The Pharma Innovation Journal 2022; 11(2): 1963-1968

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(2): 1963-1968

www.thepharmajournal.com
Received: 07-11-2021
Accepted: 15-12-2021

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Response of row arrangements and nutrient levels on growth and productivity of maize intercropped with cowpea

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Abstract
The present investigation was carried out at during summer of 2019 and 2020 at College Farm, Navsari Agricultural University, Navsari (Gujarat) find out the effect of row arrangements and nutrient levels on growth and yield of maize and cowpea intercropping system. The experiment was conducted with the objective to evaluate the appropriate row arrangement, nutrient levels and the best interaction of row arrangement and nutrient levels for maize-cowpea intercropping system. The experiment was laid-out in factorial randomized block design keeping five row arrangements and three nutrient levels with three replications. Treatments comprised of five row arrangements *viz.*, sole maize (A_1), sole cowpea (A_2), maize-cowpea (1:1) (A_3), maize-cowpea (1:2) (A_4) and maize-cowpea (2:1) and three nutrient levels *viz.*, 75% RDF (F_1), 100% RDF (F_2) and 125% RDF (F_3). Recommended dose of fertilizer used for maize and cowpea were 120:60:40 and 20:40:00 N:P2O5:K2O kg/ha respectively. Hybrid variety sugar 75 of maize of Syngenta company and GC-6 of cowpea cultivar released by SDAU, Dantiwada were taken as test crops during the investigation.
The results of the experiment showed that, growth parameters of maize *viz.*, plant height of maize was significantly influenced by row arrangement and the highest values were recorded by sole maize. However, significantly the highest the number of functional leaves, leaf area index and dry matter accumulation per plant, cob length (cm), number of cobs per plant, cob diameter (cm) and maize equivalent yield (q/ha) recorded by 2:1 row arrangement over sole maize, sole cowpea, 1:1 and 1:2 row arrangements. The significantly higher green cob yield and straw yield of maize was found under sole cropping over the rest of row arrangements and which was found at par with 2:1 row arrangement. Among the nutrient levels, application of 125% RDF was recorded significantly the higher plant height, number of functional leaves, leaf area index and dry matter accumulation per plant, cob length (cm), number of cobs per plant, cob diameter (cm) and maize equivalent yield (q/ha) over 75% RDF.
In case of yield of maize, the higher values for green cob yield, straw yield and biological yield of maize were recorded under sole maize and among the nutrient levels application of 125% RDF application recorded the higher values for green cob yield, straw yield and biological yield. On the basis of maize equivalent yield, significantly higher maize equivalent yield observed under maize-cowpea 2:1 row arrangement with application of 100% RDF and which was found at par with the combination of 2:1 row arrangement with application of 125% RDF.

Keywords: Intercropping, Maize, Cowpea, Row arrangements, Nutrient levels, Growth, yield, dry matter accumulation, maize equivalent yield

Introduction
The availability of land for agriculture is shrinking every day as it is increasingly utilized for non-agricultural purposes. World population is exponentially growing indicating the need for an attractive strategy for increasing productivity to fulfill their food requirements such as intercropping. Under this situation, one of the important strategies to increase agricultural output is the development of new high intensity cropping systems like intercropping systems. Intercropping plays an important role in the sustainable development of agriculture and food production worldwide. Intercropping increases in productivity per unit of land via better utilization of resources, minimizes the risks, reduces weed competition and stabilizes the yield. Among different maize-based cropping system, maize-cowpea is emerging as potential maize-based cropping system in India. Maize (*Zea mays L.*) is an annual C^4 plant belonging to the grassy family Poaceae with its origin as Central America and considered as one of the oldest food sources. Maize is one of the most versatile emerging crops having wider adaptability under varied agroclimatic conditions. Globally, maize is known as "Queen of cereals" because it has the highest genetic yield potential among the cereals.

Among maize types, sweet corn is one of commercial used maize type and planted for fresh market or processing (e.g., canning) uses. Sweet corn grains contain higher concentration of sugars than other corns. Sweet corn consumption has increased considerably worldwide.

Pulses play a vital role in biological nitrogen fixation, addition of considerable amount of organic matter through root biomass and leaf fall, deep root systems, mobilization of nutrients, protection of soil against erosion and improving microbial biomass, they keep soil productive and alive by bringing qualitative changes in physical, chemical and biological properties. Cowpea (*Vigna unguiculata* L. Walp.) is a member of the *Phaseoleae* tribe of the leguminosae family.

Spatial arrangement of component crops in intercropping influences the use of resources available to crops. There is potential for higher productivity of intercrops when mixtures are appropriately arranged to reduce the inter-specific competition for limiting resources, such as solar radiation, nutrients and water. Selection of crops that differ in competitive ability in time or space is essential for an efficient intercropping system as well as decisions on when to plant, at what density, and in what arrangement. The yield advantage of intercropping can be increased by varying the row arrangement of the component crops. Row arrangement is the pattern of distribution of plants over the ground, which determines the shape of the area available to the individual plant. The proper nutrient management is one of the major factors for increasing the percentage of nutrients availability in the soil which influences better growth and development of the crop. Variation in nutrient availability to the crop results in higher or lower yield, improved or reduced crop development and also fluctuates physiology of the crop.

Further aspect of row arrangement and nutrient levels probably receive more attention to know quantitative relationship and yield responses in intercropping research. Keeping in view the above facts the present study entitled Studies on growth and productivity of maize-cowpea intercropping system under different spatial arrangements and nutrient levels is planned to study the growth and yield attributes behaviour under maize-cowpea intercropping.

Material and Methods

The experiment was conducted was carried out at during summer of 2019 and 2020 at College Farm, Navsari Agricultural University, Navsari (Gujarat). The soil of the experimental field was clayey in texture, low in organic carbon content (0.48%) and available nitrogen (194.60 kg/ha), medium in available phosphorus (37.76 kg/ha) and fairly high in available potassium (293.51 kg/ha). The soil was slightly alkaline in reaction (pH 8.2). The experiment was laid- out in a factorial randomized block design with three replications. Treatment comprising five row arrangements viz., sole maize (A_1), sole cowpea (A_2), maize-cowpea (1:1) (A_3), maize-cowpea (1:2) (A_4) and maize-cowpea (2:1) and three nutrient levels *viz.*, 75% RDF (F_1), 100% RDF (F_2) and 125% RDF (F_3). Recommended dose of fertilizer used for maize and cowpea were 120:60:40 and 20:40:00 N: P2O5: K2O kg/ha respectively. Hybrid variety sugar 75 of maize and GC-6 of cowpea were taken as test crops during the investigation. The recommended dose of fertilizer (120:60:40 NPK kg/ha) for maize and (20:40:00 NPK kg/ha) for cowpea was applied. The required quantity of fertilizer was workout as per the unit area basis of maize and cowpea plant population. At the end the data was analyzed statistically as suggested by Panse and Sukhatme (1967) [14].

Results and Discussion

Growth attributes of maize

Plant height

Effect of row arrangements

The data on plant height of maize recorded at 30, 60 DAS and at harvest as influenced by various row arrangements and nutrient levels are given in Table.1 and the results showed that, plant height of maize increased with advancing crop age up to harvest stage. Among the row arrangement, the sole maize recorded the highest values on plant height at all three stages. The sole maize was found at par with the 1:2 row arrangement. The highest plant height was recorded under sole maize mainly due to lower competition of cereal legume i.e., properly utilized light, solar radiation and nutrient. Similar results were reported by Sujatha and Babalad (2018) [18] and Tamta *et al.* (2019) [19].

Effect of nutrient levels

Among the nutrient levels application of fertilizer for maize with 125% RDF recorded the significantly highest plant height over 75% RDF and which was statistically at par with 100% RDF. The lowest plant height of maize was recorded by 75% RDF during the present investigation. However, pooled data at 30, 60 DAS and at harvest showed that the crop fertilized either with 125% or 100% RDF were equally effective on plant height of maize and found significantly superior to 75% RDF. The maximum plant height in the case of the sole crop was attributed to the penetration of light, circulation of air and comparatively more nutritional area available to the sole crop under a competition-free environment. The same results were reported by Baghdadi *et al.* (2018) [3], Gudadhe *et al.* (2018) [7], Prasanth *et al.* (2019) [15] and Tamta *et al.* (2019) [19].

Number of functional leaves

Effect of row arrangements

The periodical data on the number of functional leaves of maize was significantly influenced by row arrangement and nutrient levels as presented in Table.1. The significantly highest number of functional leaves of maize were recorded by 1:2 arrangement over 1:1 and 2:1 arrangement at 30 DAS while at 60 DAS and at harvest which was found at par with sole maize. The results confirm with the findings of Undie *et al.* (2012) [20], Iderawumi (2014) [8], Dangariya *et al.* (2017) [6], Abraha (2018) [1], Gudadhe *et al.* (2018) [7] and Tamta *et al.* (2019) [19].

Table 1: Plant height and number of functional leaves of maize as influenced by row arrangement and nutrient levels.

Treatment	Plant height (cm)			Number of functional leaves		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
A. Row arrangement						
A_1. Maize Sole	48.41	158.29	220.96	5.00	10.65	12.29
A_2. Cowpea Sole	-	-	-	-	-	-
A_3. Maize- Cowpea (1:1)	43.97	141.42	178.51	6.83	11.76	13.58
A_4. Maize- Cowpea (1:2)	44.58	148.46	203.21	7.78	12.35	13.73
A_5. Maize- Cowpea (2:1)	40.96	139.35	172.30	5.72	11.29	12.48
S Em±	1.00	2.63	3.35	0.18	0.24	0.29
CD at 5%	2.85	7.51	9.55	0.52	0.67	0.82
B. Nutrient levels						
F_1. 75% RDF	40.81	136.65	185.46	5.96	10.80	11.87
F_2. 100% RDF	45.34	150.93	194.99	6.13	11.59	13.37
F_3. 125% RDF	47.29	153.06	200.77	6.92	12.15	13.82
S Em±	0.87	2.28	2.90	0.16	0.20	0.25
CD at 5%	2.47	6.50	8.27	0.45	0.58	0.71
Interaction (A X B)						
S Em±	1.73	4.56	5.80	0.32	0.41	0.50
CD at 5%	NS	NS	NS	NS	NS	NS
Sig. interactions with Y	--	--	--	--	--	--
CV (%)	9.55	7.61	7.34	12.22	8.69	9.33

Effect of nutrient levels

Significantly the maximum number of leaves per plant of maize was recorded with the application of 125% RDF which was found at par with 100% RDF at 60 DAS and at harvest. The increase in number of functional leaves may be due to optimum utilization of solar light, higher assimilates production and its conversion to starches which resulted in a higher number of functional leaves and all metabolic activities. The present result is in close agreement with Dangariya *et al.* (2017) [6], Gudadhe *et al.* (2018) [7] and Tamta *et al.* (2019) [19].

Leaf area index (LAI)

Effect of row arrangements

The periodical data on LAI of maize was significantly influenced by row arrangement and nutrient levels as presented in Table.2. The leaf area index (LAI) was increased with the advancement of crop stages and decreased thereafter due to senescence at maturity of the crop. Significantly the highest leaf area index (LAI) was registered in 1:2 row arrangement over rest arrangements and which was found at par with 1:1 for maize at 30 and 60 DAS. As the plant population of the cowpea increases there was gradual increase in the LAI of maize showed the complementary benefit in the intercropping system. Similar results were observed by Sani *et al.* (2011) [17], Chaudhary *et al.* (2012), Kumar *et al.* (2017) [10], Sujatha and Babalad (2018) [18], Yavas and Unay (2016) [24].

Effect of nutrient levels

Among the nutrient levels, application of 125% RDF produced significantly highest LAI over 75% RDF. Under the intercropping system the LAI of cowpea was showed the depression might be due to inter-crop competition and shading effects of maize on cowpea leads to decrease the incoming solar radiation for development of leaf area. Also, might be due to improvement soil physico-chemical and biological properties of soil release adequate quantities of nitrogen and phosphorus to boost up the growth of the crop there by increasing leaf area per plant. The same type of results was reported by Pandey *et al.* (2017) [3], Kumar *et al.* (2017) [10] and Baghdadi *et al.* (2018) [3].

Dry matter accumulation (g/plant)

Effect of row arrangement

The dry matter accumulation per plant was recorded at 30, 60 DAS and at harvest and are presented in Table.2. The results showed that, maize intercropped in 1:2 row arrangement with cowpea produced highest dry matter per plant and it was observed statistically at par with 1:1 row arrangement of maize and cowpea at 30 and 60 DAS and at harvest. However, the lowest dry matter accumulation was noticed from sole planting of maize at all the stages of crop growth till harvest. Dry matter production in a crop community mostly depends on LAI, photosynthetic rate and leaf angle, but the dry matter production per unit area depends on number of plants per unit area and dry matter production per plant. The similar results were reported by Kumar *et al.* (2017) [10], Abraha (2018) [1] and Tamta *et al.* (2019) [19].

Effect of nutrient levels

The nutrient levels observed the significant effect on dry matter accumulation per plant of maize and cowpea recorded during 30, 60 DAS and at harvest.

Table 2: Leaf area index (LAI) and dry matter accumulation (g/plant) of maize as influenced by row arrangement and nutrient levels

Treatment	Leaf area index (LAI)			Dry matter accumulation (g/plant)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
A. Row arrangement						
A_1. Maize Sole	1.15	2.15	1.74	28.26	146.58	220.77
A_2. Cowpea Sole	-	-	-	-	-	-
A_3. Maize- Cowpea (1:1)	1.81	3.19	2.79	32.66	191.36	260.74
A_4. Maize- Cowpea (1:2)	1.99	3.26	3.28	36.02	208.67	267.39
A_5. Maize- Cowpea (2:1)	1.36	2.73	2.09	28.56	168.37	237.95

S Em±	0.05	0.08	0.07	0.83	5.15	6.08
CD at 5%	0.15	0.22	0.19	2.38	14.69	17.34
B. Nutrient levels						
F_1. 75% RDF	1.22	2.39	2.13	29.50	166.72	228.61
F_2. 100% RDF	1.52	2.91	2.53	30.97	178.06	247.14
F_3. 125% RDF	1.99	3.19	2.77	33.65	191.45	264.37
S Em±	0.04	0.07	0.06	0.72	4.46	5.27
CD at 5%	0.13	0.19	0.16	2.06	12.72	15.01
Interaction (A X B)						
S Em±	0.09	0.13	0.11	1.44	8.93	10.53
CD at 5%	NS	NS	NS	NS	NS	NS
Sig. interactions with Y	--	--	--	--	--	--
CV (%)	13.90	11.59	11.15	11.27	12.23	10.46

Out of three nutrient levels application of 125% RDF was reported significantly superior dry matter accumulation per plant of maize and cowpea over 75% RDF and which was found at par with 100% RDF from 30 DAS to till harvest.

The increase in DMA Continuous steady release of NPK through fertilizers might have resulted in enhancing the carbohydrate metabolism and formation of starch and cellulose resulting in production of more dry matter. The results were in line with Wadile *et al.* (2016), Yadav *et al.* (2016), Gudadhe *et al.* (2018) [7] and Prasanth *et al.* (2019) [15].

Yield contributing characters and yield

Effect of row arrangement

The data on yield attributing characters viz., cob length, number of cobs per plant, cob diameter was recorded at the time of harvesting and presented in Table. 3. The results showed that, the planting of maize and cowpea in the proportion of 1:2 row ratio recorded significantly higher cob length, number of cobs per plant, cob diameter over the sole cropping of maize, cowpea, 1:1 and 2:1 row arrangement. This might be due to lowering the cereal- legume competition during critical crop growth period at cob development stage might have increased the availability of moisture and plant nutrients to the crop resulted in better development of cob length, number of cobs per plant, cob diameter. The higher green cob yield, straw yield of maize and seed yield and stover yield of cowpea was recorded under the sole cropping of maize and cowpea as presented in Table.3 and graphically illustrated in Figure.1. The higher yield levels under sole cropping might be due to the higher plant population and absence of interspecific competition among the maize and cowpea. On the basis of maize equivalent yield the significantly the higher maize equivalent yield was observed under 2:1 row arrangement over the rest of planting patterns. The results are in line with Yadav *et al.* (2016) [23], Gudadhe *et al.* (2018) [7], Kokani *et al.* (2018) [9] and Prasanth *et al.* (2019) [15],

Effect of nutrient levels

The data on nutrient levels given in the Table.3 showed the positive response as increase the levels of nutrients during the present investigation for cob length, number of cobs per plant, cob diameter, green cob yield, straw yield, and maize equivalent yield. The significantly higher cob length, number of cobs per plant, cob diameter, green cob yield, straw yield, and maize equivalent yield were recorded by application of 125% RDF over 75% RDF and which was found at par with 100% RDF. The present findings are in agreement with those of Dadarwal *et al.* (2009) [5], Nandy *et al.* (2013) [12], Verma and Tomar (2014) [21], Mathukia *et al.* (2014) [11], Almaz *et al.* (2017b) [2], Rathod *et al.* (2018) [16] and Prasanth *et al.* (2019) [15].

Table 3: Yield and yield contributing characters of maize as influenced by row arrangement and nutrient levels.

Treatment	Cob length (cm)	Number of cobs per plant	Cob diameter (cm)	Green cob yield (q/ha)	Straw yield (q/ha)	Maize equivalent yield (q/ha)
A. Row arrangement						
A_1. Maize Sole	14.93	1.05	5.13	**135.47**	**175.44**	138.09
A_2. Cowpea Sole	-	-	-	-	-	38.78
A_3. Maize- Cowpea (1:1)	18.63	1.11	5.77	80.06	98.34	101.38
A_4. Maize- Cowpea (1:2)	18.78	1.23	5.84	55.21	70.69	82.77
A_5. Maize- Cowpea (2:1)	17.32	1.07	5.58	132.17	128.06	144.06
S Em±	0.34	0.03	0.08	1.84	2.84	1.74
CD at 5%	0.96	0.08	0.22	5.25	8.09	4.92
B. Nutrient levels						
F_1. 75% RDF	16.21	1.01	5.29	83.33	96.51	81.90
F_2. 100% RDF	17.88	1.13	5.64	109.50	116.19	108.95
F_3. 125% RDF	18.17	1.20	5.80	109.34	141.70	112.19
S Em±	0.29	0.03	0.07	1.59	2.46	1.34
CD at 5%	0.84	0.07	0.19	4.55	7.01	3.81
Interaction (A X B)						
S Em±	0.59	0.05	0.13	3.19	4.92	3.01
CD at 5%	NS	NS	NS	9.09	14.02	8.52
Sig. interactions with Y	--	--	--	--	--	--
CV (%)	8.24	11.33	5.84	7.76	10.20	7.29

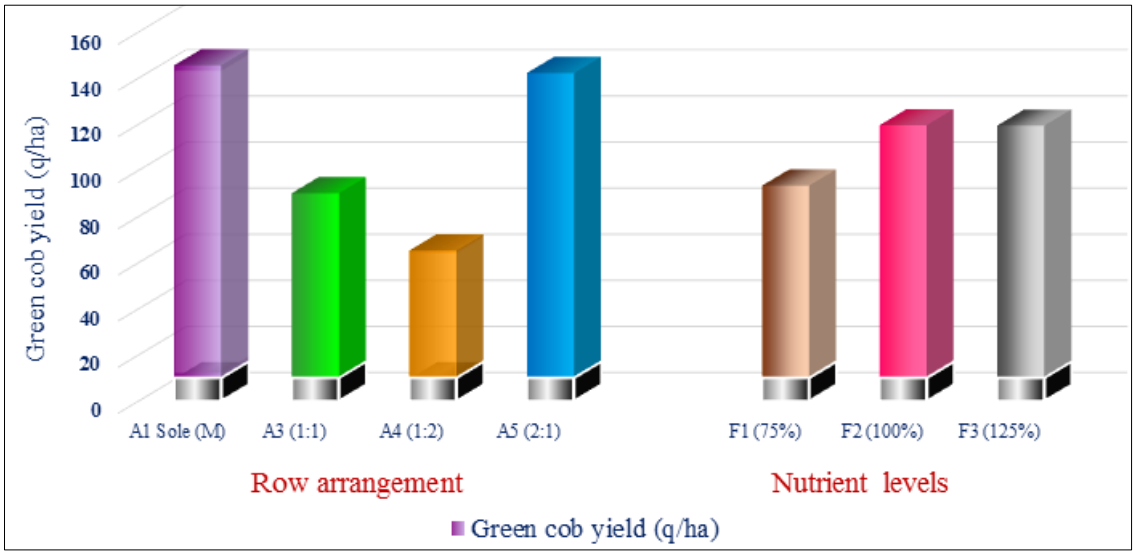

Fig 1: Green cob yield influenced by row arrangement and nutrient levels at harvest

Conclusion

On the basis of maize equivalent yield, significantly higher maize equivalent yield observed under maize-cowpea 2:1 row arrangement with application of 100% RDF and which was found at par with the combination of 2:1 row arrangement with application of 125% RDF. Therefore, the planting of maize-cowpea 2:1 row arrangement with application of 100% RDF found most profitable intercropping system for sustainable soil health and crop productivity.

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