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Intercropping of Quality Protein Maize and *toria* as Influenced by under Different Nutrient Levels and Planting Density in NEH Region of India

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ABSTRACT

A field experiment was conducted at the Instructional- cum- Research Farm of Assam Agricultural University, Jorhat, Assam during the *rabi* season of 2017-18 and 2018-19. The experiment was laid out in Factorial Randomized Block design with treatment combination of three fertility levels (60:40:40 kg NPK ha^{-1}, 90:60:60 kg NPK ha^{-1} and 120:80:80 kg NPK ha^{-1}), three paired row spacing, 55 cm x 25 cm, 65 cm x 25 cm,75 cm x 25 cm with two methods of sowing (Normal sowing and paired row sowing) and replicated thrice. Results revealed that the growth, yield attributes and yield were recorded with higher levels of fertility in maize and *toria* crop during both the years. Similarly paired row intercropping of 65 cm x 25 cm recorded significantly highest yield attributing characters, grain and stover yield of quality protein maize and *toria* along with significantly higher maize equivalent yield. Highest uptake values were recorded under 120:80:80 kg NPK ha^{-1} during both the year. In case of nutrient uptake by maize and *toria* crop in quality protein maize, Also NPK uptake by maize and *toria* crop were significantly higher due to paired row spacing of 65 cm x 25 cm for both the years.

Keywords Maize and *toria,* Nutrient levels, Paanting density, Grains Stover yield.

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INTRODUCTION

The success of any intercropping system depends on the proper selection of crop species where competition between them for light, space, moisture and nutrients is minimum and also by changing plant population with spatial orientation of either of the crops. Crop species ideal for intercropping should have the characteristics of short stature, erect growth habit, slow growth rate with low shading effect, lower nutrient and water requirement and early maturity. Maize (*Zea mays* L.) is one of the most valuable cereal crops used in the human nutrition in various parts of the globe and it is a vital feed source for livestock. In India maize is the third most important food crop after rice and wheat. In India it is grown on 8.67 Mha with the production and productivity of 21.75 Mt and 2566 kg ha^{-1}, respectively (Govt of India 2014). Maize in India contributes nearly 9% to the national food basket and more than Rs 100 million to the agricultural GDP at current prices apart from generating employment to over 100-million-man days (Tripathi *et al.* 2016). The success of *rabi* maize may be due to more sunny days, long growing season, dry and cool temperature which are more suitable to the crop and less for the pest. Maize with high nutritional value i.e. 68.5% carbohydrates, 8% fats, 4% ash, 3% crude fiber and 16.5% protein acquired a well-deserved reputation as a nutria-cereal and provides 35% of food requirement in most countries. Fertilizer requirements for intercropping systems may often differ considerably from mere addition of fertilizer requirements of individual crops, because growing two crops in association may result either in better exploitation of soil resources due to different root distribution systems, and by change in the cycling of plant nutrients or in competition between the crops for nutrients and other growth factors. Being a heavy feeder, maize requires much more nutrients compared to other crops and in order to meet the nutritional requirements the farmers of our region are applying huge quantities of fertilizers without understanding its negative impact on the soil as well as the concerned environment. The component crops in an inter cropping system utilizes the available resources more efficiently than sole crops, thus the optimum plant density ininter crops outweigh the optimum density in sole crop. Planting density also plays an important role affecting growth, development, architecture, nutrient availability, uptake. Yields of crops in inter cropping have been reported to fluctuate with component crop populations. In order to obtain better productivity as a major agronomic goal, population density of the component crop should be at the optimum level since plant density is one of the most important agronomic management decisions determining the degree of competition in the intercropping system. Keeping these things in mind present investigation was carried out to know the growth attributes, yield attributes, yield and total uptake in maize + *toria* inter cropping.

MATERIALS AND METHODS

The experiment was conducted during 2017-18 and 2018-19 at the experimental farm of Assam Agricultural University at 26°45N latitude and 94°12E longitude at an altitude of 87 meters above the mean sea level (MSL) and falls under Upper Brahmaputra Valley Zone of Assam. In general, maximum temperature raises upto 34-37°C during summer and minimum comes down to 8-10°C during winter. The total rainfall received during 2017-18 was 122.2 mm against 112.5 mm during 2018-19. During both the years of experimentation meteorological parameters were more or less same and the crops were normal. The soils of the experimental site were sandy loam in texture, acidic in reaction (pH-5.34) medium in organic carbon (0.63), available nitrogen (283.76), available potassium (180.42), and high in available phosphorus (28.32) respectively.

Maize variety Vivek QPM-9 and *toria* variety Jeuti (JT-90-1) were selected for maize + *toria* intercropping. Recommended seed rates of maize (25 kg ha^{-1}) and *toria* (8 kg ha^{-1}) were sown for both the years as per the intercrop treatment. Sowing was done in lines at different spacing according to the treatment manually for both maize and *toria.* Recommended doses of NPK kg ha^{-1} were applied in the form of urea, single super phosphate and muriate of potash, respectively and doses of fertilizers were applied in the plots as per the treatments. Full doses of phosfatic and potassic fertilizers and half dose of nitrogenous fertilizer were applied as uniformly as possible before sowing. The rest half of the nitrogenous fertilizer was applied as top dressing during the time of earthing up. Wherever necessary, gap filling and thinning operations were carried out within seven days after emergence to maintain the optimum plant population by dibbling the seeds for both maize as well as *toria.* Plant protection measures were taken as and when required. Other cultural operations were carried out as per recommendations. Maize was sown on 24 and 20 Nov in 2017-18 and 2018-19 and harvested on 10 and 15 March in 2017-18 and 2018-19 respectively. Biometric observations of all the crops were recorded at harvest through standard procedures. Soil samples from 15 cm depth were collected after harvest and soil nutrient status was determined for soil organic carbon,

Table 1. Plant height (cm) of quality protein maize under different levels of fertilizer, spacing and method of sowing.

Treatments	30 DAS		60 DAS		90 DAS		120 DAS	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Levels of fertilizer (NPK kg ha^{-1})								
F_1: 60-40-40	41.80	40.73	86.68	86.24	156.45	155.86	157.95	156.31
F_2: 90-60-60	42.13	41.05	86.79	86.32	164.48	163.92	165.17	164.21
F_3: 120-80-80	42.45	41.25	91.23	90.90	175.33	174.68	176.86	175.16
SEm (±)	0.28	0.36	0.33	0.37	0.95	0.97	0.59	0.61
CD (p=0.05)	NS	NS	0.95	1.07	2.73	2.78	1.70	1.75
Spacing								
S_1: 55 cm x 25 cm	41.81	40.91	86.56	86.17	161.72	161.02	162.82	161.43
S_2: 65 cm x 25 cm	42.16	40.76	88.02	87.61	165.54	165.01	166.54	165.31
$S_{3:}$ 75 cm x 25 cm	42.42	41.36	90.12	89 .68	168.99	168.45	170.63	168.94
SEm (±)	0.28	0.36	0.33	0.37	0.95	0.97	0.59	0.61
CD (p=0.05)	NS	NS	0.95	1.07	2.73	2.78	1.70	1.75
Method of sowing								
P_0: Normal row	42.32	41.18	88.86	88.44	166.60	166.08	167.88	166.50
P_1: Paired row	41.93	40.84	87.61	87.20	164.23	163.57	165.44	163.95
SEm (±)	0.23	0.29	0.27	0.30	0.78	0.79	0.48	0.50
CD (p=0.05)	NS	NS	0.78	0.87	2.23	2.27	1.39	1.43

available soil nitrogen, phosphorus and potassium as per the standard methods. The uptake of N, P and K by the grain/seed and stover at harvest of both maize and *toria* was estimated by multiplying the N, P and K (%) content of grain/seed and stover with their total dry matter yield (kg ha^{-1}). The data were statistically analyzed by standard tools for interpretation of the results. The two year experimental data were pooled and subjected to statistical analysis as per the method described for Factorial Randomized Block Design by Panse and Sukhatme (1985) to obtain analysis of variance.

RESULTS AND DISCUSSION

Growth, yield attributes of maize

Plant height (cm)

Plant height was increased with the increasing level of fertilizer at 30, 60, 90 and 120 days after sowing during both the year and the tallest plants were recorded in plots treated with 120:80:80 kg NPK/ha. However, the rate of increase varied depending on the growth stages and all the fertilizer levels produced significant variation in plant height at 60 DAS and onward up to harvest (Table 1). This might be due to higher interception solar radiation and better availability as well as utilization of N, P and K nutrients which greatly influenced the vegetative growth in terms of plant height. Significantly the tallest plants were noted in all the stages of observation in paired row with 75 cm x 25 cm (60/90) spacing. Plant height was found be highest in the wider planting geometry in both the years as because the plant could get adequate nutrient and space to produce highest plant height. Significant variation was observed on plant height of maize at 60, 90 and 120 DAS. Normal sown maize was found to be taller than paired row sown maize which might be due to the absence of intercrop competition in normal and sole stand of maize. Similar findings were reported by Hamdalla *et al.* (2014) and Manea *et al.* (2015).

Number of leaves plant^{-1}

The number of leaves was found to increase significantly with increasing levels of fertilizer and

Table 2. Number of leaves per plant of quality protein maize under different levels of fertilizer, spacing and method of sowing.

Treatment	30 DAS		60 DAS		90 DAS		120 DAS	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Levels of fertilizer (NPK kg ha^{-1})								
F_1: 60:40:40	7.62	7.12	8.38	8.12	8.63	8.29	8.38	8.18
F_2: 90:60:60	8.17	7.85	8.60	8.24	9.19	8.85	9.08	8.90
F_3: 120:80:80	8.34	7.98	8.66	8.58	9.36	9.02	9.27	9.12
SEm (±)	0.07	0.15	0.08	0.14	0.07	0.06	0.07	0.04
CD (p=0.05)	0.19	0.43	NS	NS	0.19	0.18	0.19	0.12
Spacing								
S_1: 55 cm x 25 cm	7.80	7.38	8.32	8.13	8.82	8.50	8.64	8.47
S_2: 65 cm x 25 cm	7.96	7.52	8.48	8.26	8.97	8.61	8.83	8.66
S_3: 75 cm x 25 cm	8.38	8.05	8.77	8.55	9.39	9.06	9.27	9.07
SEm (±)	0.07	0.15	0.08	0.14	0.07	0.06	0.07	0.04
CD (p=0.05)	0.19	0.43	NS	NS	0.19	0.18	0.19	0.12
Method of sowing								
P_0: Normal row	8.17	7.90	8.64	8.43	9.18	8.86	9.03	8.85
P_1: Paired row	7.92	7.40	8.45	8.20	8.93	8.58	8.79	8.62
SEm (±)	0.05	0.12	0.07	0.11	0.05	0.05	0.05	0.03
CD (p=0.05)	0.15	0.35	NS	NS	0.15	0.15	0.15	0.09

the highest values were registered with application of 120:80:80 kg NPK/ha at all the growth stages except 60 DAS during both the years (Table 2). Green leaves may increase due to increase in cell division, assimilation rate and metabolic activities in plant with higher fertilizer level (Kurne *et al.* 2017). Paired row spacing of 75 cm x 25 cm recorded the significantly highest number of leaves per plant at 30,90 and 120 DAS which was followed by paired row spacing of 65 cm x 25 cm and 55 cm x 25 cm. Number of leaves per plant of quality protein maize (QPM) was significantly higher under normal row sowing as compared to paired row sown intercropping method in all the stages of crop growth during both the years of experimentation. The normal planting of maize provided equal opportunity to all the plants for nutrient, moisture and light. Whereas, paired planting although maintained the required plant population but at the same time also increased the row-row to competition and by virtue of such competition, the growth attributes were also varied significantly.

Cob length (cm) and 1000 grain weight (g)

Application of fertility levels resulted in significant increase of yield attributes of maize crop (cob length and 1000 grain weight) during both the years. Significant increase in all the yield attributing characters with the corresponding increase in the levels of NPK up to 120:80:80 kg NPK ha^{-1} (Table 3). However, the test weight recorded under 60:40:40 and 90:60:60 kg NPK ha^{-1} remained at par and with each other during 2017-18. Increase in yield attributes may have been brought about by increase in amount of growth substances and naturally occurring phytohormones probably auxins with increased nutrient supply. The increase in grain weight may be due to better translocation and partitioning of photosynthates from source to sink i.e. seeds (Ahmed *et al.* 2010).

All the yield attributing parameters viz., cob length and test weight of 1000 grains of quality protein maize intercropped with *toria* were found to increase with increase in paired row spacing up to 65 cm x 25 cm and thereafter a decrease in the widest row spacing of 75 cm x 25 cm. The lower values of yield attributes under wider row spacing during both the seasons might be due to competition for growth resources within the row. Higher values

Table 3. Effect of different levels of fertilizer, spacing and method of sowing on cob length and 1000 grain weight of quality protein maize.

Treatments	Cob length (cm)		1000 grain wt (g)	
	2017-18	2018-19	2017-18	2018-19
Levels of fertilizer (NPK kg ha^{-1})				
F_1: 60:40:40	16.47	16.21	229.97	216.84
F_2: 90:60:60	18.63	18.45	240.07	225.86
F_3: 120:80:80	19.86	19.55	257.27	243.13
SEm (±)	0.26	0.10	3.75	2.61
CD (p=0.05)	0.76	0.29	10.77	7.51
Spacing				
S_1: 55 cm x 25 cm	18.59	18.34	242.09	227.42
S_2: 65 cm x 25 cm	19.75	19.57	253.32	240.17
S_3: 75 cm x 25 cm	16.61	16.30	231.90	218.23
SEm (±)	0.26	0.10	3.75	2.61
CD (p=0.05)	0.76	0.29	10.77	7.51
Method of sowing				
P_0: Normal row	19.52	19.20	248.24	234.13
P_1: Paired row	17.12	16.94	236.63	223.09
SEm (±)	0.22	0.21	3.06	2.13
CD (p=0.05)	0.62	0.62	8.79	6.13

of all these parameters were recorded under normal row planting of sole maize as compared to paired row intercropping of maize + *toria*. The possible reason for lower number of cobs plant^{-1}, cob length, cob girth and 1000 grain weight of QPM under paired row intercropping may be due to higher competition with associate crop *toria* for space, soil moisture and nutrient during entire crop season (Aziz *et al.* 2012 and Sonam *et al.* 2014)

Growth and yield attributes of intercrop (toria)

Plant height

Plant height of intercrop *toria* was found to increase with the increasing level of fertilizer application from 60:40:40 kg NPK ha^{-1} to 120:80:80 kg NPK ha^{-1} and there was significant difference among the fertilizer levels at all the stages after 30 DAS (Fig. 1). Similar positive responses to nutrient application on intercrop have been observed by Mbah *et al.* (2007). Similar to fertilizer level the paired row spacing also significantly influenced the plant height of intercrop *toria* at

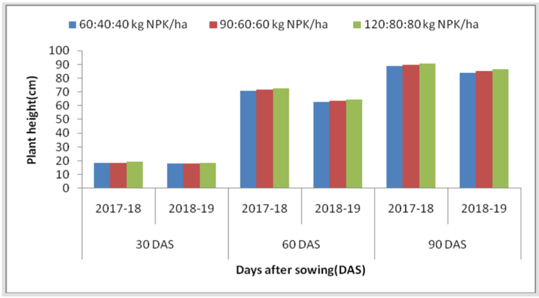

Fig. 1. Plant height of *toria* under different levels of fertilizer under paired row intercropping.

60 and 90 DAS. At 30 DAS, however, all the spacing treatments remained at par with each other during both the years of study. A non-significant difference was also observed between 55 cm x 25 cm and 75 cm x 25 cm at 60 DAS and 90 DAS during both the years (Fig. 2). Singh *et al.* (2008) also reported higher competition among the plants for utilizing vertical space for better light in intercropping system.

Number of branches per plant

Significant difference in plant height of *toria* was registered between the lowest (60:40:40 kg NPK ha^{-1}) and highest level (120:80:80 kg NPK ha^{-1}) of fertilizer (Fig. 3). The less influence of intercrop *toria* on number of branches per plant might be due to its short duration, short plant stature and also neither complementary nor competitive nature. The number of branches per plant of *toria* was found to increase with the increase in dimension of paired row spacing from 55 cm x 25 cm to 65 cm x 25 cm and thereafter

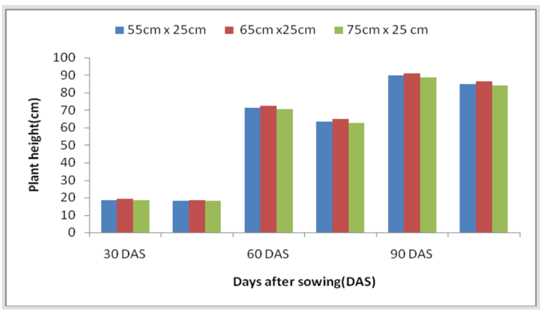

Fig. 2. Plant height of *toria* under different spacing under paired row intercropping.

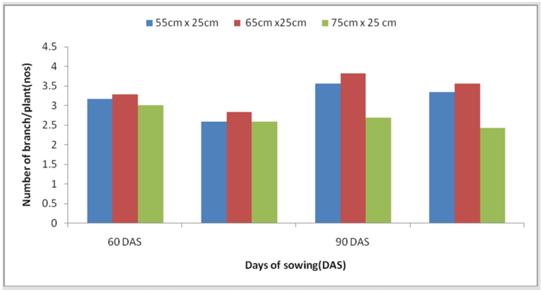

Fig. 3. Number of branches plant^{-1}of *toria* under levels of fertilizer in paired row intercropping.

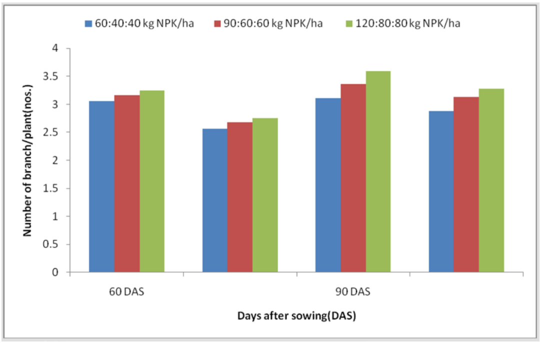

Fig. 4. Number of branches plant^{-1}of *toria* under different spacing in paired row intercropping.

a decrease with further increase in spacing to 75 cm x 25 cm at 60 and 90 DAS (Fig. 4).

Grain yield (q ha^{-1}), stover yield (q ha^{-1}) and harvest index (%) of quality protein maize

There was significant increase of both the grain and stover yield as well as harvest index of QPM with each increasing level of fertilizer (Table 4). The increase in grain and stover yields with increasing fertility levels could be explained on the basis of highly beneficial effect of higher fertilizer dose on the growth and yield contributing characters. Significant increase in grain yield of maize with increasing levels of fertilizer doses could be attributed to increased accumulation and partitioning of dry matter with the increasing fertility levels. Beremjungla and Gohain (2016) also reported that application of 100% recommended

Table 4. Effect of different levels of fertilizer, spacing and method of sowing on grain yield, stover yield and harvest index (%) of quality protein maize.

Treatments	Grain yield (q ha^{-1})			Stover yield (q ha^{-1})			Harvest index (%)	
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19
Levels of fertilizer (NPK kg ha^{-1})								
F_1: 60:40:40	43.41	42.49	42.95	85.23	84.02	84.63	33.69	33.56
F_2: 90:60:60	48.51	47.40	47.95	87.42	86.38	86.90	35.65	35.38
F_3: 120:80:80	51.90	50.94	51.42	89.58	88.71	89.14	36.66	36.43
SEm (±)	0.65	0.58	0.46	0.50	0.38	0.31	0.37	0.32
CD (p=0.05)	1.87	1.68	1.32	1.42	1.09	0.88	1.06	0.91
Spacing								
S_1: 55 cm x 25 cm	48.30	47.44	47.87	88.32	87.29	87.81	35.25	35.13
S_2: 65 cm x 25 cm	50.84	49.77	50.31	90.59	89.37	89.98	35.88	35.69
S_3: 75 cm x 25 cm	44.68	43.62	44.15	83.32	82.45	82.88	34.86	34.55
SEm (±)	0.65	0.58	0.46	0.50	0.38	0.31	0.37	0.32
CD (p=0.05)	1.87	1.68	1.32	1.42	1.09	0.88	NS	NS
Method of sowing								
P_0: Normal row	49.74	48.70	49.22	89.38	88.34	89.38	35.68	35.46
P_1: Paired row	46.14	45.19	45.66	85.44	84.40	85.44	34.98	34.79
SEm (±)	0.53	0.48	0.38	0.40	0.31	1.76	0.30	0.26
CD (p=0.05)	1.52	1.37	1. 08	1.16	0.89	NS	NS	NS

Table 5. Effect of different levels of fertilizer, spacing and method of sowing on N, P and K uptake by maize (kg ha^{-1}) of quality protein maize.

Treatments	N		P		K	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Levels of fertilizer (NPK kg ha^{-1})						
F_1: 60:40:40	154.46	150.03	25.94	22.45	90.22	84.39
F_2: 90:60:60	166.84	162.11	30.78	26.82	96.46	90.97
F_3: 120:80:80	177.91	172.07	34.12	31.12	102.89	97.75
SEm (±)	1.7	1.58	0.78	0.77	1.14	0.93
CD (p=0.05)	4.89	4.55	2.24	2.21	3.28	2.68
Spacing						
S_1: 55 cm x 25 cm	167.59	163.2	31.08	27.55	98.2	91.87
S_2: 65 cm x 25 cm	175.76	171.11	34.18	30.32	103.08	97.64
S_3: 75 cm x 25 cm	155.64	149.9	25.59	22.51	88.28	83.6
SEm (±)	1.7	1.58	0.78	0.77	1.14	0.97
CD (p=0.05)	4.89	4.55	2.24	2.58	3.28	2.81
Method of sowing						
P_0: Normal row	172.67	167.64	32.44	28.86	100.39	94.86
P_1: Paired row	160.12	155.16	28.13	24.73	92.65	87.22
SEm (±)	1.39	1.29	0.64	0.63	0.93	0.76
CD (p=0.05)	4.0	3.72	1.82	1.81	2.67	

dose of fertilizer to maize and intercrop groundnut increased the grain yield to both the crops. Both the grain and stover yield increased significantly up to 65 cm x 25 cm and thereafter there was significant reduction with further increase in paired row spacing of maize. This was as a result of optimum population density that does not allow competition among crops for nutrient and the row spacing with proper density, which seems favorable for light interception in the middle and lower canopies. Temesgen *et al.* (2017) reported similar findings in maize and common bean intercropping. Normal row planting of sole maize was found to result statistically higher grain as well as stover yield over paired row intercropping. Higher yield of sole maize might be due to higher growth and yield attributing characters like number of cob length, cob girth and test weight of 1000 grains. The lower grain yield of maize grown in association with *toria* was probably the result of inter-specific competition between corn and *toria* plants for below and above ground growth factors soil moisture, nutrient, space and solar radiation (Das *et al.*2013).Similarly increase in stover yield in normal planting may be due to higher plant population in sole planting of maize. Similar results were reported by Mandal *et al.* (2014) who reported significantly lower straw yield of intercropped soybean and groundnut than in monocropping.The effect of method of sowing on harvest index was found to be non significant.

Seed and stover yield (q ha^{-1}) of *toria*

The pooled analysis of both the seed and stover yields of *toria* also showed a similar trend of increment as in maize crop (Table 5). The increase in seed and stover yields of *toria* owing to increasing levels of fertilizer in intercrop could be attributed to overall improvement in plant growth and yield attributes as a result of greater availability of plant nutrient, photosynthates and metabolites from the source. Kheroar and Patra (2013) revealed that yield of intercrops were less in intercropping with maize and was caused due to receipt of lower amount of solar radiation. Paired row spacing of QPM + *toria* intercropping significantly influenced the seed yield of the component crop *toria* which increased significantly with increase of paired row spacing from 55 cm x 25 cm (35/75) to 65 cm x 25 cm and thereafter a decrease in seed yield with further increase of spacing to 75 cm x 25 cm recording the significantly lowest values during both the years of study as well as on pooled basis. The stover yield of *toria* also varied in similar way when analyzed on yearly or pooled basis. However, there was no statistical difference between the stover yields of *toria* recorded under the spacing 55 cm x 25 cm and 75 cm x 25 cm during 2017-18. The increased stover yield in low population density might be due to better vegetative growth and higher dry matter production (Reddy *et al.* 2018).

Nutrient (N, P and K) uptake (kg ha^{-1}) by maize crop

Total N, P and K uptake by maize crop was significantly increased with increasing levels of NPK from 60:40:40 kg ha^{-1} to 120-80-80 kg ha^{-1} during both the years of study (Table 6). The increased availability of nutrients in the root zone coupled with increased metabolic activity at the cellular level might have increased the uptake of nutrients and their accumulation in plant parts. N, P and K uptake by maize grain was affected by the row spacing treatments in maize + *toria* intercropping. uptake by maize grain also increased significantly with the increasing row spacing from 55 cm x 25 cm to 65 cm x 25 cm and thereafter a decreasing trend when the spacing was further increased to 75 cm x 25 cm during both the years of experimentation. Significant difference among the nutrient uptakes in intercropped maize might be due to better growth and development, sufficient amount supply of N, P and K during the growing period of the crops, higher accumulation of all three primary nutrients in the plant tissues and production of higher dry matter and to a lesser extent only these uptakes were affected by respected nutrient contents. The beneficial effects of different planting densities on nutrient uptake were also reported by Dawadi and Sah (2012), Mandal *et al.* (2014) and Choudhary (2014). Significantly higher uptake of the three major nutrients was observed under the normal row planting of maize as compared to paired row planting.

N, P and K uptake in *toria*

Total N, P and K uptake by *toria* crop was also similar to that of maize grain (Table 7). During both the years, the uptake of all the three primary nutrients increased significantly with every increase in fertility level recording the highest values with the highest fertilizer level 120:80:80 kg NPK ha^{-1}.The data pertaining to N, P and K uptake revealed that uptake of all these three nutrients increased with the increasing row spacing from 55 cm x 25 cm to 65 cm x 25 cm and thereafter a decreasing trend when the spacing was further increased to 75 cm x 25 cm during both the years of investigation (Table 3). Increased uptake of nutrients in row spacing might have happened primarily because of increased concentration of these

Table 6. Seed and stover yield of *toria* under different levels of fertilizer, spacing under paired row intercropping.

TreatmentS	Seed yield (q ha^{-1})			Stover yield (q ha^{-1})		
	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
Levels of fertilizer (NPK kg ha^{-1})						
F_1: 60:40:40	2.96	2.54	2.75	11.44	10.98	11.21
F_2: 90:60:60	3.79	3.42	3.61	12.53	12.10	12.31
F_3: 120:80:80	4.88	4.47	4.67	13.26	12.86	13.06
SEm (±)	0.12	0.14	0.09	0.22	0.14	0.13
CD (p=0.05)	0.26	0.30	0.19	0.47	0.29	0.27
Spacing						
S_1: 55 cm x 25 cm	3.71	3.30	3.51	12.14	11.75	11.95
S_2: 65 cm x 25 cm	4.80	4.33	4.57	13.29	12.82	13.05
S_3: 75 cm x 25 cm	3.10	2.79	2.95	11.80	11.38	11.59
SEm (±)	0.12	0.14	0.09	0.22	0.14	0.13
CD (p=0.05)	0.26	0.30	0.19	0.47	0.29	0.27

Table 7. Effect of different levels of fertilizer, spacing on N, P and K uptake (kg ha^{-1}) of *toria* crop.

Treatment	P		P		K	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Levels of fertilizer (NPK kg ha^{-1})						
F_1: 60-40-40	12.6	11.06	3.87	3.33	7.09	6.36
F_2: 90-60-60	15.34	13.87	4.66	4.1	8.2	7.46
F_3: 120-80-80	18.29	16.79	5.82	5.15	9.33	8.56
SEm (±)	0.44	0.44	0.16	0.21	0.26	0.18
CD (p=0.05)	0.93	0.95	0.35	0.44	0.56	0.38
Spacing	0	0	0	0	0	0
S_1: 55 cm x 25 cm	14.87	13.35	4.47	4.06	8.03	7.26
S_2: 65 cm x 25 cm	18.12	16.38	5.48	4.7	9.36	8.45
S_3: 75 cm x 25 cm	13.21	11.93	3.79	3.31	7.25	6.63
SEm (±)	0.44	0.44	0.18	0.21	0.26	0.18
CD (p=0.05)	0.93	0.95	0.39	0.44	0.56	0.38

nutrients in seed and stover of *toria* and secondly due to different rooting system of the crop associated in intercropping systems.

CONCLUSION

On the basis of experimental findings, it can be concluded that maize + *toria* (2:2) intercropping system proved to be better in growth and development, yield, nutrient uptake by the crops. Meanwhile, the proper plant density in combination with fertility management significantly increased productivity of intercropped maize compared with the monoculture maize. Based on two years of field experimentation it may be concluded that quality protein maize can be successfully grown with *toria* as intercrop in paired row spacing of 65 cm x 25 cm with 2:2 row ratio and 120:80:80 kg NPK ha^{-1} in upper Brahmaputra valley zone of Assam.

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