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Weed characteristics and green cob yield as influenced by crop geometry and nitrogen and iron nutrition in babycorn

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Abstract
An experiment was carried out under sandy loam soil at Tamil Nadu Agricultural University, Coimbatore, during *Rabi* and summer seasons of 2016-17 and 2017-18 to study the effect of crop geometry, nitrogen and iron nutrition on weeds and yield of babycorn (*Zea mays* L.). Weed density and drymatter was significantly lower with 45 × 15cm spacing and application of 100% recommended dose of nitrogen (RDN). Higher babycorn yield was realized with the babycorn raised at 45 × 15cm while the nutrient treatments did not differ significantly with the babycorn yield. However interaction effect was found to be conspicuous wherein application of 125% RDN with $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS to the babycorn raised at 45 × 15 cm gave higher yields and was at par with the other fertilization levels of babycorn sown at the same crop geometry level.

Keywords: Babycorn, spacing, fertilization levels, weed density, weed dry weight, green cob yield

Introduction
Babycorn, also known as young corn or cornlets is a small and immature cereal crop taken from corn (maize). In other words, babycorn is an offshoot of maize which is grown for its young, fresh, finger-like green ears, harvested at the time of silk emergence and before pollination and fertilization (Ramchandrappa *et al.*, 2004) [20]. It is consumed as a whole in contrast to the mature corn, which is too harder for human consumption. It is an emerging crop and is consumed worldwide due to its high nutritive value in various forms like vegetable, salads, etc. The production of fresh vegetables including babycorn has increased from 239.7 to 279.7 million tonnes from 2003 to 2013 (FAO, 2015) [12]. Babycorn fodder also has a high nutritive value and can be fed fresh or ensiled to livestock animals. In India, babycorn is cultivated throughout the year especially during peak winter months. The average production of babycorn in India is about 7.5-8.7 tonnes/ha (Mohinder *et al.*, 2017) [18]. Due to its high nutritive value and taste, it gained a commercial importance and the consumer demand for babycorn is increasing day by day especially in metrocities.

Crop geometry for individual plant is one of the most important factors that decides the yield of the individual crop. Though babycorn is a short duration crop which completes life cycle in 75 days, the resources such as light, space, moisture and nutrients are to be utilized effectively to obtain better yield (Thavaprakaash *et al.*, 2008) [26].

Nutrients especially nitrogen plays greater role in production of cereals and in particular maize (babycorn). Babycorn varies with maize which is a long duration crop (4-5 months) and end product is matured corn, whereas, babycorn is a short duration crop and harvested for its immature cobs. Hence, the nutrients especially N varies with maize. About 30% of cultivated soils worldwide are iron deficient (Cakmak, 2002) [7]. Iron is a main factor for chlorophyll formation and photosynthesis and is important in the enzyme systems and respiration of plants (Halvin *et al.*, 1999) [15]. Fe deficiency causes reduction in leaf Fe concentration which results in reduction in chlorophyll content (Gogorcena *et al.*, 2005) [13] thus finally affecting photosynthesis (Marschner, 1995) [17]. Under such conditions, foliar application is found to be an easy and effective way to correct the nutrient deficiencies. Also, it was found that foliar application of Fe fertilizers along with N nutrition stimulated the grain Fe accumulation (Aciksoz *et al.*, 2010) [1].

Weeds are one of the major threats in any crop and have to be controlled effectively to avoid yield losses. Crop geometry levels and nitrogen had considerable influence on weed population and dry weight (Thavaprakaash *et al.*, 2005; Rathika *et al.*, 2013) [25, 21].

Thus proper agronomic management such as proper nutrient management, optimum plant stand for proper utilization of resources and to reduce the weed growth is necessary for increasing the productivity of babycorn. Hence, the present investigation is taken up to study the effect of crop geometry, nitrogen and iron nutrition on weeds and yield of babycorn.

Material and Methods

The field experiments was conducted during *rabi* and summer seasons of 2016-17 and 2017-18 at Eastern block farm, Tamil Nadu Agricultural University, Coimbatore to study the effect of crop geometry, nitrogen and iron nutrition on weeds and yield of babycorn (*Zea mays* L.). The farm is situated in the Western Agro Climatic Zone of Tamil Nadu at 11^0 N latitude, 77^0 E longitude and at an altitude of 426.7 m above MSL. The soil was sandy clay loam in texture having pH of 7.6, EC of 0.45 dSm^{-1}, organic carbon of 0.35 per cent, low in available nitrogen (233 kg ha^{-1}) and medium in available phosphorus (14.20 kg ha^{-1}) and high in potassium (406 kg ha^{-1}). The experiment was conducted with the babycorn hybrid G-5414 in a split plot design with five levels of crop geometry *viz*, 60 × 20cm (S_1), 60 × 15cm (S_2), 45 × 20cm (S_3), 45 × 15cm (S_4), 30 × 30cm (S_5) were allotted to main plot and two levels of nitrogen along with foliar spray of iron [100% RDN (N_1), 100% RDN *fb* $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS (N_2), 125% RDN (N_3), 125% RDN *fb* $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS (N_4)] were assigned to sub-plot. The experiment was replicated thrice.

The sowing of babycorn was done into the soil @ one seed per hill at a depth of 2 to 3 cm as per the treatments. The recommended dose of nitrogen (RDN: 150 kg ha^{-1}), phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) in the form of urea, single super phosphate and muriate of potash, respectively were applied uniformly as per the treatments. The nutrients N and K were applied in two equal splits *i.e.*, one at the time of sowing and the other at 25 days after sowing. Full dose of P was applied as basal. Iron is supplied as per the treatments as $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS. All the other package of practices were carried out as per the crop schedule, mentioned in the book "Crop Production Techniques of Horticultural Crops", 2013, by Horticultural College and Reasearch Institute, TNAU, Coimbatore.

Weed observations

Weed density was recorded by talking the weed count at 30 DAS by using 0.25 m^2 quadrate at four places in each plot and expressed as number m^{-2}. The predominant weed flora observed in the experimental field was noted. The dry weight was recorded after air drying the weeds for 8 days followed by oven drying at 105 °C for 24 hours and expressed as g/ m^2.

Green cob yield

The fresh weight of green cobs from the tagged plants in net plots of different treatments from all the three replications was taken and expressed as kilogram per hectare. Harvesting was done in several pickings with an interval of 3-4 days. The number of pickings varied with the season wherein up to four pickings was done during *rabi* and three pickings during summer seasons.

Results and Discussion

Weed flora

The predominant weed flora observed in the experimental field were *Brachiaria reptans, Cyanodon dactylon, Chloris barbata, Dactyloctenium aegyptium, Dinebra retroflexa, Pennisetum cenchroides* among monocots; *Cyperus rotundus* among sedges; *Acalypha indica, Alternenthara sessilis, Amaranthus viridis, Corchorous olitorious, Datura metel, Digera arvensis, Euphorbia prostrata, Parthenium hysterophorous*, *Portulaca oleracea, Trianthema portulacastrum, Vernonia cineraria* among dicots during both the years of investigation.

Table 1: Weed density (No. m^{-2}) as influenced by crop geometry, nitrogen and iron nutrition in babycorn

Treatments	*Rabi*		Summer	
Crop geometry	**2016**	**2017**	**2017**	**2018**
S_1 : 60 cm × 20 cm	10.86	11.22	8.29	8.32
	(117.5)	(125.5)	(68.3)	(68.8)
S_2 : 60 cm × 15 cm	10.63	9.85	8.17	7.76
	(112.5)	(96.5)	(66.3)	(59.8)
S_3 : 45 cm × 20 cm	9.85	8.80	6.80	6.63
	(96.5)	(77.0)	(45.8)	(43.5)
S_4 : 45 cm × 15 cm	8.63	8.00	5.89	5.61
	(74.0)	(63.5)	(34.3)	(31.0)
S_5 : 30 cm × 30 cm	8.94	8.43	6.18	6.00
	(79.5)	(70.6)	(37.8)	(35.5)
SEd	0.12	0.18	0.09	0.11
C.D. (P=0.05)	0.28	0.41	0.21	0.25
N and Fe nutrition				
N_1 : 100% RDN	9.66	9.21	6.99	6.74
	(93.8)	(85.4)	(49.4)	(45.8)
N_2 : 100% RDN + $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS	9.74	9.23	7.01	6.80
	(95.2)	(85.8)	(49.6)	(46.8)
N_3 : 125% RDN	9.82	9.23	7.12	6.97
	(96.6)	(86.3)	(51.2)	(49.4)
N_4 : 125% RDN + $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS	9.91	9.38	7.15	6.94
	(98.4)	(89.0)	(51.6)	(48.8)
SEd	0.15	0.12	0.09	0.13
C.D. (P = 0.05)	NS	NS	NS	NS
Interaction is absent				

Interaction is absent

Figures in parentheses refer to actual weed population and those outside are $\sqrt{X + 0.5}$ transformed value

Weed density

Crop geometry levels exerted significant influence on weed density during both the years. Lower weed density was observed under narrow row spacing (S_4: 45 × 15 cm) compared to wider row spacing (S_1: 60 × 20cm). A lower weed density of 8.94, 8.43, 6.18 and 6.00 No./m^2 was observed with S_4 (45 × 15cm) in *rabi* 2016, *rabi* 2017, summer 2017 and summer 2018 seasons, respectively, while S_1 (60 × 20cm) recorded a higher weed density in all seasons (Table 1). Generally the penetration of light is important for the emergence and growth of weeds. Wider row spacing would permit the light to reach the ground at the early stage of the crop until the crop could cover the land with its leaves. In the present study also, it was true that though there was same population, due to wider interrows, the population of weeds was higher. Thavaprakaash *et al.* (2005) [25]; Rathika *et al.* (2013) [21] also observed similar results.

Weed density did not differ much with the nutrient levels irrespective of the season. There are no much evidences that weed density is influenced by N rate and Fe nutrition.

Interaction effect between the crop geometry and the nutrient treatments on weed density was also observed to be non-significant (Table 1). Similar findings were reported by Kristensen *et al.* (2008) [16] who stated that nitrogen fertilization increased weed biomass and crop biomass but there was little evidence that the relative effects of crop density and spatial pattern on weed suppression were influenced by nitrogen fertilization.

Weed drymatter

Crop geometry levels considerably influenced the weed drymatter in babycorn. Babycorn raised at 45 x 15cm (S_4) crop geometry registered lower weed drymatter over the other crop geometry levels during the study (Table 2). This might be due to early canopy closure and availability of lesser space in narrow row spacing, which suppressed the growth of weeds resulting in lower drymatter accumulation by weeds. These results were in accordance with that of Arvadiya *et al.* (2012) [4] and Dalley *et al.* (2004) [9].

The effect of nutrient treatments on weed drymatter was significant. Among the nutrient treatments, N_1 (100% RDN) had reduced weed drymatter (10.34, 9.05, 5.24 and 6.12 g m^{-2}) at 30 DAS during *rabi* 2016, *rabi* 2017, summer 2017 and summer 2018 seasons, respectively) as compared to N_3 and N_4 but was on par with N_2 (Table 2). With the increase in the nitrogen level, the availability of nitrogen increased, which might have enhanced the growth of the weeds.

Table 2: Weed drymatter (g m^{-2}) as influenced by crop geometry, nitrogen and iron nutrition in babycorn

At 30 DAS												
Treatments	***Rabi* 2016**						***Rabi* 2017**					
	S_1	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
N_1	11.55	11.30	10.52	8.69	9.62	10.34	10.89	10.26	9.36	6.61	8.11	9.05
	(133.0)	(127.3)	(110.2)	(75.0)	(92.0)	(107.5)	(118.0)	(104.8)	(87.2)	(43.2)	(65.2)	(83.7)
N_2	11.70	11.45	10.68	8.82	9.80	10.49	11.12	10.51	9.41	6.67	8.15	9.17
	(136.4)	(130.7)	(113.6)	(77.3)	(95.5)	(110.7)	(123.2)	(110.0)	(88.0)	(44.0)	(66.0)	(86.2)
N_3	12.41	12.17	11.45	9.50	10.41	11.19	12.50	11.96	11.20	8.78	10.17	10.92
	(153.4)	(147.7)	(130.7)	(89.8)	(108.0)	(125.9)	(155.8)	(142.6)	(125.0)	(76.6)	(103.0)	(120.6)
N_4	12.63	12.41	11.50	9.85	10.68	11.42	12.78	11.89	11.12	8.93	10.51	11.05
	(159.1)	(153.4)	(131.8)	(96.6)	(113.6)	(130.9)	(162.8)	(140.8)	(123.2)	(79.2)	(110.0)	(123.2)
Mean	12.07	11.83	11.04	9.22	10.13		11.82	11.16	10.27	7.75	9.24	
	(145.5)	(139.8)	(121.6)	(84.7)	(102.3)		(140.0)	(124.6)	(105.9)	(60.8)	(86.1)	

	***Rabi* 2016**				***Rabi* 2017**			
	S	**N**	**S at N**	**N at S**	**S**	**N**	**S at N**	**N at S**
SEd	0.12	0.16	0.37	0.32	0.18	0.12	0.28	0.41
C.D (P=0.05)	0.31	0.34	0.75	0.67	0.43	0.25	0.57	0.84

At 30 DAS												
Treatments	**Summer 2017**						**Summer 2018**					
	S_1	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**	**S_1**	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
N_1	6.38	5.97	5.19	3.94	4.72	5.24	7.61	6.98	5.87	4.01	6.14	6.12
	(40.2)	(35.2)	(26.4)	(15.0)	(21.8)	(27.7)	(57.4)	(48.2)	(34.0)	(15.6)	(37.2)	(38.5)
N_2	6.52	6.28	5.34	4.16	4.57	5.37	7.85	7.41	6.43	4.18	5.87	6.35
	(42.0)	(39.0)	(28.0)	(16.8)	(20.4)	(29.2)	(61.2)	(54.4)	(40.8)	(17.0)	(34.0)	(41.5)
N_3	6.64	6.73	5.59	4.79	5.07	5.76	8.48	8.07	6.94	6.02	6.43	7.19
	(43.6)	(44.8)	(30.8)	(22.4)	(25.2)	(33.4)	(71.4)	(64.6)	(47.6)	(35.8)	(40.8)	(52.0)
N_4	6.91	6.79	5.67	4.87	5.15	5.88	8.68	8.28	7.41	5.87	6.69	7.38
	(47.2)	(45.6)	(31.6)	(23.2)	(26.0)	(34.7)	(74.8)	(68.0)	(54.4)	(34.0)	(44.2)	(55.1)
Mean	6.61	6.45	5.45	4.44	4.88		8.16	7.68	6.66	5.02	6.28	
	(43.3)	(41.2)	(29.2)	(19.4)	(23.4)		(66.2)	(58.8)	(44.2)	(25.6)	(39.1)	

	Summer 2017				**Summer 2018**			
	S	**N**	**S at N**	**N at S**	**S**	**N**	**S at N**	**N at S**
SEd	0.08	0.08	0.17	0.17	0.10	0.11	0.27	0.23
C.D (P=0.05)	0.18	0.16	0.35	0.35	0.23	0.24	0.55	0.57

Figures in parentheses refer to actual weed population and those outside are $\sqrt{X + 0.5}$ transformed value

(***** RDF for Babycorn: 150-60-40 NPK kg /ha; * RDN : Recommended Dose of Nitrogen)

Similar increase in the drymatter of weeds with increasing level of nitrogen in maize was also reported by Angiras and Singh (1988) [2] and Badiyala *et al*. (1991) [5].

Weed drymatter differed significantly due to the interaction effect between crop geometry and nutrient treatments. Lower weed drymatter was recorded with the treatment combination

S_4N_1 (45 × 15 cm *fb* 100% RDN) which was found to be on par with S_4N_2 while a higher weed density was observed with S_1N_4 in all the seasons of study (Table 2). Increased crop competitiveness resulting in shading of the weeds in narrowly spaced crops might have led to reduced weed growth compared to that of the widely spaced crops. With the increase in fertilization level, both crop and weed were benefitted which led to higher weed biomass from increased nutrients. Similar results were reported by Dalley *et al.* (2004) [9], Fanadzo *et al.* (2007) [11] and Saudy (2013) [23].

Effect on yield

Anticipation of the results showed a positive influence of crop geometry on green cob yield of babycorn. Babycorn raised at 45 × 15cm (S_4) produced a higher cob yield over the other crop geometry levels and S_1 (60 × 20cm) recorded a lower cob yield, regardless of the season (Table 3). The percentage increase in yield of S_4 over S_1 was 67.9, 74.1, 39.8 and 58.6 during *rabi* 2016, *rabi* 2017, summer 2017 and summer 2018 seasons, respectively. In order to exploit the yield potential it is essential to regulate the plant densities to an optimum level by means of a balanced inter and intra row spacing competitiveness without any detrimental effect on the yield. Though the cob yield per plant decreases with increase in plant density, it will be compensated by increased plant population. These results are in conformity with Bairagi *et al.* (2015) [6] and Chamroy *et al.* (2017) [8].

No significant difference was observed due to the nitrogen levels and iron on green cob yield during the study period. Similar results were reported by Thakur and Sharma (1999) [24], Rajendran and Singh (1999) [19] and Sahoo (2011) [22] who stated that increasing levels of nitrogen application up to 180 kg ha^{-1} produced higher cob yield but did not differ significantly with 150 kg ha^{-1} in babycorn. In the present study also, the RDN was 150 kg/ha. When the dose was increased by 25 per cent, the dose was 187.5 kg/ha, which was similar to that of the earlier reports.

Table 3: Green cob yield (kg/ha) of babycorn as influenced by crop geometry, nitrogen and iron nutrition in babycorn

Treatments	*Rabi* 2016						*Rabi* 2017					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
N_1	5631	7021	7052	9160	7208	7214	4953	6381	6514	8377	6656	6576
N_2	5716	7433	7132	9057	7167	7301	5020	6428	6400	8545	6667	6612
N_3	5664	7281	7261	9822	7782	7562	5112	6466	6711	9008	6925	6844
N_4	5705	7393	7471	10100	7729	7680	5066	7050	6628	9148	7064	6991
Mean	5679	7282	7229	9535	7472		5038	6581	6563	8770	6828	

	Rabi 2016				*Rabi* 2017			
	S	N	S at N	N at S	S	N	S at N	N at S
SEd	270	233	521	608	271	218	488	608
C.D (P=0.05)	622	NS	1063	1261	624	NS	997	1262

Treatments	Summer 2017						Summer 2018					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
N_1	4856	5982	5996	7099	5944	5975	3849	5051	5048	6277	5197	5084
N_2	5036	6111	5915	7148	5909	6024	3900	5060	5087	6271	5155	5095
N_3	5145	6065	6055	7277	6331	6175	4145	5057	5173	6394	5269	5208
N_4	5579	6203	6069	7297	6354	6300	4141	5283	5210	6491	5333	5292
Mean	5154	6090	6009	7205	6135		4009	5113	5130	6358	5239	

	Summer 2017				Summer 2018			
	S	N	S at N	N at S	S	N	S at N	N at S
SEd	131	214	479	316	191	191	428	435
C.D (P=0.05)	303	NS	977	649	441	NS	874	899

With regard to interaction, it had a positive effect on green cob yield of babycorn over seasons. Raising of babycorn at 45 × 15cm spacing (S_4) together with application of 125% RDN followed by $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS (N_4) recorded the maximum green cob yield in all the seasons (10100, 9148, 7297 and 6491 kg/ha during *rabi* 2016, *rabi* 2017, summer 2017 and summer 2018 seasons, respectively) and was on par with S_4N_3, S_4N_2 and S_4N_1 (Table 3). For a crop like babycorn, which is harvested at an early stage unlike normal maize, an optimum plant stand is essential for a proper ground cover ensuring efficient utilization of the nutrients to produce higher yields. In the present study, the babycorn raised at 45 × 15cm spacing when supplied with 125% RDN followed by $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS has efficiently utilized the resources resulting in higher yields Similar results were observed by Ameta and Dhakar (2000) [3], Gosavi and Bhagat (2009) [14] and Dar *et al.* (2014) [10].

Conclusion

In conclusion, sowing of babycorn at 45 × 15cm spacing resulted in an optimum plant stand which was effective in minimizing the weed competition and also recorded higher yields over the other spacing levels at all the levels of nutrients. However, not only the dry weights of weeds were observed to be comparatively higher with the increase in the nutrient level but also the baby corn yield. Although Fe didn’t have any significant effect on the yield, it has a role in correcting the iron deficiencies such as chlorosis especially in case of alkaline soils. Thus, we can conclude that application of 100% RDN followed by $FeSO_4$ foliar spray @ 1% at 30 and 45 DAS to the babycorn raised at 45 × 15cm is sufficient for realizing higher yields in babycorn in Tamil Nadu.

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