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Effect of weed control techniques and row spacing on the growth and productivity of *rabi* maize (*Zea mays* L.)

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Abstract

Experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur to quantify the effect of different weed control techniques and row spacing on weed dynamics and productivity of *rabi* maize. The outcome of different combination with the spacing and weed control techniques' influence on plant populations recorded to be significantly higher with the treatment 45cm + atrazine 1.0 kg/ha PE proceeded by power weeder (25-30 DAS) and the treatment proceeded by 45cm + atrazine 1.0 kg/ha PE followed by topramezone 25.2 g/ha, POST. The taller plants were recorded with the treatment 60cm + directed spray of paraquat 500 g/ha at 25 DAS. The treatment 45cm + atrazine 1.0 kg/ha PE proceeded by topramezone 25.2 g/ha, POST also produced considerably higher number of seeds per cob, weight of the cob, no. of rows cob^{-1} and girth of the cob. Overall, the treatment with 45 cm spacing and with the pre-emergent application of atrazine 1.0 kg/ha PE followed by post-emergence application of topramezone 25.2 g/ha produced considerably higher yield. Significantly higher stover yield (7.18 t/ha) was recorded with the treatment 45cm + atrazine 1.0 kg/ha PE proceeded by power weeder (25-30 DAS) and 45cm + atrazine 1.0 kg/ha PE proceeded by topramezone 25.2 g/ha, POST. Lower grain yield and stower yield is observed under weedy check.

Keywords: Power weeder, topramezone, paraquat, atrazine

Introduction

Maize is one of the most important cereal crops for in India. It is planted during the *kharif*, *rabi* (in peninsular India and Bihar), and spring (in northern India). It is still largely a *kharif* season crop, not withstanding the recent rise of *rabi* maize in India's overall maize production. It is produced on approximately 201 M Ha worldwide, with 5754.7 kg/ha productivity, and has a wider range of soil, climate, biodiversity, and management techniques (FAOSTAT 2020) [7]. Around 10% of the nation's food grain production is maize. India produced 31.51 million tonnes across a 9.9-million-hectare area in 2020–21.

In maize, chemical weed management is preferable to hand weeding since it is less expensive, quicker, and provides greater control. Herbicides have been a great help, and their broad use has been immediately accepted by farmers as a significantly more effective method of weed management. A selective herbicide might be used that can control the weeds without damaging the crops. Integrated weed control can result in sustainable food production, less toil, and lower crop weed removal costs. IWM components that might be employed for successful weed management on smallholder farms include low pesticide dosages, cover crops, mulching, mechanical approaches, and high crop density.

To attain the potential production level, thorough weed management is essential. Weed management is practised for as long as agriculture has been, yet its methods and philosophy have developed over time. The existing weed management methods in India are characterised by a high dependence on manual work and animal power. They are both in short supply and becoming increasingly unviable. Not only is hand weeding tedious and labour-intensive, it is also unsuccessful. It is usually unfeasible due to poor soil conditions. As a result, combining chemical herbicides with cultural practises for business is rapidly increasing across the country, causing a slew of environmental difficulties in the process. The combination of physical/cultural control and pesticide use improves soil conditions, allowing for more cost-effective weed management. In addition, optimal plant spacing streamlines field operations, decreases plant competition for nutrients, water, and light, and promotes an appropriate microclimate in the plant canopy to reduce the risk of infection and infestation (Lauer, 1994) [11].

As a result, an integrated approach is required to meet the country's evolving weed control issue. Taking these facts into consideration, a field study entitled "Effect of row spacing and weed management practises on the growth and productivity of *rabi* maize (*Zea mays* L.)" was conducted.

Materials and Methods

The study was carried out during *rabi* 2022-23 at University Instructional-cum-Research Farm, IGKV, Raipur at 21°.25' N latitude and 81°.62' E longitude (Fig. 1). Table 1 lists the experiment's treatment specifics. The experiment was conducted in randomized block design with 16 treatments replicated thrice.

Fig 1: The experimental site

Table 1: The experiment's treatment specifics

Sr. No.	Treatments
T_1	45cm + power weeder at 25 DAS
T_2	60cm + power weeder at 25 DAS
T_3	45cm + power weeder at 25 DAS *followed by* intra-row weeding
T_4	60cm + power weeder at 25 DAS *followed by* intra-row weeding
T_5	45cm + atrazine 1.0 kg/ha PE *followed by* power weeder (25-30 DAS)
T_6	60cm + atrazine 1.0 kg/ha PE *followed by* power weeder (25-30 DAS)
T_7	45cm + atrazine 1.0 kg/ha PE *followed by* topramezone 25.2 g/ha, POST
T_8	60cm + atrazine 1.0 kg/ha PE *followed by* topramezone 25.2 g/ha, POST
T_9	45cm + directed spray of paraquat 500 g/ha at 25 DAS
T_{10}	60cm + directed spray of paraquat 500 g/ha at 25 DAS
T_{11}	45cm + live-mulch of cowpea upto fruiting
T_{12}	60cm + live-mulch of cowpea upto fruiting
T_{13}	45cm + hand weeding at 20 and 40 DAS
T_{14}	60cm + hand weeding at 20 and 40 DAS
T_{15}	Weedy check for 45 cm
T_{16}	Weedy check for 60 cm

DAS= Days after sowing

At the crop harvest, the no. of plants was measured/m of row length. Average plant population was calculated. Each plot's crop stand was counted at random from five locations using a one-meter scale. Each plot's five tagged plants had their height measured in cm. At harvesting, five plants marked were used to count the cobs, and the mean no. of cobs per plant was computed. The number of seeds per cob and the average no. of seeds per plant were counted from the marked plants. At harvest, cobs were weighed from five tagged plants in each net plot, and the average weight per plant was calculated. The length and the girth of the cob was measured using vernier callipers and is expressed in cm. Grain yield obtained from each cob was used to compute green cob yield and expressed in kg/ha. The stover yield of the tagged plants were calculated by subtraction of seed yield from bundle weight and expressed in kg/ha.

Results and Discussion

The outcome of different combination in spacing and effects of weed control methods on plant population was found to be significant higher with the treatment T_5 at the time of harvest followed by T_7. The taller plants were recorded with the treatment T_{10} (Table 2). The treatment Weedy check for 60 cm recorded significantly lower plant population of 11.40 and lower plant height of 189.33 cm. Similar findings were recorded by other research that the treatments including hand weeding and intercropping twice, at 15 & 30 DAS, pre-emergent application of atrazine 0.5 kg/ha along with manual weeding and intercropping at 30 DAS, and pre-emergent application of pendimethalin 0.9 kg/ha + hand weeding and intercropping at 30 DAS produced better plant height over weedy check (Barad *et al.*, 2016; Chetariya, 2017; Singh *et al.*, 2021) [3, 5, 19].

Almost all the treatments were having significantly higher number of cobs per plant other than T_{13} and T_{14}. The treatment T_7 recorded significantly higher number of seeds per cob (523), higher weight of the cob (219.83 g) and girth of the cob (15.68 cm). The treatment recorded considerably higher no. of rows per cob in treatment T_5 was on par with treatment T_7. The treatment T_{13} recorded significantly higher cob length of 21.40 cm (Table 3). The treatment weedy check for 45 cm and weedy check for 60 cm recorded significantly lower plant parameters when compared to other treatments.

The higher no. of cobs/plant of 1.43 with 45 x 20 cm over 60 x 15 cm spacing was recorded by Mathukia *et al.* (2014) [14] when the spacing of. The treatments hand weeding and intercropping twice, at 15 and 30 DAS, pre-emergent application of atrazine 0.5 kg/ha and manual weeding and intercropping at 30 days after sowing, and pre-emergent application of pendimethalin 0.9 kg/ha + manual weeding and intercropping at 30 days after sowing produced higher no. of cobs plant^{-1}(Barad *et al.*, 2016) [3]. Bajeetunnisa *et al*. (2020) [1] published that the application of herbicides at 50 cm of spacing gave maximum no. of grains/cob. Considerably maximum cob weight (130.24 g) was also achieved through one HW at 30 DAS by Samanth *et al.*, (2015) [17]. While, heavier cobs were obtained with the application of atrazine 1.25 kg a.i. ha^{-1} (PE) proceeded by one hoeing at 30 DAS was reported by Kumar (2017) [10]. Similar results were reported by Dar *et al.*, (2014) that tighter planting geometry of 50 x 15 cm produced largest girths over 50 x 20, 60 x 15 and 60 x 20 cm. The longest cob (23.01 cm) reported with manual weeding done twice and two intercultural operations taken at 15 and 30 days after sowing, atrazine 0.5 kg/ha as pre-emergence + hand weeding at 30 DAS and pendimethalin 0.9 kg/ha as pre-emergent spray and one manual weeding at 30 days after sowing was reported by Chetariya, 2017 [5]. Significantly higher test weight 20.62 g per 100 grains was also reported in maize with the treatment atrazine 0.5 kg/ha + manual weeding twice (15 and 30 days after sowing) by Prasad *et al.*, (2008) and with intercultural operation at 35 DAS by Mundra *et al.*, (2003) [16].

Data on weed control efficiency of various weed management practices at 20, 40, 60 and 80 DAS for 45 cm and 60 cm are presented in Table 4. At 20 and 80 DAS for 45 cm spacing the treatment atrazine 1.0 kg ha^{-1} PE *fb* topramezone 25.2 g ha^{-1}, POST (T_7) and for 60 cm spacing the treatment atrazine 1.0 kg ha^{-1} PE *fb* topramezone 25.2 g ha^{-1}, POST (T_8) recorded significantly highest weed control efficiency. At 40 DAS for 45 cm spacing the treatment atrazine 1.0 kg ha^{-1} PE *fb* topramezone 25.2 g ha^{-1}, POST (75.57%) and for 60 cm spacing, atrazine 1.0 kg ha^{-1} PE *fb* topramezone 25.2 g ha^{-1}, POST (64.95%) was found to be most effective treatment in controlling the weeds. Treatment having 60cm + power weeder at 25 DAS *fb* intra-row weeding (T_4) was found to be comparable to that of T_8. At 60 DAS, 45 cm spacing (T_7) and 60 cm spacing (T_6) was found to have higher weed control efficiency. The lowest weed control was recorded with the treatment weedy check.

Larger grain yield was observed when maize planted at closer spacing, and compared to wider spacing. Closer the spacing, the space for weed growth is reduced and henceforth, higher the crop yield. These results were in accordance with the sweet corn hybrid yield with 40 x25 cm over 60 and 50 cm (Bhatt, 2012) [4]. Overall, when maize planted with 45 cm spacing, produced higher grain yield (T_1, T_3, T_5, T_7, T_9, T_{11}, T_{13}) as compared to maize planted with 60 cm spacing (T_2, T_4, T_6, T_8, T_{10}, T_{12}, T_{14}) irrespective of weed management treatments. Similarly, many researchers have recorded higher yield under closer spacing when compared to wider spacing (Gollar and Patil, 2000; Kar and co-authors, 2006; Shakarami and Rafiee, 2009; Balkcom and co-authors, 2011; Modolo and co-authors, 2014) [8, 9, 18, 2, 15].

Considerably greater grain yield of maize (5.67 t/ha) was obtained with the treatment T_7 which was significantly superior over other treatments except T_3, T_5, and T_{13} irrespective of weed management practices. However, using atrazine with same spacing but in place of topramezone if we use power weeder T_5 (5.58 t/ha) recorded the comparable yield with T_7. Maize planted with 45cm + hand weeding at 20 and 40 DAS also produced the comparable yield. The application of herbicides atrazine at 0.5 kg a. i./ha followed by topramezone at 25.2 g a. i./ha was effective in controlling weeds in maize as compared to application of atrazine alone and was comparable with hand weeding twice at 20 and 45 DAS (Lavanya *et al.*, 2022) [12]. Similar results were recorded that higher grain yield reported with topramezone and atrazine @ 25.2 + 250 g a. i. ha^{-1} as PoE (Swetha, 2015; Madhavi *et al.*, 2013) [20, 13]. Overall, the treatment with the spacing of 45 cm along with the pre-emergence application of atrazine 1.0 kg/ha PE *proceeded by* post-emergence application of topramezone 25.2 g/ha (T_7) produced significantly higher grain yield. The post-emergence application of atrazine 1.0 kg/ha PE *proceeded by* power weeder at 25-30 days after sowing (T_5) and the treatment with the spacing of 45cm followed by hand weeding at 20 and 40 DAS (T_{13}) were at par with T_7. weedy check for closer spacing of 45cm and wider spacing of 60cm had lowest crop yield respectively. Tripathi *et al.*, (2005) [21] also found significantly higher yield of maize with the treatment's atrazine 0.5 kg/ha with 1 manual weeding at 30 days after owing (3146 kg/ha) and manual weeding (Table 3).

Considerably greater stower output of 7.18 t ha^{-1} was recorded with the treatment T_5 and the treatment T_7 recorded the stower of 7.13 t ha^{-1}. Significantly lower stover yield was recorded with the treatment T_{10} (Table 3).

Table 2: Effect of spacing and weed management practices on plant population and plant height of *rabi* maize at different

Treatments		Plant population	Plant height (cm)
T1	45cm + power weeder at 25 DAS	15.40^{c}	196.53^{bcde}
T2	60cm + power weeder at 25 DAS	11.80^{g}	181.73^{e}
T3	45cm + power weeder at 25 DAS *followed by* intra-row weeding	15.40^{c}	207.87^{abc}
T4	60cm + power weeder at 25 DAS *followed by* intra-row weeding	11.73^{gh}	212.47^{ab}
T5	45cm + atrazine 1.0 kg/ha PE *followed by* power weeder (25-30 DAS)	15.87^{a}	203.53^{abcd}
T6	60cm + atrazine 1.0 kg/ha PE *followed by* power weeder (25-30 DAS)	11.60^{h}	205.67^{abcd}
T7	45cm + atrazine 1.0 kg/ha PE *followed by* topramezone 25.2 g/ha, POST	15.60^{b}	192.53^{cde}
T8	60cm + atrazine 1.0 kg/ha PE *followed by* topramezone 25.2 g/ha, POST	11.80^{g}	192.27^{cde}
T9	45cm + directed spray of paraquat 500 g/ha at 25 DAS	14.07^{e}	213.40^{ab}
T10	60cm + directed spray of paraquat 500 g/ha at 25 DAS	10.80^{j}	218.80^{a}
T11	45cm + live-mulch of cowpea upto fruiting	15.40^{c}	200.67^{abcde}
T12	60cm + live-mulch of cowpea upto fruiting	12.00^{f}	212.73^{ab}
T13	45cm + hand weeding at 20 and 40 DAS	15.00^{d}	202.27^{abcd}
T14	60cm + hand weeding at 20 and 40 DAS	11.60^{h}	198.40^{bcde}
T15	Weedy check for 45 cm	15.47^{bc}	187.53^{de}
T16	Weedy check for 60 cm	11.40^{i}	189.33^{cde}
S.Em ±		0.19	6.63
CD (5%)		0.18	19.14

Table 3: Effect of spacing and weed management practices on plant parameters of *rabi* maize

Treatments		No of cobs per plant	No of seeds per cob	Weight of the cob (g)	Length of the cob (cm)	Girth of the cob (cm)	No of rows per cob	Grain yield (t ha^{-1})	Stowed yield (t ha^{-1})
T1	45cm + power weeder at 25 DAS	1.93^{a}	492^{abc}	198.33^{abcd}	19.52^{cde}	15.27^{abcd}	33.93^{abcd}	4.70^{cdef}	6.00^{def}
T2	60cm + power weeder at 25 DAS	1.87^{a}	488^{abc}	166.33^{def}	18.33^{gh}	15.25^{abcd}	33.73^{abcd}	4.17^{fg}	5.60^{f}
T3	45cm + power weeder at 25 DAS *followed by* intra-row weeding	1.95^{a}	470^{bcd}	212.00^{abc}	20.23^{bcd}	15.31^{abc}	34.5^{abc}	5.13^{abc}	6.42^{cd}
T4	60cm + power weeder at 25 DAS *followed by* intra-row weeding	1.93^{a}	455^{cde}	194.03^{abcde}	18.80^{efg}	15.13^{abcdef}	34.3^{abc}	4.53^{def}	5.93^{ef}
T5	45cm + atrazine 1.0 kg/ha PE *followed by* power weeder (25-30 DAS)	2.00^{a}	516^{ab}	218.20^{a}	21.30^{a}	15.53^{ab}	36.13^{a}	5.58^{ab}	7.17^{a}
T6	60cm + atrazine 1.0 kg/ha PE *followed by* power weeder (25-30 DAS)	1.93^{a}	427^{de}	200.33^{abcd}	18.01^{gh}	14.63^{defg}	33.43^{abcde}	5.08^{bcd}	6.58^{bc}
T7	45cm + atrazine 1.0 kg/ha PE *followed by* topramezone 25.2 g/ha, POST	1.90^{a}	523^{a}	219.83^{a}	20.90^{ab}	15.68^{a}	35.63^{a}	5.67^{a}	7.13^{a}
T8	60cm + atrazine 1.0 kg/ha PE *followed by* topramezone 25.2 g/ha, POST	1.93^{a}	459^{cde}	199.65^{abcd}	18.78^{efg}	15.16^{abcde}	31.9^{bcde}	4.82^{cde}	6.12^{cde}
T9	45cm + directed spray of paraquat 500 g/ha at 25 DAS	1.87^{a}	473^{bcd}	160.37^{efg}	19.59^{cde}	14.99^{bcdefg}	32.93^{abcde}	3.37^{h}	4.38^{g}
T10	60cm + directed spray of paraquat 500 g/ha at 25 DAS	1.93^{a}	432^{de}	126.30^{g}	18.53^{fg}	14.51^{fg}	31.67^{cde}	2.75^{i}	3.52^{h}
T11	45cm + live-mulch of cowpea upto fruiting	1.90^{a}	454^{cde}	177.00^{cdef}	19.33^{def}	15.23^{abcd}	31.53^{cde}	3.67^{gh}	4.73^{g}
T12	60cm + live-mulch of cowpea upto fruiting	1.97^{a}	450^{cde}	155.34^{fg}	18.79^{efg}	14.57^{efg}	31.47^{cde}	3.33^{h}	4.30^{g}
T13	45cm + hand weeding at 20 and 40 DAS	1.93^{a}	513^{ab}	217.03^{ab}	21.40^{a}	15.60^{ab}	35.4^{ab}	5.55^{ab}	6.90^{ab}
T14	60cm + hand weeding at 20 and 40 DAS	1.67^{b}	475^{abcd}	181.80^{bcdef}	20.43^{abc}	15.25^{abcd}	33.33^{abcde}	4.38^{ef}	5.60^{f}
T15	Weedy check for 45 cm	1.64^{b}	420^{e}	156.27^{fg}	17.87^{gh}	14.72^{cdefg}	30.48^{de}	2.62^{i}	3.70^{h}
T16	Weedy check for 60 cm	1.93^{a}	419^{e}	154.00^{fg}	17.37^{h}	14.37^{g}	30.17^{e}	2.25^{i}	3.62^{h}
S.Em ±		0.06	17	12.60	0.34	0.22	1.71	8.05	5.09
CD (5%)		0.18	49	36.38	0.98	0.64	3.50	0.57	0.47

Table 4: Weed control efficiency (%) at 20, 40, 60 and 80 DAS

Treatments		20 DAS	40 DAS	60 DAS	80 DAS
T1	45cm + power weeder at 25 DAS	39.13	58.15	61.80	56.97
T2	60cm + power weeder at 25 DAS	38.15	53.93	60.61	55.88
T3	45cm + power weeder at 25 DAS *fb* intra-row weeding	54.28	66.69	73.81	66.69
T4	60cm + power weeder at 25 DAS *fb* intra-row weeding	53.00	64.38	71.76	60.32
T5	45cm + atrazine 1.0 kg ha^{-1} PE *fb* power weeder (25-30 DAS)	63.77	70.80	86.21	67.32
T6	60cm + atrazine 1.0 kg ha^{-1} PE *fb* power weeder (25-30 DAS)	60.37	62.13	79.11	61.44
T7	45cm + atrazine 1.0 kg ha^{-1} PE *fb* topramezone 25.2 g ha^{-1}, POST	72.68	75.57	87.43	72.64
T8	60cm + atrazine 1.0 kg ha^{-1} PE *fb* topramezone 25.2 g ha^{-1}, POST	63.02	64.95	76.98	64.50
T9	45cm + directed spray of paraquat 500 g ha^{-1} at 25 DAS	39.13	60.20	51.37	63.40
T10	60cm + directed spray of paraquat 500 g ha^{-1} at 25 DAS	39.89	58.78	50.41	55.25
T11	45cm + live-mulch of cowpea upto fruiting	40.87	62.30	59.58	62.83
T12	60cm + live-mulch of cowpea upto fruiting	36.92	57.94	58.08	61.70
T13	45cm + hand weeding at 20 & 40 DAS	46.89	66.84	83.98	69.15
T14	60cm + hand weeding at 20 & 40 DAS	58.24	62.15	71.08	65.01
T15	Weedy check for 45 cm	-	-	-	-
T16	Weedy check for 60 cm	-	-	-	-

Conclusion

Maize yield was considerably impacted by spacing and various weed control practises. When compared to maize planted at 60 cm intervals, maize planted at 45 cm intervals yielded the maximum grain yield. Because closer spacing prevents the density of weeds which minimizes the amount of crop weed competition, this results in enhanced production. The no. of seeds per cob, weight per cob, girth cob^{-1} and the no. of rows per cob were all considerably greater when chemical herbicides, such as atrazine + topramezone, were used. Herbicides work swiftly to kill weeds that are detrimental to crop growth because they compete with crops for water, nutrients, and light, release toxins, modify soil and air temperatures, and harbour pests. Overall, as compared to other treatments, the 45 cm + atrazine 1.0 kg/ha PE *followed by* and topramezone 25.2 g/ha treatment had improved plant metrics.

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