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EVALUATION OF VARIOUS MAIZE BASED INTERCROPPING SYSTEM

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SUMMARY

A field experiment was conducted at CCS HAU, Hisar in randomized block design with thirteen treatments and replicated thrice to evaluate the efficiency of maize based intercropping systems by taking green gram, urdbean, groundnut and okra in two different proportions (planting geometries). Intercropping of maize with different crops (groundnut, urdbean, okra, green gram) was observed more profitable in terms of Land equivalent ratio (LER) as compared to sole planting. Okra crop was found most suitable and compatible intercrop for intercropping in maize. In terms of planting geometries tested for intercropping, paired row planting of maize at 45:60 cm along with two rows of intercropping between two pairs was found more efficient and profitable as compared to 1:1 row pattern of maize +intercrop. Among all the intercropping treatments, paired row maize (45:60 cm)+ two rows of okra recorded higher LER (1.54) and maize equivalent yield (10324 kg/ha) which were 54.0 and 69.7 percent higher than sole maize crop, respectively. Maize seed yield was observed highest with green gram intercropping in both paired row planting and 1 : 1 planting geometry while, equivalent yield was observed maximum with okra based intercropping system in both planting geometry.

Key words : Maize, intercropping, LER, MEY

Livestock is the main source of livelihood for the population residing in rural areas having small and marginal land areas for crop production. India has 520 million herd (livestock population) and Indian cattle produces far below the global average (Anonymous, 2020). India holds first rank in milk production by virtue of high livestock population not productivity. The major hurdles in high productivity of livestock are deficit fodder amount, lower quality of fodder and low genetic potential of breeds. The deficit of crude protein and total digestible nutrients (TDN) in India is about 24.6 and 19.9 per cent, respectively (Anonymous, 2020). On an average, 80- 90 per cent of fodder demands for livestock are currently obtained from fodder crops. Cereals crops since centuries have been known for their higher productivity when compared to other crops. Maize is an important cereal crop across the world with its grain as well as fodder production for humans and livestock. It is highly popular fodder crop in summers and shows high yield potential (Kumar *et al*., 2019). It ranks third in the world after wheat and rice among cereal crops (Arya *et al.*, 2015 and 2020). It is grown in tropical to temperate regions of the word due to higher adaptability and has multiple uses from direct consumption by human and livestock to industrial processed products (Kumar *et al.*, 2020). High quality grain and fodder production in enormous amount gave it the title of "Queen of Cereals" and "King of Fodder". Maize is highly preferred over sorghum as it do not contain toxins like HCN in sorghum and can be fed to livestock at any stage of crop growth and so presents a safe fodder source for the animals (Kumar *et al.*, 2016 and 2022). It is less water requiring and high water use efficient as well as productive crop when compared to crops like rice (Shweta *et al*., 2020 and 2022). Presently, India is facing the harmful effects of intensive cultivation since after the green revolution such as stagnated crop productivity, soil health degradation and environmental pollution (Matson *et al*., 1997; Wittwer *et al*., 2017). The reduced biodiversity with intensive cropping is a severe issue as it causes serious imbalance in the ecosystem homeostasis which is harmful for the whole civilization (Tilman *et a*l., 2002; *Guo et al*., 2010; Liu *et al*., 2013). It emphasizes the need to diversify the system by combine cultivation of two or more crops belonging to the different families such as cereals with legumes.

Crop combination should be selected that they don't have adverse effect on each other instead complement or supplement each other. Intercropping is defined as the ecological planting pattern where two or more than two crops are grown altogether on the same piece of land helping in efficient use of available resources to attain sustainable production with a view to guarantee food security (Kumar *et al.*, 2020). Legume based component crops are preferred more in intercropping due to their ability to fix nitrogen with nodules and improving the soil physical, chemical and biological properties by continuous addition of organic matter during their growth period (Kheroar and Patra, 2013). Also, legumes are mostly short statured and bind soil particles tightly with their roots thus avoiding the water and wind erosion. Legume like pigeon pea is known as biological plough due to its high rooting depth. Due to less nutrient requirements and short growing period, they offer minimal competition as well as great opportunities to be combined with cereal crops and inclusion in intercropping systems (Sanginga *et al.*, 2002). Shetty *et al*. (1995) explained major advantages like flexibility, profit maximization, soil conservation and maintenance, risk minimization from crop failure and better resource use efficiency for farmers to adopt intercropping. Keeping all the facts in view, the present study was undertaken to find a suitable maize based intercropping system to ensure fodder and feed availability. Okra, Urd bean, green gram and groundnut were taken as intercrop in the experiment.

MATERIALS AND METHODS

A field experiment was conducted at CCS HAU, Hisar, Haryana during *Kharif* 2019. The site experiences semi-arid climatic conditions and is located at 29°10' N latitude and 75°46' E longitude at an elevation of 215.2 m above mean sea level. The mean weekly weather data during crop season *Kharif,* 2019 as depicted in Fig. 1 was recorded from meteorological observatory of CCS HAU, Hisar. Maximum and minimum temperature recorded during the cropping period was 38.6°C and 23.7 °C. During the harvest season, a total of 244.2 mm of rainfall was received and seven rainy days were observed. Sunshine hours varied from 0.7 to 8.2 hrs. The experiment was laid in randomized block design (RBD) with thirteen treatments and three replications resulting in a total of thirteen plots. The treatments were: Sole maize (T_1), Sole mungbean (T_2), Sole Okra (T_3), Sole groundnut (T_4), Sole urdbean (T_5), Maize + Okra (1:1) (T_6), Maize + urdbean(1:1) (T_7), Maize + groundnut (1:1) (T_8), Maize + green gram(1:1) (T_9), Paired row maize (45:60 cm) + 2 rows of Okra (T_{10}), Paired row maize (45:60 cm) + 2 rows of urdbean (T_{11}), Paired row maize (45:60 cm) + 2 rows of groundnut (T_{12}) and Paired row maize (45:60 cm) + 2 rows of green gram (T_{13}). The varieties used were HQPM-1 (Maize), MH 421 (Mung bean), UH-1 (Urd), HNG-810 (Groundnut) and Versa Uphar (Okra). The soil of the field was slightly alkaline (pH= 8.0), low in organic carbon and available nitrogen, medium in available phosphorus, highly rich with available potassium and texture was sandy loam. The crop was grown according to the package of practice for maize crop recommended by CCSHAU, Hisar. Agrometeorolgical indices during the main crop period as given in Fig. 2 were calculated using the following formulas:

Accumulated Growing Degree Days (AGDD) = $\sum_{ds}^{dh}[(\mathbf{T_{max} + T_{min}})/2 - \mathbf{Tb}$

Helio Thermal Units (HTU) = GDD*D

Accumulated Helio Thermal Units (AHTU) = $\sum_{ds}^{dh}[(\mathbf{T - T_b})\mathbf{D}] - \mathbf{T_b}$

Photo Thermal Units = GDD*DL

Accumulated Photo Thermal Units (APTU) = $\sum_{ds}^{dh}[(\mathbf{T - T_b})\mathbf{DL}] - \mathbf{T_b}$

where, T_{max} = Daily maximum temperature (°C)
T_{min} = Daily minimum temperature (°C)
T_b = Base temperature (10°C)
ds = Date of emergence
dh = Date of harvest
D = Hours of Bright sunshine
DL= Day Length

The harvesting of intercrops was done manually followed by manual harvesting and mechanical threshing of maize crop. Data on yield and yield attributes of maize as well as intercrop was recorded and statistically analyzed with OPSTAT software. The F variance test was used to compare the mean of two treatments. Different indices of intercropping were calculated to study economic viability and feasibility of the intercropping systems as suggested by Pal *et al*. (1985); Willey and Rao (1980); Padhi *et al*. (2010).

RESULTS AND DISCUSSION

Maize yield was significantly reduced due to intercropping. Lowest yield was observed with groundnut (2240 kg ha^{-1}) in paired row cropping and maximum with green gram in one to one ratio. It may be due to less growing duration of mung bean crop

TABLE 1
Seed yield, Land equivalent ratio and maize equivalent yield as observed under different intercropping system

Treatments	Seed yield (kg/ha)		Land Equivalent Ratio (LER)			Maize Equivalent yield (kg/ha)
	Maize	Inter	Maize	Inter	System	
Sole maize (T_1)	3125	-	-	-	-	3125
Sole groundnut (T_2)	-	1000	-	-	-	2851
Sole urdbean (T_3)	-	527	-	-	-	1709
Sole Okra (T_4)	-	11500	-	-	-	12432
Sole green gram (T_5)	-	945	-	-	-	3676
Maize + groundnut (1:1) (T_6)	2366	605	0.72	0.61	1.33	1725
Maize + urdbean (1+1) (T_7)	2475	145	0.76	0.28	1.03	470
Maize + okra (1+1) (T_8)	2410	8500	0.74	0.74	1.48	9189
Maize + green gram (1+1) (T_9)	2600	426	0.79	0.45	1.25	1657
Paired row maize (45:60 cm) + 2 rows of groundnut (T_{10})	2240	748	0.68	0.75	1.43	2133
Paired row maize (45:60 cm) + 2 rows of urdbean (T_{11})	2330	170	0.71	0.32	1.03	551
Paired row maize (45:60 cm) + 2 rows of okra (T_{12})	2315	9550	0.71	0.83	1.54	10324
Paired row maize (45:60 cm) + 2 rows of green gram (T_{13})	2370	560	0.72	0.59	1.32	2178
C. D. (p=0.05)	128	-	0.03	0.03	0.04	174

compared to others as well as less nutrient requirement. Yield of intercrops were reduced significantly when compared to their respective solo cropping. The results are in confirmation with the findings of Sultana *et al.* (2013) who observed that yield attributes and yield are reduced of both maize and legumes in intercropping when compared to their sole cropping. Yield reduction due to intercropping varied from 16.80- 24.28 per cent in 1:1 intercropping and 24.16- 28.32 per cent in paired row intercropping. Lower yield reduction of maize in 1:1 intercropping is due to more area available for its cultivation and also less competition. Similar results of high maize yield with green gram compared to groundnut and urd bean were also reported by Ezung *et al.* (2022). Intercropping of maize with different crops (Groundnut, urdbean, okra, green gram) was observed more profitable in terms of LER compared to sole planting (Table 1). Land equivalent ratio was observed highest with okra intercropping both in one to one ratio and paired row intercropping. Land equivalent ratio is used to workout the efficiency of an intercropping system (Seran and Brintha, 2009b). The reason behind land equivalent ratio more than one is observed due to the combined effect of better resource utilization and increased plant density in intercropping (Willey and Osiru, 1972; Fisher, 1977a and b). Tsubo *et al.* (2005) also reported legume-cereal intercropping as more production one than their sole cropping. Maize equivalent yield was observed highest with the okra intercropping both in 1:1 and 1:2 intercropping.

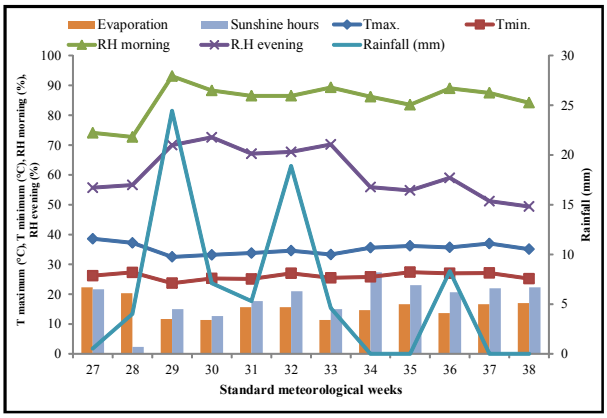

Fig. 1. Weekly meteorological data of crop season.

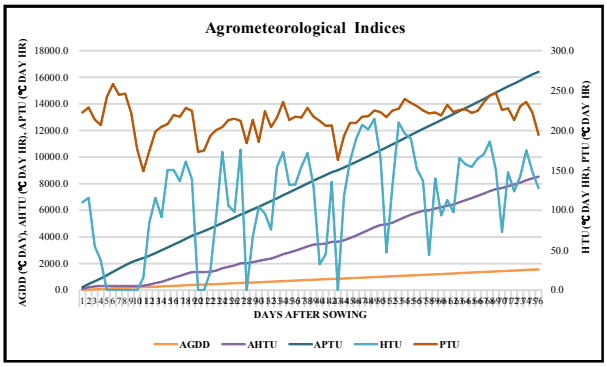

Fig. 2. Agrometeorological indices during the crop period.

CONCLUSION

From one year field study, it can be concluded that among all the intercrops tested, okra was found most suitable and compatible for intercropping in maize. Out of planting geometries tested for intercropping, paired row planting of maize at 45:60 cm along with two rows of intercropping between two pairs was found more profitable compared to 1:1

row pattern of maize + intercrop. Among all the intercropping treatments, paired row maize (45:60 cm) + two rows of okra recorded higher LER (1.54) and maize equivalent yield (10324 kg/ha) which were 54.0 and 69.7 percent higher than sole maize.

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