Growth response of intercropped maize (*Zea mays* L.) and urdbean (*Vigna mungo* L.) under different planting patterns and nutrient management practices

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ABSTRACT : A field experiment was carried out at GBPUA&T, Pantnagar to study the influence of planting pattern and nutrient management on growth dynamics of intercropped maize (*Zea mays* L.) and urdbean (*Vigna mungo* L.). The experiment consisting of two intercropping planting pattern (single rows at 67.5 cm with 1+1 additive and paired rows at 45/90 cm with 2+2 additive), three fertilizer application methods (broadcast, furrow and side placement) and two levels of nitrogen in maize (75 and 100% of recommended) vis-à-vis the sole crops of maize and urdbean was conducted in a factorial RBD with three replications. Maize growth was not affected due to variation in planting patterns. Application of fertilizers in furrows and 100% recommended nitrogen dose (RND) in maize resulted in higher growth and better values of physiological parameters viz. plant height, shoot dry matter accumulation and LAI. Dry matter accumulation, LAI, CGR, and NAR of urdbean were found higher in paired row system compared to normal intercropping. Significant reduction in growth of intercropped urdbean was recorded over its sole crop. Grain yield of intercropped maize (3.57 t/ha) was statistically similar to its sole crop. Planting pattern did not affect maize grain yield but urdbean recorded significantly 19.5% higher grain yield under paired row system. Furrow and side placement methods were significantly superior to broadcast method with respect to maize grain yield by an advantage of 13.2 and 8.4%, respectively. Application of 100% RDN in maize resulted significantly 8.8% more grain yield than that of 75% RDN. The study indicated that there was negligible impact of intercropping on maize growth and urdbean showed better growth in paired row panting pattern.

Key words: Fertilizer, growth, maize, planting pattern, urdbean

Maize (*Zea mays* L.) is mainly grown during *kharif* season (July to September) in India and rotated with various crops like wheat, mustard, chickpea, potato, sugarcane, pea, etc. In north western plains zone of India continuous practice of cereal based cropping systems like rice- wheat and maize- wheat has created various problems like rising nutrient deficiencies, yield stagnation, build up of complicated weed flora, etc. To overcome such problems there is an immense need of modification in conventional cereal based system. Intercropping seems a good option for diversification of cropping system. Natural resources can be utilized more effectively under intercropping cropping systems than in the sole cropping systems (Li *et al.,* 2001). Incorporation of legumes in cropping system as intercrop helps in diversifying the system, enriches soil fertility and benefits the main cereal crop by minimizing weeds and supplementing its nitrogen demand. The deep and tap root system of legumes complement the shallow and fibrous root system of cereals leading to greater above ground and below ground adjustment in exploiting the rhizosphere as well as micro environment above the soil surface. One of the major concerns under cereal legume intercropping is shading of cereal crop in the underneath legume crop. Maize is a wide spaced crop and it can accommodate intercrop within the available interspace by adjusting the crop geometry. Pairing of maize rows can be further a good option to attain a better intercrop growth as shading effect of maize on associated crops is minimized (Rashid *et al.,* 2002). Fertilizer application is also one of the important considerations in cereal + legume intercropping because nutrients, particularly nitrogen top dressed to maize crop may revert reproductive growth of legume to vegetative growth and thus may reduce the grain yield of legume crop. Growth of different crops affected differently under intercropping systems which can be modified by using appropriate planting geometry and efficient fertilizer management practices. Paired row planting of maize along with proper placement of nutrients can overcome this problem by spatial difference in nutrient availability as the nitrogen is top dressed in intra-pair space of maize rows. Application of optimum dose of nutrients with appropriate method is considered as a key to success in increasing yield of any crop. The research findings have indicated that furrow application or side placement of fertilizers not only increases nutrient availability to growing plants but also reduces various losses which are associated with broadcasting over soil surface like sublimation, volatilization, leaching, etc. and also minimizes its negative impact on intercropped legume crop. Further, nitrogen fixed by legume crop not only fulfills its own requirement but also nourish companion crop under intercropping system hence, helps in nitrogen saving (Kumar *et al.*, 2003). The present study was conducted to analyze the influence of planting pattern and nutrient management on growth behavior of the maize and urdbean under intercropping system.

MATERIALS AND METHODS

The field experiment was carried out during *kharif* 2014 at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India. The soil of the experimental field was silty-clay-loam in texture, neutral in reaction (pH 7.4), high in organic carbon (0.79%), low in available N (203.4 kg/ha), high in available phosphorus (26.1 kg/ha) and medium in available potassium (234.2 kg/ha). A total of 14 treatments consisted of two intercropping patterns of maize and urdbean in additive manner *viz*. normal planting in 1+1 row ratio (at 67.5 cm rows) and paired row planting in 2+2 row ratio (at 45/90 cm); three methods of fertilizer application in maize *viz.* furrow application, side placement and broadcast and two levels of nitrogen in maize *viz*. 75 and 100% of recommended (120 kg/ha) along with sole crops of maize and urdbean were tested in factorial randomized block design with two extra treatments in three replications. The plots dimension was 5.4 m × 4.0 m. Sole crops of maize and urdbean were grown with 100 % of their recommended fertilizer doses (120-60-40 and 18-48-24 kg N-P_2O_5-K_2O/ha, respectively) with broadcast method at spacing of 67.5 cm × 22 cm and 30 cm × 10 cm, respectively. In intercropping system, fertilizer application method in maize was as per treatments while urdbean was fertilized by broadcast method. Maize was sown 5 cm deep in furrows. Urdbean was introduced in inter row space of maize by opening 5 cm deep furrows manually. In normal planting one row of urdbean was introduced in between two rows of maize while in paired row planting two rows of urdbean were grown in between two paired rows of maize. Maize composite variety 'Amar' and urdbean 'Pant Urd-31' were used. The sources of nutrients were NPK mixture (12-32-16), urea and muriate of potash. Nitrogen in sole and intercropped maize was applied in split in 4 equal doses at planting and 20, 35 and 50 days after sowing. Whole amount of phosphorus and potassium in maize and whole nitrogen, phosphorus and potassium in intercropped and sole urdbean was given as basal. Intercropped urdbean was fertilized according to plant population. In paired row geometry urea was top dressed in intra pair row space to avoid nitrogen access to urdbean grown in inter pair space. In furrow placement method, fertilizers were directly applied in seed furrows while in side placement 5 cm deep furrows were opened at 5 cm away from seed rows. Maize and urdbean were sown simultaneously on July 10 and harvested on October 14 and October 10, 2014, respectively. For effective weed control pendimethalin @ 1.0 kg a.i./ha was sprayed one day after sowing and one manual weeding was done in all treatments at 23 days after sowing of crop. The plant assimilatory material accumulation pattern was computed by using growth analysis formula as reported by Radford (1967). SPAD value was measured with the help of SPAD meter from three randomly selected plants from each plot and the value was averaged. Number of root nodules in urdbean was counted in five plants. The data recorded on various parameters were analyzed as per the analysis of variance technique for factorial randomized block design with extra treatment at 5% level of significance.

RESULTS AND DISCUSSION

Maize

Plant height of maize was not differed statistically by both intercropping patterns at all the growth stages (Table 1). Furrow application of fertilizers being at par with side placement resulted in significantly taller plants at all growth stages than broadcast method with 5.9% more height at harvest. A significant reduction in plant height at all growth stages was observed with decrease in dose of nitrogen from 100 to 75% recommended. At harvest, a reduction of 4.2% in plant height was noted under 75% recommended dose of nitrogen (RDN). Non significant differences were noted between intercrop and sole crop of maize for plant height at all stages of crop growth. More plant height under furrow application and side placement of fertilizers may be credited to more availability of nutrients near the plants root zone. Similar results were also reported by Mashingaidze *et al.* (2010) in maize due to banding of fertilizers in seed furrows and by Adekayode and Ogunkoya (2010) with side placement. Nitrogen is to be known for its great role in cell division and cell elongation and thus influences plant height. Therefore, taller plants under 100% RDN may be due to

Table 1: Plant height and shoot dry matter of maize at different growth stages as affected by different planting patterns and nutrient management

Treatments	Plant height (cm)				Shoot dry matter (g/plant)			
	30 DAS	45 DAS	60 DAS	Harvest	30 DAS	45 DAS	60 DAS	Harvest
Intercropping pattern								
Normal (1+1)	50.0	129.8	153.8	154.3	8.5	22.7	49.9	100.62
Paired (2+2)	51.1	133.4	158.1	158.5	8.9	23.5	51.3	104.90
SEm ±	0.9	1.5	1.5	1.6	0.2	0.4	0.7	3.22
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Methods of fertilizer application								
Furrow application	53.1	135.1	159.8	160.4	9.3	24.5	55.5	111.95
Side placement	50.1	132.3	157.0	157.4	8.9	23.0	49.9	102.59
Broadcast	48.5	127.5	151.0	151.5	7.9	21.8	46.4	93.75
SEm ±	1.2	1.8	1.8	1.9	0.2	0.5	0.9	3.94
CD at 5%	3.4	5.2	5.3	5.6	0.6	1.4	2.6	11.50
Nitrogen dose (% of recommended)								
100	52.1	134.9	159.3	159.8	9.2	24.2	53.5	111.63
75	49.0	128.4	152.6	153.1	8.1	22.1	47.7	93.89
SEm ±	0.9	1.5	1.5	1.6	0.2	0.4	0.7	3.22
CD at 5%	2.7	4.2	4.3	4.6	0.5	1.2	2.1	9.39
Intercropping vs. sole cropping								
Intercrop	50.6	131.6	155.9	156.4	8.7	23.1	50.6	102.76
Sole crop	53.3	134.6	154.6	155.0	8.3	23.4	49.4	101.25
SEm ±	2.3	3.6	3.6	3.8	0.4	1.0	1.8	7.88
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

more availability of nitrogen. Higher plant height under 100 % recommended nitrogen dose was also observed by Layek *et al.* (2012). A progressive increase in dry matter accumulation was recorded with the advancement of crop age and it reached the highest at harvest, irrespective of the treatments (Table 1). Both the intercropping patterns had non-significant differences for shoot dry matter accumulation at all stages of crop growth. But methods of fertilizer application were found significant where furrow application and side placement being statistically equal recorded significantly more shoot dry matter accumulation per plant than broadcast method at all growth stages. The increment in shoot dry matter accumulation under furrow application was to the tune of 17.7, 12.3, 19.6 and 16.2% at 30, 45, 60 DAS and at harvest stage, respectively over broadcast method. Shoot dry matter accumulation per plant was also significantly affected by amount of nitrogen and declined with decrease in dose. Application of 100% RDN had significantly more shoot dry matter accumulation by 11.9, 8.6, 10.8 and 18.9% at 30, 45, 60 DAS and at harvest stage over 75% RDN, respectively. Intercropped and sole crop of maize had non-significant difference for shoot dry matter accumulation per plant. Dry matter accumulation depends on net photosynthesis which is governed by several factors including nutrient availability. Therefore, high shoot dry matter accumulation per plant under furrow application and side placement treatments might be due to easy and more availability of N, P and K to roots which resulted into more plant growth as evident by plant height and leaf area index. More availability of nitrogen in 100% RDN treatment may be ascribed to better growth and thus more dry matter accumulation. These results are in conformity of Latha and Prasad (2008) who reported significantly higher dry matter accumulation in maize with more nitrogen dose in intercropping system with mungbean. Non significant difference between intercrop and sole crop of maize for plant height and dry matter accumulation revealed competitiveness ability of maize in association with urdbean. Mohan *et al.* (2005) also reported at par plant height and dry matter accumulation of maize under sole and intercropping schemes.

SPAD values at 30 and 60 DAS were not differed statistically by intercropping patterns, different methods of fertilizer application and variable doses of nitrogen (Table 2). Maize grown in intercropping and sole cropping system also remained on par for SPAD values. It indicated that relative amount of chlorophyll remained same in all the treatments. An increasing trend in leaf area index (LAI) from 30 to 45 DAS was observed and thereafter it declined (Table 2). Intercropping patterns did not affect the LAI significantly at any stages of crop growth. Spatial arrangement of fertilizers significantly influenced LAI of maize. Significantly higher values of LAI were obtained with furrow application of fertilizers

Table 2: SPAD value, LAI and CGR of maize as affected by different planting patterns and nutrient management

Treatments			SPAD value			LAI	CGR ($g/m^2/day$)	
	30 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30-45 DAS	45-60 DAS	60 DAS- harvest
Intercropping pattern								
Normal	(1+1)	43.48	43.01	0.710	2.603	2.236	7.05	13.4210.62
Paired (2+2)	44.71	43.79	0.734	2.592	2.298	7.20	13.72	11.35
SEm ±	0.68	0.64	0.009	0.048	0.055	0.19	0.35	0.69
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Methods of fertilizer application								
Furrow application	44.77	44.69	0.750	2.725	2.411	7.54	15.30	11.94
Side placement	43.47	43.01	0.743	2.616	2.305	6.99	13.26	10.98
Broadcast	44.05	42.50	0.674	2.450	2.084	6.85	12.14	10.02
SEm ±	0.83	0.78	0.011	0.058	0.067	0.23	0.43	0.84
CD at 5%	NS	NS	0.032	0.170	0.196	NS	1.26	NS
Nitrogen dose (% of recommended)								
100	44.96	44.09	0.766	2.695	2.392	7.37	14.49	12.30
75	43.23	42.71	0.678	2.500	2.142	6.88	12.64	9.67
SEm ±	0.68	0.64	0.009	0.048	0.055	0.19	0.35	0.69
CD at 5%	NS	NS	0.026	0.139	0.160	NS	1.03	2.00
Intercropping vs. sole cropping								
Intercrop	44.09	43.40	0.722	2.597	2.267	7.12	13.57	10.98
Sole crop	43.50	43.60	0.725	2.614	2.252	7.47	12.87	10.96
SEm ±	1.66	1.56	0.022	0.117	0.134	0.47	0.86	1.68
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

than broadcast, but did not vary statistically with side placement at all growth stages. Similarly, higher LAI was found when 100% RDN was applied to maize crop than that of 75% of recommended. Variation between intercrop and sole crop remained statistically same for LAI. It indicated negligible impact of urdbean intercropping on development of leaf area of maize. Significantly higher LAI under furrow application and side placement and with 100% RDN might be because of more leaf area because of proper supply of nutrients under these treatments. Maqbool *et al.* (2016) also reported significantly more LAI of maize with banded application of fertilizers. Similarly, Layek *et al.* (2012) found significantly higher LAI under 100% of recommended nitrogen dose than 75 % of recommended. Crop growth rate (CGR) increased with the advancement of crop age and reached maximum at 45 - 60 DAS and decline afterward (Table 2). Between the intercropping patterns, non significant difference in CGR at all growth period was observed. CGR was affected significantly by method of application of fertilizers during 45-60 DAS growth stage, where furrow application showed significantly higher value (15.3 $g/cm^2/day$) than broadcast application but remained on par with side placement. Similar trend in CGR was also recorded during other growth stages also but the differences were non significant. A decrease in nitrogen dose from 100 to 75% caused significant reduction in CGR at all stages of crop growth except during 30-45 DAS. Between sole and intercropping treatment, non-significant differences were observed for CGR at all growth stages. Since CGR depends on rate of dry matter accumulation per day in a unit area, hence variations in dry matter accumulation per plant between treatments caused differences in crop growth rate. Relative growth rate (RGR) declined with advancement in age of the plant (Table 3). Differences in RGR in relation to intercropping patterns, methods of fertilizer application and nitrogen doses were found non-significant during all the stages of crop growth. Similarly, non significant differences were also observed between intercropped and sole cropped maize. Net assimilation rate (NAR) increased with the advancement of crop age but did not vary significantly due to different intercropping patterns at either of the stages (Table 3). Among the various methods of fertilizer application, significant differences in NAR were observed only at 45-60 DAS where furrow application recorded significantly highest value (0.608 $mg/cm^2/day$). The variation in nitrogen dose failed to bring significant differences in NAR. Leaf area ratio (LAR) at different growth stages remained statistically same between both the intercropping patterns (Table 3). Methods of fertilizer application and nitrogen doses also did not cause significant effect on LAR during both the growth periods. Between sole cropping and intercropping of maize, higher value of LAR was observed under sole cropping but the differences were non-significant. Planting pattern did not cause statistical variation in maize grain yield

(Table 3). Furrow application of fertilizers being on par with side placement produced significantly higher grain yield (3.77 t/ha) than broadcast to the tune of 13.2 and 8.4 %, respectively. Significantly 8.8% higher grain yield was obtained under 100% RDN compared to 75% recommended dose. Better growth of maize in terms of plant height, dry matter accumulation, LAI, CGR, RGR, etc. in furrow application, side placement and 100% recommended nitrogen dose may be reasoned for more grain yield under these treatments. Layek *et al.* (2014) also reported similar results. Non significant variations in between intercropped and sole crop for yield revealed that intercropping of urdbean in maize has no adverse effect on maize grain yield.

Urdbean

A rapid increase in plant height was observed between 30 and 60 DAS (Table 4). Planting pattern, fertilizer application methods and nitrogen doses applied to maize did not influence plant height of urdbean significantly at any stage of crop growth. These results corroborate the findings of Mohan *et al.* (2005) who also found non significant differences in plant height under intercropping and different row ratios. Shoot dry matter accumulation in urdbean was non-significant for planting geometry at 30 and 60 DAS but at harvest, paired row planting was significantly superior to normal planting by 16.4% (Table 4). Different means of fertilizer application significantly influenced shoot dry matter accumulation of intercropped urdbean only at 60 DAS where statistically higher value (16.8 g/plant) was recorded under broadcast method than furrow application but it remained on par with side placement. Variations in nitrogen dose applied to maize did not exert significant differences in shoot dry matter accumulation at any stage of crop growth. Sole crop of urdbean accumulated significantly 25.3 and 34.8% higher dry matter than intercropped urdbean at 60 DAS and harvest, respectively but differences were found on par at 30 DAS. Better light interception due to more available space between two pairs (i.e. 90 cm) under paired row planting might favoured photosynthetic activity which resulted in more shoot dry matter accumulation. More shoot dry matter accumulation per plant in urdbean under broadcast method might be due to more availability of nutrients to urdbean plants owing to application of fertilizers over whole planting area. It resulted in luxuriant vegetative growth and consequently more shoot dry weight. The competition faced by intercropped urdbean resulted into poor growth and thus less dry matter accumulation compared to sole crop. Bhatnagar and Pal (2014) were also of similar opinion. Significantly more number of root nodules per plant was observed at early stage of crop (i.e. at 30 DAS) in paired

Table 3: Effect of planting patterns and nutrient management on RGR, net assimilation rate, leaf area ratio and grain yield of maize

Treatments	RGR (mg/g/day)			NAR ($mg/cm^2/day$)		LAR (cm^2/g)		Grain yield
	30-45 DAS	45-60 DAS	60 DAS-harvest	30-45 DAS	45-60 DAS	30-45 DAS	45-60 DAS	(t/ha)
Intercropping pattern								
Normal (1+1)	66.11	52.38	19.40	0.496	0.566	133.71	92.37	3.54
Paired (2+2)	64.84	51.83	20.39	0.503	0.572	129.70	90.68	3.60
SEm ±	1.44	1.27	0.90	0.015	0.014	2.59	1.53	0.08
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Methods of fertilizer application								
Furrow application	65.21	54.52	19.81	0.505	0.608	129.51	89.41	3.77
Side placement	63.65	51.62	20.11	0.481	0.552	132.95	93.54	3.61
Broadcast	67.56	50.19	19.77	0.511	0.547	132.66	91.62	3.33
SEm ±	1.77	1.56	1.10	0.018	0.018	3.17	1.88	0.09
CD at 5%	NS	NS	NS	NS	0.052	NS	NS	0.27
Nitrogen dose (% of recommended)								
100	64.27	52.99	20.74	0.493	0.586	131.09	91.09	3.72
75	66.68	51.22	19.06	0.506	0.551	132.32	91.96	3.42
SEm ±	1.44	1.27	0.90	0.015	0.014	2.59	1.53	0.08
CD at 5%	NS	NS	NS	NS	NS	NS	NS	0.22
Intercropping vs. sole cropping								
Intercrop	65.47	52.11	19.90	0.499	0.569	131.71	91.52	3.57
Sole crop	69.37	50.02	20.45	0.521	0.542	134.45	92.59	3.54
SEm ±	3.54	3.12	2.20	0.036	0.035	6.34	3.76	0.19
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS

row than normal planting but the differences became on par at later stage at 60 DAS (Table 4). Different methods of fertilizer application and variable nitrogen dose in maize crop did not affect number of nodules per plant in urdbean statistically. Although due to intercropping number of root nodules per plant was reduced by 10.2 and 12.9% at 30 and 60 DAS, respectively compared to sole cropping but differences were non-significant. None of the treatments was found significant for SPAD value of urdbean at any crop growth stage (Table 4). Non significant variations in SPAD values at both the stages were also recorded between intercrop and sole crop. Differences between both the planting systems with respect to LAI were significant only at 60 DAS, where normal planting attained significantly value than paired row planting (Table 5). LAI of urdbean was also not influenced significantly due to different methods of fertilizer application and nitrogen doses applied in maize crop. Intercropped urdbean showed severe reduction in LAI to a tune of 66.8 and 44.4% at 30 and 60 DAS, respectively over sole crop. Shading effect caused by maize plants to underneath urdbean plants in intercropping system may be ascribed to poor growth which in turn resulted in to reduced leaf area and LAI. Polthanee and Treloges (2003) also found lower LAI under intercropped urdbean than its sole crop. CGR increased as the age of crop progressed (Table 5). Both planting patterns exhibited significant difference in CGR at 60 DAS to harvest stage where paired row planting recorded significantly more value (11.70 g/m^2/day) than normal planting. But the differences remained on par during 30 to 60 DAS. CGR of urdbean did not affect significantly due to different methods of fertilization and nitrogen doses applied in maize crop however, higher values were obtained under broadcast method and 100% nitrogen dose. Sole crop of urdbean attained significantly higher CGR than that of intercropped one during both the growth stage interval. CGR of urdbean was reduced by 68.8 and 37.9 % owing to intercropping compared to sole cropping during 30 to 60 DAS and 60 DAS to harvest stages, respectively. Since CGR is outcome of dry matter production per day hence high value of dry matter accumulation in paired row planting and in sole crop resulted in to more CGR in these treatments. These results corroborate the findings of Addo-Quaye *et al.* (2011) who reported significantly higher CGR under double row planting of soybean with maize as compared to single alternate row planting.

A trend of reduction in values of RGR was noted with the progress of crop growth stages (Table 5). None of the treatments had significant variations in RGR at both the

Table 4: Influence of intercropping pattern, methods of fertilizer application and nitrogen doses on plant height, dry matter accumulation, number of root nodules and SPAD value of urdbean at different growth stages.

Treatments	Plant height (cm)			Dry matter accumulation (g/plant)			Number of root nodules		SPAD value	
	30 DAS	60 DAS	harvest	30 DAS	60 DAS	harvest	30 DAS	60 DAS	30 DAS	60 DAS
Intercropping pattern										
Normal (1+1)		21.3	74.0	80.3	2.1	15.0	33.6	45.8	30.2	45.8
48.5										
Paired (2+2)	21.0	71.9	80.7	2.2	15.8	39.1	53.1	27.6	46.1	48.3
SEm ±	0.4	1.1	1.1	0.1	0.5	1.0	2.0	1.1	0.34	0.9
CD at 5%	NS	NS	NS	NS	NS	3.0	5.9	NS	NS	NS
Methods of fertilizer application										
Furrow application	21.2	74.2	82.0	1.9	14.2	34.3	49.3	28.8	46.4	47.1
Side placement	20.7	74.0	81.6	2.2	15.2	36.6	45.0	26.6	45.9	49.0
Broadcast	21.5	70.7	77.8	2.4	16.8	38.2	54.0	31.2	45.7	49.0
SEm ±	0.5	1.3	1.4	0.1	0.6	1.2	2.5	1.3	0.42	1.2
CD at 5%	NS	NS	NS	NS	1.7	NS	NS	NS	NS	NS
Nitrogen dose (% of recommended)		100 %	21.5	74.5	81.9	2.2	15.2	36.1	47.6	28.1
46.0	48.2									
75 %	20.9	71.4	79.3	2.1	15.6	36.6	51.3	29.6	45.9	48.5
SEm ±	0.4	1.1	1.1	0.1	0.5	1	2.0	1.1	0.34	0.9
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Intercropping vs. sole cropping										
Intercrop	21.2	72.9	80.5	2.2	15.4	36.4	49.4	28.9	45.9	48.4
Sole crop	20.9	67.3	75.3	2.4	19.3	49.1	55.0	33.2	46.3	50.3
SEm ±	1.0	2.7	2.7	0.2	1.2	2.5	5.0	2.7	0.84	2.3
CD at 5%	NS	NS	NS	NS	2.5	5.4	NS	NS	NS	NS

Table 5: Effect of planting patterns and nutrient management on growth parameters and grain yield of urdbean

Treatments	Leaf area index		CGR (g / m^2/day)		RGR (mg/ g/day)		NAR (mg/cm^2/	LAR (cm^2/g)	Grain yield (kg/ha)
	30 DAS	60 DAS	30-60 DAS	60 DAS-harvest	30-60 DAS	60 DAS-harvest	30-60 DAS	30-60 DAS	
Intercropping pattern									
Normal (1+1)	1.79	6.08	7.43	9.48	65.94	24.35	0.247	270.3	450
Paired (2+2)	1.89	4.30	7.77	11.70	65.72	27.82	0.314	215.9	538
SEm ±			0.38	0.61	1.99	1.30	0.010	10.7	23
CD at 5%	NS	0.62	NS	1.78	NS	NS	0.030	31.3	68
Methods of fertilizer application									
Furrow application	1.75	5.37	6.82	9.91	67.48	26.65	0.251	273.0	473
Side placement	1.83	4.93	7.56	11.01	65.34	26.56	0.292	232.1	498
Broadcast	1.94	5.28	8.42	10.85	64.67	25.04	0.297	224.3	510
SEm ±	0.08	0.26	0.47	0.75	2.43	1.60	0.013	13.1	28
CD at 5%	NS	NS	NS	NS	NS	NS	0.037	38.3	NS
Nitrogen dose (% of recommended)									
100	1.89	5.37	7.62	10.89	64.08	26.50	0.270	244.3	462
75	1.79	5.01	7.59	10.29	67.59	25.66	0.290	242.0	526
SEm ±	0.07	0.21	0.38	0.61	1.99	1.30	0.010	10.7	23
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
Intercropping vs. sole cropping									
Intercrop	1.84	5.19	7.60	10.59	65.83	26.08	0.280	243.1	494
Sole crop	5.54	9.33	24.37	37.98	69.51	28.28	0.228	767.4	1603
SEm ±	0.17	0.52	0.90	1.68	4.86	3.19	0.025	26.2	57
CD at 5%	0.36	1.12	1.93	3.61	NS	NS	NS	56.4	124

growth stage interval. NAR was affected significantly by different treatments (Table 5). Between planting patterns, paired row system recorded significantly higher NAR (3.14 mg/cm^2/day) than that of normal planting. Broadcast method recorded significantly higher NAR (0.297 mg/cm^2/day) than furrow application but it remained on par with side placement. Different nitrogen doses did not affect NAR of urdbean crop. Similarly, intercropped and sole urdbean did not differ statistically. NAR is a function of dry matter content and leaf area. Therefore, variation in NAR may be credited to differences in dry matter accumulation per plant and leaf area index. Intercropping patterns recorded significant variations in LAR (Table 5). Significantly more LAR (270.3 cm^2/g) was observed in normal planting than that of paired row planting. Furrow application of fertilizer resulted in significantly more LAR (273.0 cm^2/g) than broadcast application and side placement. Both nitrogen doses found at par with respect to LAR. Sole crop exhibited significantly higher value of LAR (767.36 cm^2/g) than intercropped urdbean. Proportionately more leaf area development in comparison to dry matter accumulation under normal planting, furrow application and sole urdbean was the reason for significantly more values of LAR under these treatments. Significantly higher grain yield of urdbean was obtained under paired row system which was 19.6 % higher than normal row planting (Table 5). The high yield was due to better growth under paired row system. Grain yield did not vary significantly due to different methods of fertilizer application and nitrogen doses applied in maize. Intercropped urdbean suffered with 69.2 % reduction in grain yield in comparison to its sole crop. It was because of poor growth as maize plants exerted shading effect on underlying urdbean plants. These results confirm the findings of Dwivedi and Shrivastava (2011).

CONCLUSION

Maize and urdbean in intercropping system can express their maximum growth and produce more dry matter in paired row system (45/90 cm) of planting. Side placement or furrows application of fertilizers is helpful for proper growth of intercropped maize and urdbean.

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