30 cm × 10 cm spacing (Fig. 2). In intercropped treatments, legumes were sown in 1 or 2 rows in between two pairs of maize as per the treatments. There was mild attack of borers in maize and legumes and Chloropyriphos (20% EC) was sprayed at the rate of 2 ml per litre of water during crop growth stage (25 DAS) and pests were controlled. Hand weeding was done twice at 15 and 30 days after sowing. To raise the crops successfully five irrigations were provided.

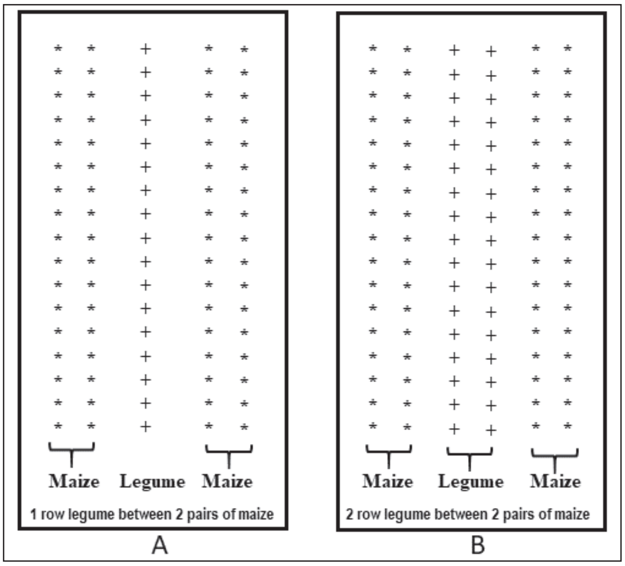

Fig. 2: Planting geometry of **(A)** maize paired row and legume (2:1) and **(B)** maize paired row and legume (2:2)

Statistical analysis

The experimental data were analysed statistically by using analysis of variance (ANOVA). The standard error of means (SEm±) and critical difference at 5% probability level of significance (CD, $p \leq 0.05$) (Panse and Sukhatme, 1985). In case of legumes, statistical analysis was not done for some parameters because of dissimilarity in growth habit and population. The Excel software (Microsoft Office Home and Student version 2019-en-us, Microsoft Inc., Redmond, Washington, USA) was used for statistical analysis and drawing graphs and figures.

RESULTS AND DISCUSSION

Growth parameters

Growth parameters of maize and legumes, namely, plant height and dry matter accumulation in sole as well as intercropping were recorded, analyzed statistically and presented in the Tables 2 and 3.

Plant height

The height of the maize plants recorded at 30 DAS clearly showed that there was significant difference among the treatments (Table 2). Sole maize (T_1) produced the tallest plants (55.2cm) at the same growth stage and the treatment was significantly superior than T_5: maize **+** green gram (2:1), T_6: maize + groundnut (2:1), T_7: maize + black gram (2:1) and T_{10}: maize + black gram (2:2). However, sole maize remained statistically at par with T_8: maize + green gram (2:2) and T_9: maize + groundnut (2:2). Maximum plant height of maize was associated with sole maize (T_1) at 60DAS and it showed significant difference among the treatments. Tallest maize plants were observed in sole maize (163.7 cm) at the same growth stage and it was significantly superior to T_5: maize + green gram (2:1), T_8: maize + green gram (2:2), T_{10}: maize + black gram (2:2). However sole maize remained statistically at par with T_6: maize + groundnut (2:1), T_7: maize + black gram (2:1) and T_9: maize + groundnut (2:2). Similarly plant height of maize recorded at harvest also clearly expressed significant difference among the treatments. Sole maize (T_1) produced the tallest plants (230.4 cm) and it was significantly superior to T_5: maize + green gram (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2) and T_{10} maize + black gram (2:2).

However, sole maize remained statistically at par with T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:1) in exhibiting the plant height. The plant height of maize was increased progressively with the increase in crop age. There was significant difference among the treatments in enhancement of plant height of maize at vegetative as well as at harvest stage. At all the growth stages, sole maize recorded the maximum plant height than intercropped maize and it is probably due to no competition faced by sole maize, whereas intercropped maize treatments were in association with legumes and competed for resources favorable for growth (Maitra *et al.* 2001; 2019). The results corroborate the findings of Mandal *et al.* (2014) and Rajeshkumar *et al.* (2018).

In case of plant height of legumes, very close values were noted in sole and intercropping with maize.

Table 2: Effect of intercropping system on plant height of maize and legume at different growth stages

Treatments	Plant height of maize (cm)			Plant height of legumes (cm)		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
T_1 Sole Maize	55.2	163.7	230.4			
T_2 Sole Green gram				19.2	25.6	27.2
T_3 Sole Groundnut				13.4	36.5	58.1
T_4 Sole Black gram				21.5	32.3	38.6
T_5 Maize + green gram (2:1)	48.2	132.8	210.6	20.1	26.6	28.1
T_6 Maize + groundnut (2:1)	51.6	158.9	225.2	15.2	38.7	56.8
T_7 Maize + black gram (2:1)	51.8	155.6	213.6	21.9	33.2	38.5
T_8 Maize + green gram (2:2)	53.6	147.3	215.4	19.6	26.3	27.9
T_9 Maize + groundnut (2:2)	53.6	158.6	226.2	14.6	37.8	56.1
T_{10} Maize + black gram (2:2)	51.7	149.6	216.1	22.6	32.5	37.6
SEm ±	1.00	2.72	4.16	NA	NA	NA
CD (P=0.05)	3.08	8.39	12.52	NA	NA	NA

NA = Not analysed; DAS = Days after sowing.

Table 3: Effect of intercropping system on dry matter accumulation by maize and legumes

Treatments	Dry matter accumulation at harvest (g/plant)		(g/m²)
	Maize	Legume	Combined
T_1 Sole Maize	176.12		1402
T_2 Sole Green gram		6.07	261
T_3 Sole Groundnut		11.46	344
T_4 Sole Black gram		6.93	217
T_5 Maize + green gram (2:1)	141.94	6.12	1170 (1132+38)
T_6 Maize + groundnut (2:1)	164.16	11.73	1380 (1301+79)
T_7 Maize + black gram (2:1)	158.14	6.84	1304 (1251+53)
T_8 Maize + green gram (2:2)	152.23	6.14	1272 (1202+70)
T_9 Maize + groundnut (2:2)	171.92	11.58	1483 (1342+141)
T_{10} Maize + black gram (2:2)	160.12	6.76	1364 (1262+102)
SEm ±	3.39	NA	25.4
CD (P=0.05)	10.42	NA	78.1

NA = Not analysed; DAS = Days after sowing.

Green gram in association with maize both in 2:1 and 2:2 proportions expressed slightly more plant height than pure stand of green gram at different growth stages. Intercropped groundnut showed more pant height than sole groundnut at 30 and 60 DAS, but at harvest sole groundnut registered taller plants. Plant height of black gram was also same as noted in groundnut. Such variation of plant height was probably complementarity among the crops and as summer crops legumes preferred partial shade, but optimum light for their growth. The results are in similarity with the findings of Ummed Singh *et al*. (2008).

Dry matter accumulation

The maximum accumulation of dry matter (Table 3) was found with T_1: sole maize during harvest stage, which was on par with $T_{9:}$ maize + groundnut (2:2). Further, sole maize (T_1) produced significantly more dry matter than $T_{5:}$ maize + green gram (2:1), T_6 maize + groundnut (2:1), T_7: maize + blackgram (2:1), $T_{8:}$ maize + greengram (2:2) and $T_{10:}$ maize + blackgram (2:2). Though there was no variation in plant population of maize between its pure stand and intercropped treatments, probably due to inter-species competition under presence of legumes maize expressed comparatively inferior dry matter accumulation as both the species shared nutrients and resources from the common pool (Manasa *et al.* 2018; Maitra *et al.* 2020; 2021). Earlier researchers also recorded similar type of observation in maize-based intercropping (Mandal *et al.* 2014; Raza *et al.* 2019).

At harvest stage, different legumes produced almost a similar dry matter per plant in sole and intercropped treatments. As the legumes are of different species and having variation in physiological and morphological characteristics, they are not analysed statistically. However, combined dry matter production per unit area was calculated and presented (Table 3). Maize + groundnut (2:2) resulted in the maximum combined dry matter production and the treatment was significantly superior to all other treatments inclusive of sole maize. Sole maize produced significantly more dry matter than intercropping maize + green gram (2:1), maize + black gram (2:1) and maize + green gram (2:2). Further, sole maize was statistically at par with maize + groundnut (2:1) and maize + black gram (2:2). Such differences were noted because of duration of crops and biomass production capability of legume species (Sarkar *et al.* 2000; Maitra *et al.* 2001). Moreover, inter-species competition might influence dry matter accumulation. The results are in conformity with the findings of Alom *et al.* (2010).

Yield of crops

Grain yield of maize was significantly influenced by maize + legume intercropping system (Fig. 3 and 4). Highest grain yield was observed with T_1, sole maize (5668 kg ha^{-1}) and it was significantly superior to T_5: maize + green gram (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2), T_{10}: maize + black gram (2:2). However, maize yield recorded in the treatment sole maize (T_1) was on par with T_6: maize + groundnut (2:1) and T_9: maize + groundnut (2:2). Earlier Pandey *et al.* (1999) observed similar results as sole maize produced more yield than intercropped maize and such result was probably due to inter species competition in intercropping. Stover yield of maize was also influenced by maize + legume intercropping system. Maximum Stover yield of maize was recorded with T_1: sole maize (8164.2 kg ha^{-1}), however, it being statistically at par with T_9: maize + groundnut (2:2) produced significantly more straw yield than T_5: maize + green gram (2:1), T_6: maize + groundnut (2:1), T_7: maize + black gram (2:1), T_8: maize + green gram (2:2) and T_{10}: maize + black gram (2:2). The results corroborate with the findings of Rajeshkumar *et al.* (2018). In case of legumes, sole legumes recorded maximum grain/ pod yields because of their plant stand compared to 1 or 2 rows of legumes in maize paired rows. However, the extra yield was obtained

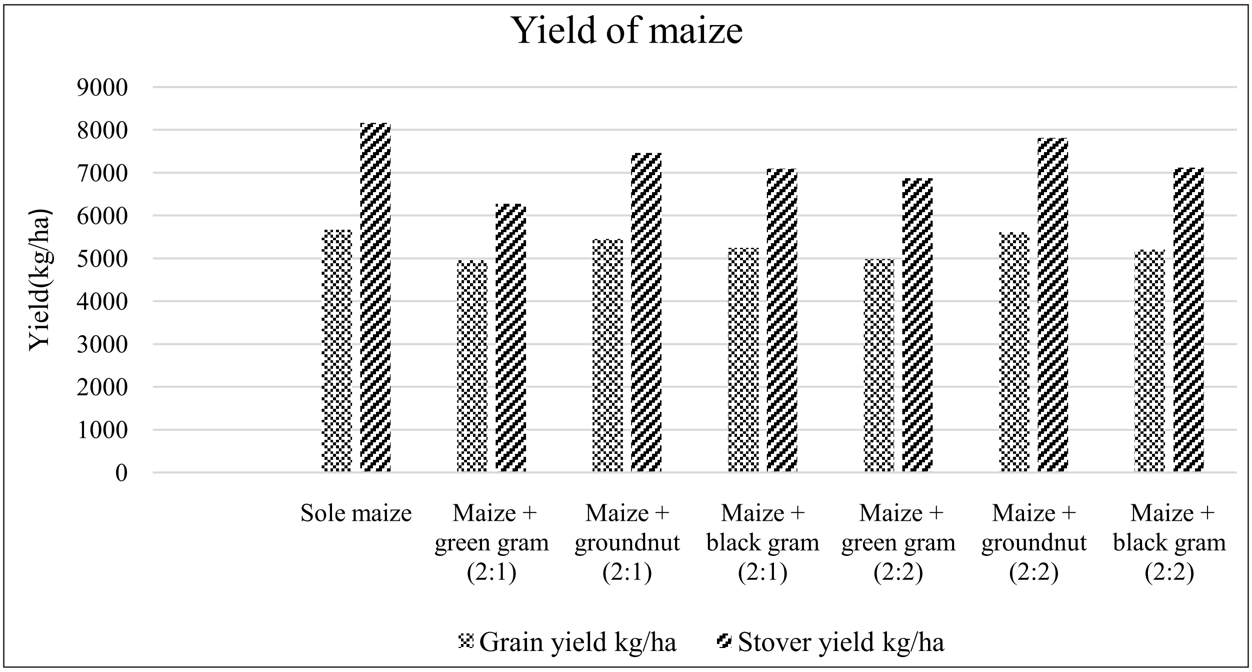

Fig. 3: Grain and stover yield of maize as influenced by sole and intercropping system

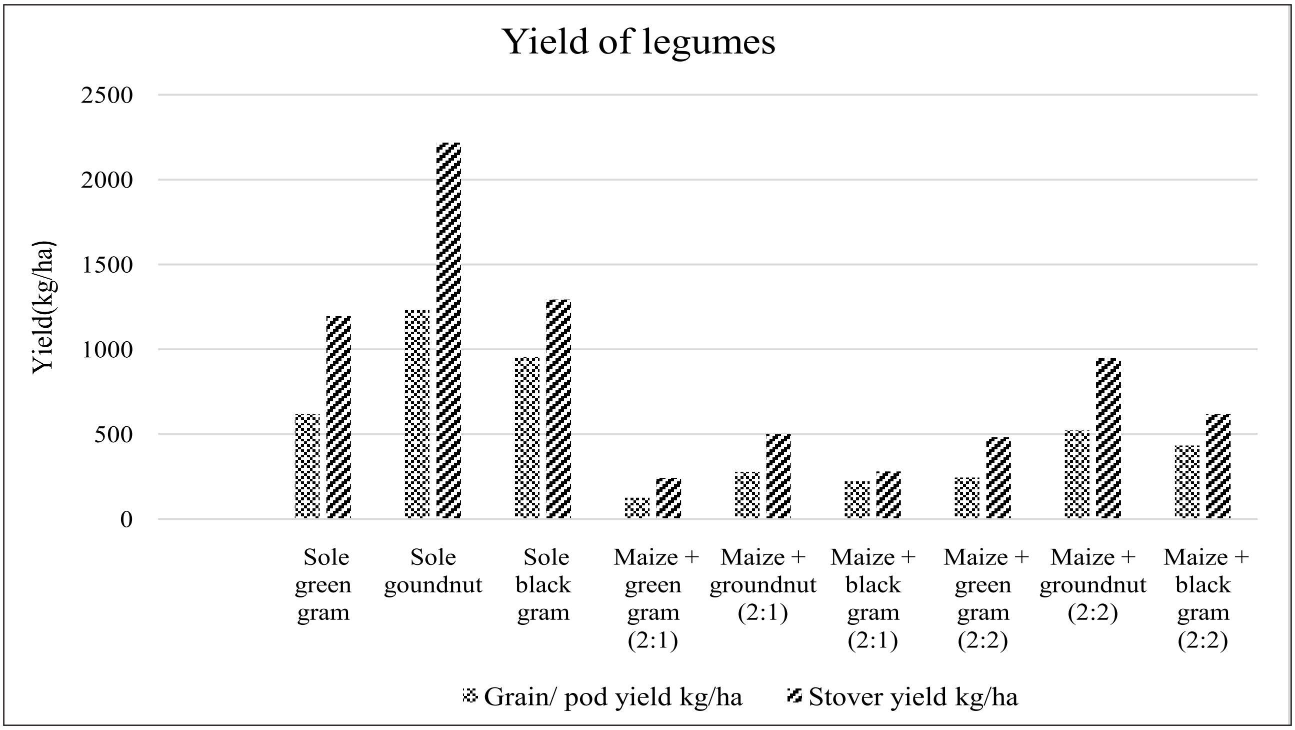

Fig. 4: Grain and stover yield of legumes as influenced by sole and intercropping system

in intercropping black gram and groundnut with 2:2 ratio that clearly indicated advantage of the intercropping system. The results are in conformity with the finding of Mandal *et al*. (2014).

CONCLUSION

As maize is widely spaced crops, intercropping can be adopted preferably with legumes to ensure multiple benefits of cereal-legume association. In the additive series of intercropping, maize got its desired population as compared to pure stand; thus, intercropped maize exhibited growth parameters and yield close to its pure stand and paired row geometry of planting provided enough scope to the intercropped legumes to express satisfactory growth and productivity probably due to temporal and spatial complementary effect. Higher dry matter production is synonymous to better utilization of land, soil moisture, sunlight and atmospheric carbon dioxide. Intercropping maize + groundnut at 2:2 and maize with blackgram at 2:2 was noted to perform superior to other intercropping combinations and sole cropping. The current study indicates that intercropping maize + groundnut at 2:2 ratio and maize + blackgram at 2:2 ratio can be chosen in south Odisha conditions during summer for efficient land utilization and better growth of crops.

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