Row Spacing and Mulching Effect on Growth and Nutrient Uptake of Maize (*Zea mays* L.) under Guava (*Psidium guajava* L.) based Agri-horti System

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Abstract

Observation was made on "Row spacing and mulching effect on growth and nutrient uptake of maize (*Zea mays* L.) under guava *(Psidium guajava* L.) based agri-horticutural system at Agronomy farm of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha Mirzapur, Uttar Pradesh (India) during kharif season of 2012-13. The site of experimental field is situated at 25º 10' North latitude, 82º37' East longitudes, 427 meters above mean sea level in the semi-arid eastern plain zone. The field experiment was conducting under seven years old guava based agri-horti system with split plot design having three levels of row spacing (30 cm, 45 cm and 60 cm) and four level of mulching (No mulch, paddy straw mulch, green weed mulch and dust mulch). The height, girth and canopy of the tree in seven years old guava were up to 3.15 m, 21.50 cm and 5.90 m, respectively. Paddy straw mulch recorded significantly higher plant height (215.06 cm) with all other treatments. However, lower plant height (207.07 cm) was noticed with control treatment (M_0). Paddy straw mulch got significantly more number of leave plant^{-1} (12.71) over the dust mulch and no mulch at 80 DAS but at par with green weed mulch (12.47) and significantly higher dry matter accumulation plant^{-1} (65.33 g) with 60 cm row spacing at harvest stage. The maximum nitrogen, phosphorus and potassium uptake by grain and stover by maize was observed in the 45 cm row spacing with paddy straw mulch.

KEYWORDS: *agri-horti system, growth, guava, maize, mulch, nutrient uptake.*

INTRODUCTION

Like wheat and rice, maize (*Zea mays* L.) is also used as fasten food in many countries and ranks third most essential cereal crop in India. Uttar Pradesh (U.P.), where every sixth Indian lives, contributes to 20.37 percent of the country's agricultural production (GOI, 2005). If Indian agriculture has to prosper, the situation in Uttar Pradesh has to improve in all sectors including crop diversification (Kareemulla *et al.*, 2005; Saxena, 2000). Agroforestry is an ideal scientific approach for eco-restoration of degraded lands and sustainable management. Numerous studies have described the beneficial effects of agroforestry systems in long-term soil productivity and sustainability (Kirby and Potvin, 2007; Nair *et al.*, 2009) but the magnitude of the beneficial effects may vary with a number of site specific factors and attributes of associated tree species.

Increased nutrient inputs and recycling, reduction in nutrient losses, and improved soil physical properties are all characteristics of agroforestry systems as compared to sole cropping systems under hilly ecosystems (Nair, 1993). Udawatta *et al*. (2008) have reported improved soil aggregate stability, nutrients availability and microbial activity under agroforestry systems in comparison to other land use systems. Tree species has the potential to increase the crop productivity however, the effects are inconsistent. Several studies have shown increased or decreased crop productivity under certain circumstances. For instance, intercultural, weed control, tillage, mulching etc. applied to the crop also benefits the trees in Agroforestry system (Schroth, 1995). Maize occupies an important position in the world economy and trade as a food, feed and industrial grain crop. To meet the growing demand, per hectare yield of maize is estimated to rise to 2.36 tons as against 1.7 tons currently, by the end of 2020. Appropriate tillage and mulch practices are used to conserve soil moisture and increase the yield of crops. Crop residues at the soil surface act as shade which serves as a vapor barrier against moisture losses from the soil, causing slow surface runoff. Rathore *et al.* (1998) have reported that more water conserves in the soil profile during the early growth period with straw mulch than without it. Subsequent uptake of conserved soil moisture, moderated plant water status, soil temperature and soil mechanical resistance, leading to better root growth and higher grain yields. Applications of crop residue mulches increase soil organic carbon contents (Saroa and Lal, 2003). Mulches are loose coverings or sheet of organic material that is placed on the soil surface. It helps to preserve moisture, repression of weeds, improving soil consistency, insect pest assault and guard roots from severe temperature. Organic mulches improve soil, pleasant soil temperature, hinder weed growth, lessen soil moisture evaporation and improve the visual qualities of landscapes. A good layer of mulch will help to preserve moisture and suppress weed germination. Mulch enhanced root and increased maize grain yield by increasing plant N-uptake efficiency, falling N discharge losses and improving nutrient preservation over un-mulched plots (Aulakh *et al*., 2000). Straw mulch is practiced successfully in many advanced countries like America and Australia where it improved many soil aspect as support soil moisture retention ability, prevent wind erosion, control of weeds, nutrient return and soil structure improvement. Keeping this in view, the present investigation was planned to determine the effect of different row spacing techniques in combination with mulch application on growth and nutrient uptake behavior of maize under guava based agri-horti system

MATERIALS AND METHODS

The study was conducted in six year old guava based agri-horti system which was planted in August 2007 at a spacing of 7.0 x 7.0 meter at Agronomy farm of Rajiv Gandhi South Campus Banaras Hindu University Barkachha Mirzapur Uttar Pradesh (India) during Kharif season of 2012-13, which is situated in *Vindhyan* region of district Mirzapur, 25º10’ latitude, 82º37’ longitude and altitude of 427 meters above mean sea level. This region comes under agro-climatic zone III A (semi-arid eastern plain zone) and the region is mostly rain fed. Maximum temperature in summer is as high as 39.65˚C and minimum temperature in winter falls below 8.12˚C. The annual rainfall of locality was 774.7 mm in year 2012.

Experiment was laid out in split plot design having three replications. Soil analysis was done before the sowing of the crop and after the harvesting of the crop. The net plot size were 3.9 m x 3.0 m for 30 cm row spacing, 3.60 m X 3.0 m for 45 cm row spacing and 3.0 m x 3.0 m for 60 cm row spacing, respectively. The experiment was comprised of three row spacing methods viz. 30 cm row spacing (S_1), 45 cm row spacing (S_2), 60 cm row spacing (S_3) and four different mulches viz. No mulch (M_0), Paddy straw mulch (M_1), Green weed mulch (M_2) and Intercultural operation (M_3). Maize hybrid MRM 3777 was used as an experimental material. Standard procedures were adopted for recording growth, yield and quality parameters. Mulching material (No mulch, paddy straw mulch and green weed mulch) was applied in the field after the sowing of the maize. The significance of the treatment effect was judged with the help of 'F' test (Variance ratio). The difference of the treatments mean was tested using critical difference (C. D.) at 5% level of probability (Gomez and Gomez, 1976). Standard procedures were adopted for recording the data of agronomic and yield related parameters. The height, canopy spread and collar girth of the guava tree was measured with the help of measuring tape. First of all the spread of crown in east-west and north-south direction was marked with a wooden stick at last shoot tip of each direction. Crown diameter obtained with using following calculation:

Canopy Spread = $(D_1+D_2)/2$

where, D_1 = Crown length in east-west direction

D_2 = Crown length in north-south direction

RESULTS AND DISCUSSION

Growth parameters of guava tree. The height, girth and canopy of the tree in seven years old guava were up to 3.15 m, 21.50 cm and 5.90 m, respectively (Table 1). Statistically non significant differences observed in the mentioned growth parameters of guava might be due to shorter growth phase of maize which could not realized the noticeable changes in the limited observation period.

Table 1. Growth Parameters of guava tree

Fruit Tree (Guava)	Height (m)	Canopy diameter (m)	Tree girth (cm)
At the sowing time	3.15	5.90	21.50
At harvest time	3.65	6.32	21.59
C.D. (p = 0.05)	NS	NS	NS

NS- Not Significant

Plant Height (cm). The plant height was influenced by row spacing and it was found significant at 60, 80 and at harvest DAS crop growth stages. It was observed that plant height increased with decreasing in row spacing. Row spacing 30 cm produced significantly taller plant (210.70 cm) than 60 cm row spacing but at par with the row spacing at harvest . Straw mulch recorded significantly higher plant height (215.06 cm) with all other treatments (Table 2). However, lower plant height (207.07 cm) was noticed with control treatment (M_0). Interaction between row spacing and mulching for plant height was maximum recorded by paddy straw mulch x 30 cm row spacing and significantly superior over all other interaction levels at harvest (Table 3). Similar results were also reported by Khurshid *et al*. (2006).

Number of leaves plant^{-1}. Number of leaves plant^{-1}as influenced by row spacing was not found significant. While due to mulching found significant at all the stage of crop growth (Table 2 & 3). Paddy straw mulch got significantly more number of leave plant^{-1} (12.71) over the dust mulch and no mulch at 80 DAS but at par with green weed mulch (12.47).

This type of response may due to mulch inter row plant competition under closer row spacing for space, moisture, nutrients, light, water and other environmental resources. These results are consistent with those of Wicks *et al.,* (1994) and Lal (1995) who reported that early maize growth was retarded by higher mulch levels as a result of reduced soil temperature but maize grew taller and faster under greater mulch levels subsequently due to increased soil moisture and adequate temperature which stimulated root development and growth. These results are also in consonance with Bhatt *et al.,* (2004), Khurshid *et al.,* (2006) that mulching with crop residue at the rate of 4 and 6 t/ha not only affected both physical and chemical properties of the soil but also maintained good grain yield.

Dry matter accumulation plant^{-1} (DMAP^{-1}). The highest dry matter accumulation per plant (59.22 g plant^{-1}) was recorded with the application of paddy straw mulch and the lowest (55.08 g plant^{-1}) was noticed with control Dry matter accumulation per plant was significantly increased with increased row spacing from 30 cm to 60 cm at all the crop stages while it was found significantly only 60 DAS and 80 DAS (Table 2). The maximum dry matter accumulation (59.63 g plant^{-1}) was found at 60 cm spacing. Interaction between row spacing and mulching for plant dry matter production, paddy straw mulch produced significantly higher dry matter accumulation plant^{-1} (65.33 g) with 60 cm row spacing at harvest stage (Table 3). This result is in close similarity with Sahoo and Panda (1999).

Grain yield (q ha^{-1}). Grain yield (q ha^{-1}) as influenced by row spacing and mulching were found significant. A close analysis of data revealed that 45 cm row spacing produced significantly higher grain yield (52.21 q ha^{-1}) over the 30 cm and 60 cm row spacing. Due to mulching treatments, grain yield significantly improved and highest grain yield (52.32 q ha^{-1}) was recorded with the application of paddy straw mulching and followed by green weed mulch (50.11 q ha^{-1}) and dust mulch (49.38 q ha^{-1}) and all the mulching treatments produced significantly higher grain yield than control (48.39 q ha^{-1}), however dust mulch and no mulch at par with each other (Table 2). These finding are in agreement with Amini *et al*. (2013), Gosavi and Bhagat (2009).

The interaction effect of row spacing and mulching for grain yield (q ha^{-1}) was found significant at each level of interaction. At level paddy straw mulch, interaction of paddy straw mulch with 60 cm row spacing was found significantly superior over others. Lower grain yield from living mulch and weedy check treatments might be due to heavy weed infestation and partial weed control as compared to hand weeding and black plastic mulch. These results for the mulches effect are in line with those of Maurya & Lal (1981) who reported that black plastic and straw mulches yielded more than un-mulched treatments and white plastic mulch. But increase in the final yield was not parallel to increase in the number of plants ha^{-1}, because of other factors like, increase plant competition and crowding stress etc., at higher plant populations. Akbar *et al.,* (1996) reported highest grain yield obtained from population of 100000 plants ha^{-1}. Grain yield increased with increasing plant population (Mudarres *et al.,* 1998; Bahadur *et al*., 1999; Dastfal *et al*., 1999), and Ahmad & Khan (2002).

Table 2. Effect of row spacing and mulching on growth attributes of maize under guava based agri-horti system

Treatment	Plant height (cm)			Number of leaves plant^{-1}			DMAP $^{-1}$			Yield (q ha^{-1})
Row Spacing	60 DAS	80 DAS	At harvest	60 DAS	80 DAS	At harvest	60 DAS	80 DAS	At harvest	
S_1 (30 cm)	195.50	207.12	210.70	11.20	12.18	8.10	49.74	52.21	54.54	47.05
S_2 (45 cm)	193.83	204.33	208.48	10.97	12.33	8.20	51.25	54.05	56.81	52.21
S_3 (60 cm)	186.72	201.12	205.75	10.50	12.42	8.28	52.89	57.09	59.63	50.08
SE	2.69	0.90	1.05	0.15	0.03	0.08	0.37	0.69	1.35	0.52
CD	10.56	3.53	4.11	NS	NS	NS	1.46	2.53	5.30	2.05
Mulches										
M_0 (No mulch)	181.62	196.16	201.07	10.73	12.00	7.88	49.63	52.51	55.08	48.39
M_1 (Paddy Straw Mulch)	201.27	211.74	215.06	11.42	12.71	8.56	53.62	57.44	59.22	52.32
M_2 (Green Weed Mulch)	197.96	207.07	210.62	10.80	12.47	8.26	51.42	54.58	59.04	50.11
M_3 (Dust Mulch)	187.22	201.78	206.49	10.60	12.07	8.08	50.49	53.27	54.63	49.32
SE±	1.87	1.30	0.91	0.16	0.08	0.10	0.43	0.57	1.05	0.32
C.D. (p = 0.05)	5.55	3.87	2.71	0.47	0.25	0.28	1.27	1.70	3.12	0.95
Interaction (SxM)	SIG	SIG	SIG	NS	NS	NS	NS	NS	SIG	SIG

DAS = Day after Sowing
NS = Not Significant

Nitrogen, Phosphorus and potassium uptake by Grain and Stover of maize (kg/ha)

Nitrogen, phosphorus and potassium uptake by grain and stover of maize as influenced by row spacing and mulching practices (Table 4). Nitrogen and phosphorus uptake by grains and stover in the 45 cm row spacing with paddy straw mulch (M_1) recorded significantly higher total nitrogen and phosphorus uptake (92.46 kg/ha) and (30.36 kg/ha) and potassium uptake by stover was maximum in compared to the grain. Highest potassium uptake was found with the application of paddy straw mulch (M_1) followed by green weed mulch (M_2), dust mulch (M_3) and no mulch (M_0). The results are in close conformity with the finding of Singh and Kumar (2009).

Table 3. Interaction effect of row spacing and mulching (At harvest time) on growth attributes and yield of maize under guava based agri-horti system

Treatments	Plant height (cm)			Dry matter accumulation plant^{-1}			Yield (q ha^{-1})		
	S_1 (30 cm)	S_2 (45 cm)	S_3 (60 cm)	S_1 (30 cm)	S_2 (45 cm)	S_3 (60 cm)	S_1 (30 cm)	S_2 (45 cm)	S_3 (60 cm)
M_0 (No mulch)	199.33	202.53	201.33	52.50	53.67	59.07	44.91	48.17	48.77
M_1 (Paddy Straw Mulch)	219.70	214.47	211.00	57.33	55.00	65.33	49.16	54.90	52.91
M_2 (Green Weed Mulch)	215.30	209.03	207.53	54.33	59.67	63.13	47.29	53.24	49.81
M_3 (Dust Mulch)	208.47	207.87	203.13	54.00	53.50	56.40	46.82	52.52	48.82
SE ±	1.57			1.82			0.55		
C.D (p = 0.05)	4.70			5.40			1.65		

Table 4. Influence of different treatments on uptake of N, P and K by grain and stover of maize (kg ha^{-1})

Treatment	Nutrient uptake by maize (kg ha^{-1})					
Row Spacing	N		P		K	
	Grain	Stover	Grain	Stover	Grain	Stover
S_1 (30 cm)	53.87	25.19	19.59	6.37	47.54	51.50
S_2 (45 cm)	63.36	29.10	22.25	8.11	54.83	56.47
S_3 (60 cm)	60.95	27.56	21.37	7.51	52.11	55.22
SE	0.59	0.63	0.32	0.16	1.05	0.58
CD	2.30	2.48	1.26	0.62	4.11	2.29
Mulches						
M_0 (No mulch)	52.82	23.29	19.15	6.08	47.73	52.36
M_1 (Paddy Straw Mulch)	68.52	30.75	22.78	8.69	55.80	57.10
M_2 (Green Weed Mulch)	60.29	28.16	21.61	7.66	52.04	54.86
M_3 (Dust Mulch)	55.95	26.94	20.75	6.88	50.39	53.27
SE ±	0.62	0.26	0.26	0.09	0.54	0.84
C.D. (p = 0.05)	1.85	0.77	0.78	0.27	1.61	2.49
Interaction (S x M)	NS	NS	NS	NS	NS	NS

CONCLUSION

This study confirms the valuable contribution of row spacing and mulching on growth and N, P, and K uptake by the maize. 45 cm row spacing and paddy-straw mulch being cheaper, more available and easier to lie, was proved to be more beneficial for soil moisture conservation and total uptake of nutrient.

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