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GROWTH AND YIELD OF MAIZE AS INFLUENCED BY MAIZE BASED INTERCROPPING SYSTEM FOR SOUTHERN DRY ZONE OF KARNATAKA

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ABSTRACT

A field experiment was carried out during *Kharif* season of 2013 at Zonal Agricultural Research Station, V. C. Farm, Mandya, Karnataka to study the performance of maize under maize based intercropping system for southern dry zone of Karnataka on its growth and yield. Treatments consisted of sole (maize) and intercrops (pigeonpea, soybean and field bean) at different row proportions. Paired row maize with pigeonpea at 45/75cm spacing (T_4) recorded significantly higher growth parameters (plant height, leaf area, total dry matter accumulation and crop growth rate), yield parameters (cob length, no. of rows per cob, weight of kernels per plant and kernel yield) and it was statistically on par with paired row maize with pigeonpea at 30/90cm spacing (T_1), paired row maize with soybean at 30/90cm spacing (T_2) and maize + pigeonpea at 2:1 row ratio (T_7). Maize equivalent yield was highest in paired row maize with soybean at 30/90cm spacing (9897 kg ha^{-1}) which was closely followed by paired row maize with pigeonpea at 45/75cm spacing (9863 kg ha^{-1}) and paired row maize with pigeonpea at 30/90cm spacing (9051 kg ha^{-1}). Thus, under Southern Transitional Zone of Karnataka pigeonpea can be a most compatible intercrop with maize.

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INTRODUCTION

The extent of cultivable land is gradually decreasing, mainly because of rapid urbanization and industrialization due to the global population explosion resulting in ever increasing pressure on cultivated land for food and commercial crops.Food supply is one of the most important problems the world is enduring nowadays; intercropping is used in many parts of the world for the production of food and feed crops (Carruthers *et al.,* 2000).One of the potential and novel opportunities to meet this demand is by scientific intercropping of pulses with cereals and other non legume companion crops which in turn increase the arable area under pulse crops and also have certain inbuilt advantage over pure cropping (Velayutham and Somasundaram, 2000). The main objective of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilizationof land resources and farming inputs including labours without reducing base crop yield (Marer *et al.,* 2007; Zhang *et al.,* 2007).Intercropping of cereals with legumes has been popular in tropics (Tsubo *et al.,* 2005) due to its advantages for soil conservation, lodging resistance (Anil *et al.,* 1998), weed control (Banik and Sharma, 2009), yield increment, high crude protein percentage and protein yield (Kariaga, 2004).

Legumes in maize based cropping systems are considered to be better alternatives for securing nitrogen economy and increasing yield of maize besides bonus yield, greater productivity per unit time and space and higher net returns of intercropping system over monoculture (Thayamini and Brintha, 2010) due to their differential rooting habit, differential growth, demand for resources, complementary interactions as brought by nitrogen fixation of legumes and legumes add enormous organic biomass (leaf, nodules, roots, etc.,). Maize is one such crop which provides opportunity for inclusion of intercrops because of its wider row spacing and plasticity of the crop to row spacing.Maize + legume intercropping was found moreproductive and remunerative compared to sole cropping and also it was a more productive system, less risky technology and intercropped soil surface remained moist during dry spell of 6-8 days (Kamanga *et al.,* 2010; Kumar *et al.,* 2008).

Farmers' field was noticed to have had the highest amount of vegetative biomass when legume crops are intercropped with maize (Amos *et al.,* 2010) and efforts have been made to identify suitable intercropping in maize (Zea mays L.) for various agro-climatic zones of Karnataka.Since, the research information is meager on paired row agro-techniques of maize based intercropping systemthe present investigation was carried out to study the performance of maize under maize based intercropping system on its growth and yieldin southern dry zone of Karnataka.

MATERIALS AND METHODS

A field experiment was conducted in Zonal Agricultural Research Station, V. C. Farm, Mandya, Karnataka during *kharif* 2013 which is situated between 11°30′ to

13⁰ 05′ North latitude and 76° 05′ to 77° 45′ East longitude with an altitude of 695 meters above mean sea level. It falls under the Region III and Southern Dry Zone of Karnataka (Zone VI).The soil of experimental site was sandy loam in texture, neutral in soil reaction (6.85) with low in organic carbon content (0.45 %) and available nitrogen (245.56), but medium level of available phosphorus (28.92kg ha^{-1}) and potassium (173.27kg ha^{-1}).The experiment was laid out in a randomized complete block design with thirteen treatments replicated thrice. Treatments comprised of T_1:Paired row maize intercropped with pigeonpea at 30/90cm spacing; T_2:Paired row maize intercropped with soybean at 30/90cmspacing;T_3: Paired row maize intercropped with field bean at 30/90cm spacing; T_4:Paired row maize intercropped with pigeonpea at 45/75cm spacing; T_5: Paired row maize intercropped with soybean at 45/75cm spacing; T_6: Paired row maize intercropped with field bean at 45/75cm spacing; T_7: Maize + pigeonpea (2:1); T_8: Maize + soybean (1:1); T_9: Maize + field bean (1:1); T_{10}: Sole maize; T_{11}: Sole pigeonpea; T_{12}: Sole soybean; T_{13}: Sole field bean. Out of thirteen treatments statistical analysis was done only from T_1 to T_{10} excluding T_{11}, T_{12} and T_{13} and hybrids/ varieties used were maize: HEMA (NAH 1137), pigeonpea: BRG-2,soybean: JS-335 and field bean: HA-4, which were sown in August 2013 according to the treatments. Farm yard manure was applied at the rate of 10 $tha^{-1}$to each plot three weeks prior to sowing.The recommended dose of fertilizer for maize (150 kg N, 75 kg P_2O_5 and 40 kg K_2O ha^{-1}), pigeonpea (25 kg N, 50 kg P_2O_5 and 25 kg K_2O ha^{-1}), soybean (30 kg N, 80 kg P_2O_5 and 38 kg K_2O ha^{-1}) and fieldbean (25 kg N, 50 kg P_2O_5 and 25 kg K_2O ha^{-1}) were applied in the form of urea, single super phosphate and muriate of potash as basal dose. In case of maize, 50 per cent of N was applied as basal and remaining dose of nitrogen (75 kg ha^{-1}) was applied as top dressing at 40 DAS. In case of intercropping treatments fertilizers were applied in proportionate to the sole optimum population for main and intercrops separately. The other management operations were done as per recommended package of practices for both main and intercrops. Growth and yield parameters were recorded as per standard procedures. Available N, P and K in Soil (Jackson, 1973) samples were analyzed following standard methods.Maize equivalent yield (MEY) was calculated on the basis of prevailing market prices of both maize and intercrops.

RESULTS AND DISCUSSION

Effect on growth parameters

Paired row maize intercropped with pigeonpea at 45/75cm spacing observed significantly higher plant height (214.6 cm), No. of leaves per plant (15.87) and leaf area (5580 cm^2 $plant^{-1}$). But it was on par with paired row maize intercropped with pigeonpea at 30/90cm spacing, paired row maize intercropped with soybean at 30/90cm spacing and maize + pigeonpea at 2:1 row proportion at harvest as compared to

Table 1: Growth parameters of maize as influenced by spacing and intercrops in maize based intercropping system

Treatments	Plant height (cm)	No. of leaves per plant	Leaf area(cm^2 $plant^{-1}$)	TDMA (g $plant^{-1}$)	CGR(g m^{-2} day^{-1})
T_1: PR-PP (30/90 cm)	209.4	15.50	5508	375.90	23.89
T_2: PR-SB (30/90 cm)	207.3	15.21	5462	365.87	23.47
T_3: PR-FB (30/90 cm)	175.1	13.50	4022	333.74	21.64
T_4: PR-PP (45/75 cm)	214.6	15.87	5580	390.83	24.82
T_5: PR-SB (45/75 cm)	192.2	14.49	4536	351.20	22.69
T_6: PR-FB (45/75 cm)	182.6	13.37	3584	338.96	21.89
T_7 : Maize + pigeonpea (2:1)	205.3	15.02	5303	358.73	23.11
T_8 : Maize + soybean (1:1)	188.6	13.84	4248	345.40	22.43
T_9 : Maize + field bean (1:1)	173.7	13.03	4509	323.19	21.05
T_{10}: Sole maize	172.4	12.96	3714	310.77	20.27
S.Em.+	6.41	0.67	484.35	5.87	0.38
CD at 5%	19.05	2.00	1439.09	17.43	1.13

Note: PR-PP: Paired row maize intercropped with pigeonpea; PR-SB: Paired row maize intercropped with soybean; PR-FB: Paired row maize intercropped with field bean; TDMA: Total dry matter accumulation; CGR: Crop growth rate

Table 2: Yield parameters and yield of maize as influenced by spacing and intercrops in maize based intercropping system

Treatments	Cob length (cm)	No. of rows per cob	Weight of kernels per plant (g)	100 kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1: PR-PP (30/90 cm)	15.6	16.83	168.70	32.03	8009	7293
T_2: PR-SB (30/90 cm)	15.4	16.60	163.63	31.50	7977	7127
T_3: PR-FB (30/90 cm)	13.7	14.00	136.69	29.67	6156	5506
T_4: PR-PP (45/75 cm)	16.2	17.57	174.18	34.93	8539	7831
T_5: PR-SB (45/75 cm)	14.8	14.97	156.07	30.50	7025	7610
T_6: PR-FB (45/75 cm)	14.0	14.33	143.46	30.00	6578	7673
T_7 : Maize + pigeonpea (2:1)	15.3	16.47	159.57	31.10	7720	7085
T_8 : Maize + soybean (1:1)	14.2	15.03	145.71	30.17	6842	6631
T_9 : Maize + field bean (1:1)	13.4	13.87	131.43	29.67	6727	6503
T_{10}: Sole maize	13.1	13.28	129.93	31.33	6656	6419
S.Em.+	0.68	0.71	8.36	1.45	423.81	440.14
CD at 5%	2.01	2.12	24.83	NS	1259.20	1307.73

Note: PR-PP: Paired row maize intercropped with pigeonpea; PR-SB: Paired row maize intercropped with soybean; PR-FB: Paired row maize intercropped with field bean; NS: Non Significant

Table 3: Maize Equivalent Yield (MEY) as influenced by spacing and intercrops in maize based paired row intercropping system

Treatments	Yield (kg ha^{-1}) a	b	MEY (kg ha^{-1})
T_1: PR-PP (30/90 cm)	8009	385	9050
T_2: PR-SB (30/90 cm)	7977	768	9897
T_3: PR-FB (30/90 cm)	6156	229	6917
T_4: PR-PP (45/75 cm)	8539	489	9863
T_5: PR-SB (45/75 cm)	7025	630	8584
T_6: PR-FB (45/75 cm)	6578	276	7495
T_7 : Maize + pigeonpea (2:1)	7720	311	8563
T_8 : Maize + soybean (1:1)	6842	600	8324
T_9 : Maize + field bean (1:1)	6727	190	7359
T_{10}: Sole maize	6656	-	6656
T_{11}: Sole pigeonpea	-	861	2331
T_{12}: Sole soybean	-	1559	3856
T_{13}: Sole field bean	-	190	3962
S.Em.+	NA	NA	405
CD at 5%	-	-	1182

Note: PR-PP: Paired row maize intercropped with pigeonpea; PR-SB: Paired row maize intercropped with soybean; PR-FB: Paired row maize intercropped with field bean; a: Maize yield; b: respective intercrop and sole crop; yield; NA: Not analysed

sole maize (Table 1). This may be due to better compatibility of row proportions and application of respective recommended dose ofnutrients to both the component crops which resulted in higher nutrient uptake by main crop of maize (Pritee Aswathy *et al.,* 2014; Jasbir Singh and Thenua, 2014).

Intercropped stands are known to extract more nutrients thansolid sole stands (Rao, 2004). As compared to sole maize significantly higher total dry matter accumulation (390.83g plant^{-1}) and crop growth rate (24.82 g m^{-2} day^{-1}) was recorded in paired row maize with pigeonpea at 45/75 cm spacing and was being on par with paired row maize with pigeonpea at 30/90 cm spacing and paired row maize with soybean at 30/90 cm spacing (Table 1). This might be due to better utilization of solar radiation and CO_2 as there was no competition with intercrop resulting in better N uptake and less weed infestation (Talukder *et al.,* 2003; Alam *et al.,* 2005; Alom *et al.,* 2010). Among legume-cereal intercropping system, the combination of maize + pigeonpea was considered to be highly suitable with a minimum competition for nutrients (Ghosh *et al.,* 2007).

Effect on yield and yield parameters

Yield and yield parameters were favourably influenced by maize based intercropping system (Table 2). Among treatments paired row maize intercropped with pigeonpea at 45/75cm spacing observed higher yield attributes such as cob length (16.2 cm), no. of rows per cob (17.57), weight of kernels per plant(174.18 g) and kernel yield (8539 kg ha^{-1}). But it was on par with paired row maize intercropped with pigeonpea at 30/90cm spacing, paired row maize intercropped with soybean at 30/90 cm spacing and maize + pigeonpea at 2:1 row proportion. However sole maize recorded lower yield attributes (Table 2). Higher stover yield was recorded in paired row maize with pigeonpea at 45/75 cm spacing (7831 ka ha^{-1}) as compared to sole maize (6419 kg ha^{-1}) and was being on par with paired row maize with pigeonpea at 30/90 cm spacing (7293 ka ha^{-1}) and maize + fieldbean at 1:1 row ratio (6503 ka ha^{-1}). This may be due to added higher growth and yield attributes along with better utilization of the available resources (Mandal *et al.,* 2014). Whereas 100 kernel weight of maize was not significantly influenced by treatments.The presence of pigeonpea in the paired row system probably had more synergistic effect and thereby maize crop in association with pigeonpea in pairedrow system reported comparable yield due to their differential maturation time adding to better utilization of area and time. Row arrangement, in contrast to arrangement of component crops within rows, may also influence the productivity of an intercropping system (Oseni and Aliyu, 2010).

All intercropping treatments showed more maize equivalent yield (MEY) than sole maize yield. This result proved the fact that maize with legume intercropping is more profitable than monocropping of maize (Table 3). MEY was higher in paired row maize with soybean at 30/90 cm spacing and it was closely followed by paired row maize with pigeonpea at 45/75 cm spacing and paired row maize with pigeonpea at 30/90 cm spacing compared to solemaize. Similar results were reported by Mandal *et al.,* 2014.Higher maize equivalent yield under intercropping systems was attributed toyield advantages achieved in intercroppingsystem(Marer*et al.,*2007). The difference in MEY was mainly as a consequence of differences in the yield of maize, additional component crop yield and price of individual component crops.

Comparatively lesser growth and yield parameters were observed in paired rows of maize with intercrops at 30/90 cm spacing as compared to 45/75 cm spacing. This might be attributed to more space made available to maize at 45/75 cm spacing with intercrops than at 30/90 cm spacing, which might have helped maize plant in exploitation of natural resources more efficiently and resulted into higher dry matter accumulation as also reported by Aravindkumar *et al.* (2004). Yield reductions in intercropping could also be associated to inter-specific competition for nutrients, moisture or space (Adaniyan *et al.,* 2007).

Regarding the performance of maize under maize based intercropping system pigeonpea would be the best combination for large scale adoption when planted in 45/75 cm spaced paired rows of maize in southern dry zone of Karnataka. Soybean + maize was the next best intercrop followed by field bean + maize.

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