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Research Article

Growth and Yield of Quality Protein Maize (*Zea mays* L.) as Influenced by Weed and Nutrient Management

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ABSTRACT

A field experiment was conducted during kharif and rabi seasons of 2015-16 and 2016-17 at Udaipur to evaluate the effect of weed and nutrient management on quality protein maize.The experiment consisted of nine weed management treatments viz., weedy check, hand weeding at 15 DAS and 35 DAS, tembotrione 0.125 kg ha^{-1} at 20 DAS, alachlor 2 kg ha^{-1} as PE fb hand weeding at 35 DAS, atrazine 0.5 kg ha^{-1} as PE fb hand weeding at 35 DAS, tembotrione 0.125 kg ha^{-1} at 20 DAS fb hand weeding at 35 DAS, alachlor 2 kg ha^{-1} + atrazine 0.5 kg ha^{-1} as PE fb hand weeding at 35 DAS, alachlor 2 kg ha^{-1} as PE fb tembotrione 0.125 kg ha^{-1} at 20 DAS and atrazine 0.5 kg ha^{-1} as PE fb tembotrione 0.125 kg ha^{-1} at 20 DAS with three nutrient management treatments viz., NPK, NPK+Zn and NPKS+Zn, thereby making 27 treatment combinations. The experiment was laid out in split plot design, assigning weed management to main plots and nutrient management to sub plots. The treatments were replicated thrice. Maize cv. Pratap QPM-1 was used as test crop. Maximum reduction of weed density and dry matter as well as highest weed control efficiency (72.07 %) was recorded in crop subjected to atrazine fb tembotrione closely followed by alachlor fb tembotrione and two hand weeding at 15 and 35 DAS. atrazine fb tembotrione recorded the maximum growth characters and produced significantly higher grain (4516 kg ha^{-1}) and stover (7459 kg ha^{-1}) yield compared to other treatments. Nutrient management had no significant effect on weed density while weed dry matter was significantly affected by different nutrients during both the years. Nutrient application of NPKS+Zn significantly improved various growth parameters, viz., plant height and dry matter at successive growth stages and recorded significantly higher grain (4275 kg ha^{-1}) and stover (7227 kg ha^{-1}) yield.

Keywords: *Atrazine, Alachlor, Tembotrione, Quality protein maize, Weed management, Nutrient management, Grain yield, Stover yield.*

INTRODUCTION

Maize (*Zea mays* L.) also called as the queen of cereals, is one of the major cereal crops with wide adaptability under various diversified agro-climatic edaphic conditions around the world. In this crop, the content of essential amino acids *viz.*, lysine and tryptophan is low while leucine and isoleucine content is high (Jat et al., 2013).

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The QPM is a hybridized variety of maize specially bread by addition of *Opaque* -2 mutant gene, which improve lysine and tryptophan and reduce leucine and isoleucine contents and produce quality protein with balanced composition of amino acids (Prasanna et al., 2001). Major area of maize in India is during *kharif* season in which weed is one of the most important yield limiting factor and significantly reduces the yield. Maize is infested by a wide range of weed flora, *viz., Echinochloa colona, Cyperus rotundus, Cynodon dactylon, Commelina benghalensis, Digera arvensis and Trianthema portulacastrum* dominate during early stages of the crop growth and toward the tasseling and maturity of the crop (Saini & Angiras, 1998). However, the most critical period for crop weed competition are first six weeks after planting of crop which may reduce yield by 28-100% (Dass et al., 2012). During this critical period weeding is essentially required by either chemical or non-chemical means. Weeding by hands (labour) and mechanical means are expensive and many a times timely operations are not possible due to continuous rains in monsoon season. However, application of single herbicide does not provide satisfactory weed control for the desired period. Atrazine and alachlor have been widely recommended for effective control of weeds in maize (Tahir et al., 2011). Atrazine, recommended as a pre-emergence herbicide, is not effective against some of the weeds, both grassy and non-grassy as well as the sedge *Cyperus rotundus* (Singh et al., 2015). Hence, there is need for some alternate post-emergence herbicide like tembotrione which can provide broad spectrum weed control in *kharif* maize without affecting the crop growth and yield of crop (Singh et al., 2012 b). Nutrient management also plays key role in sustaining the productivity of this system, QPM is high nutrient requiring ones and respond well to higher levels of chemical fertilizers. Quality protein maize is a nitrogen exhaustive crop and requires very high dose of the nutrient (Singh, 2010 & Om et al., 2014). Thus higher yield of QPM can be obtained through the judicious and higher uses of two major nutrients (N and P) as these two nutrients alone contribute 40-60 per cent of the crop yield (Das et al., 2010). Among the secondary and micronutrients, S and Zn have also a specific vital role in growth and development of crops (Duraisami et al., 2007). It is proven fact that productivity of any crop cannot be further increased by use of high doses of fertilizer alone. So the nutrient management with balanced use of nutrients increases the yield and also maintains soil health.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* and *rabi* seasons of 2015-16 and 2016-17 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur. The site is situated at South-Eastern part of Rajasthan at an altitude of 579.5 metre above mean sea level with 24º35’ N latitude and 74°42’ E longitude. The region falls under agro-climatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. This zone possesses a typical sub-tropical climatic conditions characterized by mild winters and moderate summers associated with high relative humidity. The mean annual rainfall of the region is 637 mm. Soil of experimental site was clay loam in texture and slightly alkaline in reaction (pH 8.1 and 8.0) and medium in available nitrogen (285.0 and 279.61 kg ha^{-1}) and phosphorus (20.42 and 19.27 kg ha^{-1}) and high in available potassium (324.16 and 318.15 kg ha^{-1}) and low in available sulphur (9.7 and 9.3 kg ha^{-1}) during both the years *i.e.*, 2015-16 and 2016-17, respectively. The experiment consisted of nine weed management treatments *viz*., weedy check, hand weeding at 15 DAS and 35 DAS, tembotrione 0.125 kg ha^{-1} at 20 DAS, alachlor 2 kg ha^{-1} as PE *fb* hand weeding at 35 DAS, atrazine 0.5 kg ha^{-1} as PE *fb* hand weeding at 35 DAS, tembotrione 0.125 kg ha^{-1} at 20 DAS *fb* hand weeding at 35 DAS, alachlor 2 kg ha^{-1} + atrazine 0.5 kg ha^{-1} as PE *fb* hand weeding at 35 DAS, alachlor 2 kg ha^{-1} as PE *fb* tembotrione 0.125 kg ha^{-1} at 20 DAS and atrazine 0.5 kg ha^{-1} as PE *fb* tembotrione 0.125 kg ha^{-1} at 20 DAS with three nutrient management treatments *viz*., NPK, NPK+Zn and NPKS+Zn, thereby making 27 treatment combinations. The experiment was laid out in split plot design, assigning weed management to main plots and nutrient management to sub plots. The treatments were replicated thrice. Maize cv. Pratap QPM-1 was used as test crop, sown at the seed rate of 20 kg ha^{-1} at inter row of 60 and plant to plant spacing of 25 cm. Furrows were opened through desi plough and seeds were sown manually at the depth of 5 cm. As per the treatment full dose of phosphorus, potash, sulphur and zinc and half dose of nitrogen were applied at sowing by drilling in crop rows through urea, DAP, mineral gypsum and zinc sulphate. The remaining dose of nitrogen was top dressed at knee height stage through urea. As per treatment, both atrazine and alachlor were sprayed one day after sowing (as pre-emergence) while tembotrione was applied twenty days after sowing (as post-emergence) with knapsack sprayer. In each plot narrow and broad leaved weeds were counted from two randomly selected area of 0.25 m^2 using 0.5 m x 0.5 m quadrate and expressed as number m^{-2}. The mean data were subjected to square root transformation $\sqrt{(x+0.5)}$ to normalize their distribution. These weeds were dried at 65 ^{0}C temperature in oven till a constant weight was obtained which was expressed as weed dry matter in terms of g m^{-2}.

Five plants were selected randomly, tagged in each plot and height was measured from ground level to tip of tassel at 30 DAS and at harvest by metre scale at maturity and average height was worked out in centimetres. The dry matter accumulation plant^{-1} was recorded at 30, 60 DAS and at harvest by uprooting five randomly selected plants from each plot. These samples (i.e. above ground plant parts) were placed in perforated paper bags followed by sun drying for two days and finally kept in oven at 65 ^{o}C till a constant weight was noted. Dry matter accumulation plant^{-1} was computed for each treatment at each stage and it was expressed as g plant^{-1}. After shelling and winnowing grain yield of each net plot was weighed separately and recorded as grain yield in kg plot^{-1}. Thereafter, it was converted to kg ha^{-1}. After picking cobs, the sun dried stover from net plot was weighed for individual plot and final stover yield was expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Effect on weeds

In two years of field study, QPM was mainly infested with mixed flora of narrow and broad-leaved weeds *viz.*, *Echinochloa colona* (L.), *Cynodon dactylon* (L.), *Cyperus rotundus* (L.), *Dinebra retroflexa* (Vahl) Panz., *Brachiaria reptans* (L.), *Amaranthus viridis* (L.), *Digera arvensis* (Forsk.), *Trianthema portulacastrum* (L.) and *Commelina benghalensis* (L.). All the weed management treatments caused significant reduction in weed density of narrow-leaved weeds, broad-leaved weeds and total weeds as well as their dry matter accumulation at various growth stages during both the years of study. During both the years, atrazine *fb* tembotrione was found the most effective in order to reduce the density and dry matter of all categories of weeds at all stages compared to other treatments. The data of weed density and dry matter at all stages indicated overall superiority of atrazine *fb* tembotrione followed by alachlor *fb* tembotrione, two hand weedings and alachlor+atrazine *fb* hand weeding (Table 1, 2 & 3). The herbicide combination of atrazine *fb* tembotrione was more effective and had activity on a wide spectrum of weeds including grasses and broad leaved weeds in maize. Atrazine belongs to triazines group of herbicides which are widely known to inhibit growth of emerged seedlings. Alachlor applied as pre-emergence inhibit seed germination by interfering with the metabolic activities *i.e.* inhibition of α-amylase and protease production induced by GA_3. Tembotrione is currently registered as an important post-emergence herbicide use in corn and has showed quite satisfactory results on weed control, particularly for grasses (Waddington & Young, 2006). As a member of the triketone family of active ingredients, tembotrione shows properties of a weak acid and HPPD inhibitor. Two hand weeding at 15 and 35 DAS removed the weeds completely and created condition more favourable for crop growth and ultimately resulted in the lowest density of later emerged weeds and their lowest biomass with higher weed control efficiency during the crop growth period. Among all the herbicide treatments atrazine *fb* tembotrione recorded the highest weed control efficiency (72.07 %) followed by alachlor *fb* tembotrione and two hand weeding (Table 4). The possible reason might be due to the fact that performance of crop is directly proportional to the weed control efficiency. The higher weed control efficiency under these treatments could be attributed to the lower weed population and total weed dry matter as well. The results corroborated with the findings of Sunitha et al. (2010), Nadiger et al. (2013), Idziak and Woznica (2014), Sanodiya et al. (2014), Kumar and Jha (2015), Swetha et al. (2015), Stanzen et al. (2016) and Rana et al. (2017). Varying nutrient management treatments failed to affect the weed density as well as dry matter (Table 1, 2 & 3) in either of the years. Profound effect of different nutrient management treatments on weeds has also been reported by Choudhary et al. (2013) and Owla et al. (2015).

Effect on crop

Weed management treatments adopted during both the years of experimentation caused significant increase in all growth parameters of QPM *i.e.* plant height, crop dry matter accumulation, CGR and RGR at respective stages of observation compared to weedy check. Increase in overall growth of crop at all stages of observation was mainly due to significant reduction in weed competition, which otherwise would have interfered with the crop for incident solar radiation, nutrients and moisture. Competition for incidence photosynthetic phyton flux density (PPFD) in mixed maize communities is a major factor affecting crop yield (Tollenaar et al., 1994). The results of the investigation reflect that various weed control treatments provided significant improvement in growth parameters of maize crop. Higher plant height, CGR, RGR and greater accumulation of dry matter by crop plants under weed control treatments is an indirect effect on account of least competition for plant growth inputs *viz.*, light, space, water and nutrients etc. Under reduced density and dry matter of weeds, plants get sufficient space for optimum expansion of leaves and branches as early as possible (Gupta, 2012). Thus, under least crop-weed competition, adequate availability of light, optimum temperature, space along with improvement in physiological and morphological characters of the plants can be reasoned for greater photosynthetic rate thereby more accumulation of dry matter (Duncan, 1971 & Korpff, 1993). This is well established by presence of significant negative correlation between crop and weed dry matter at successive growth stages. All weed control measures increased growth parameters of crop at successive stages over weedy check. Among the treatments, atrazine *fb* tembotrione recorded the maximum growth characters followed by alachlor *fb* tembotrione and two hand weeding (Table 5&6). The superiority of these treatments was because of better control of all categories of weeds which resulted in reduced weed competition with crop. Results so obtained are in close conformity with the finding of Singh et al. (2007), Rao et al. (2009), Verma et al. (2009) and (Barad et al., 2015).

Economic yield is a function of dry matter accumulation, efficiency to translocate photosynthates from assimilatory area to sink to accumulate in different plant parts and ultimately on yield attributing traits. By controlling weeds with the use of different measures significantly higher grain and stover yield were recorded during both the years of investigation (Table 6). Atrazine *fb* tembotrione followed by alachlor *fb* tembotrione and two hand weeding was found significantly superior in this regard. The increased grain and stover yields were obviously the results of better weed management. Owla et al. (2015), Kour et al. (2016) and Rana et al. (2017) also reported similar results. Across the years different nutrient management treatments resulted in increased grain and stover yield of QPM and application of NPKS+Zn gave maximum grain and stover yield during both the years of experimentation (Table 7). Significant increase in grain and stover yield due to application of NPKS+Zn could be ascribed to the fact that yield of the crop is a function of several yield components. The results of present investigation indicated higher production of maize under influence of balanced fertilization are in close conformity with findings of Jena et al. (2013), Paramesh et al. (2014), Gul and Kanday (2015) and Joshi et al. (2016).

Table 1: Effect of weed management and nutrient management on weed density at 60 DAS

Treatments	Weed density (No. m^{-2})								
	Narrow-leaved weeds			Broad-leaved weeds			Total weeds		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Weed management									
Weedy check	13.97 (194.87)	13.50 (181.86)	13.74 (188.36)	11.32 (127.78)	10.48 (109.31)	10.90 (118.55)	17.97 (322.65)	17.08 (291.17)	17.52 (306.91)
and weeding 15 & 35 DAS	6.02 (35.83)	5.90 (34.31)	5.96 (35.07)	6.06 (36.27)	5.90 (34.39)	5.98 (35.33)	8.51 (72.09)	8.32 (68.70)	8.41 (70.40)
Tembotrione	7.16 (50.77)	7.05 (49.21)	7.10 (49.99)	6.87 (46.78)	6.82 (46.02)	6.85 (46.40)	9.90 (97.55)	9.78 (95.23)	9.84 (96.39)
Alachlor *fb* hand weeding	6.80 (45.78)	6.72 (44.62)	6.76 (45.20)	6.62 (43.37)	6.55 (42.44)	6.59 (42.90)	9.47 (89.15)	9.36 (87.05)	9.41 (88.10)
Atrazine *fb* hand weeding	6.71 (44.57)	6.62 (43.41)	6.67 (43.99)	6.49 (41.72)	6.43 (40.84)	6.46 (41.28)	9.31 (86.29)	9.20 (84.25)	9.26 (85.27)
Tembotrione *fb* hand weeding	7.01 (48.74)	6.95 (47.82)	6.98 (48.28)	6.80 (45.74)	6.72 (44.72)	6.76 (45.23)	9.74 (94.48)	9.64 (92.54)	9.69 (93.51)
Alachlor+atrazine *fb* hand weeding	6.32 (39.54)	6.24 (38.44)	6.28 (38.99)	6.26 (38.76)	6.10 (36.71)	6.18 (37.73)	8.87 (78.30)	8.70 (75.15)	8.78 (76.72)
Alachlor *fb* Tembotrione	6.09 (36.58)	6.00 (35.53)	6.04 (36.06)	6.16 (37.48)	6.00 (35.51)	6.08 (36.50)	8.63 (74.07)	8.46 (71.04)	8.54 (72.56)
Atrazine *fb* Tembotrione	5.94 (34.76)	5.77 (32.85)	5.86 (33.81)	6.10 (36.71)	5.89 (34.21)	5.99 (35.46)	8.48 (71.47)	8.22 (67.06)	8.35 (69.27)
S.Em. .±	0.10	0.07	0.05	0.11	0.07	0.06	0.14	0.08	0.07
C.D. (P = 0.05)	0.31	0.20	0.15	0.33	0.21	0.16	0.41	0.25	0.20
Nutrient management									
NPK	7.32 (58.76)	7.18 (56.32)	7.25 (57.54)	6.97 (50.54)	6.77 (47.13)	6.87 (48.83)	10.09 (109.30)	9.85 (103.44)	9.97 (106.37)
NPK+Zn	7.33 (59.04)	7.21 (56.60)	7.27 (57.82)	6.97 (50.58)	6.76 (47.15)	6.87 (48.87)	10.10 (109.63)	9.87 (103.75)	9.99 (106.69)
NPKS+Zn	7.36 (59.34)	7.19 (56.43)	7.27 (57.89)	6.96 (50.41)	6.77 (47.10)	6.86 (48.76)	10.11 (109.75)	9.86 (103.54)	9.98 (106.64)
S.Em.±	0.05	0.04	0.02	0.04	0.03	0.02	0.05	0.04	0.03
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

*Data subjected to $\sqrt{X+0.5}$ transformation and figures in parenthesis are original weed count m^{-2}

Table 2: Effect of weed management and nutrient management on weed dry matter at 60 DAS

Treatments	Weed dry matter (g m^{-2})								
	Narrow-leaved weeds			Broad-leaved weeds			Total weeds		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Weed management									
Weedy check	179.19	166.80	173.00	158.44	149.61	154.03	337.64	316.41	327.02
Hand weeding 15 & 35 DAS	61.54	61.39	61.46	58.82	56.65	57.73	120.36	118.03	119.20
Tembotrione	90.37	85.77	88.07	61.40	67.11	64.26	151.77	152.89	152.33
Alachlor *fb* hand weeding	74.26	71.46	72.86	67.81	60.82	64.31	142.08	132.27	137.17
Atrazine *fb* hand weeding	70.42	66.30	68.36	64.38	58.12	61.25	134.80	124.42	129.61
Tembotrione *fb* hand weeding	78.29	74.55	76.42	70.74	62.68	66.71	149.03	137.22	143.13
Alachlor+atrazine *fb* hand weeding	65.17	64.84	65.00	61.98	60.83	61.41	127.15	125.67	126.41
Alachlor *fb* Tembotrione	60.89	60.52	60.70	57.76	53.93	55.84	118.65	114.45	116.55
Atrazine *fb* Tembotrione	60.38	60.13	60.26	57.17	53.41	55.29	117.54	113.55	115.54
S.Em. ±	0.78	2.09	1.11	0.43	0.46	0.31	0.90	2.15	1.17
C.D. (P = 0.05)	2.34	6.26	3.21	1.28	1.38	0.90	2.70	6.44	3.36
Nutrient management									
NPK	82.27	79.05	80.66	73.15	69.21	71.18	155.42	148.26	151.84
NPK+Zn	82.32	79.13	80.72	73.21	69.26	71.24	155.54	148.39	151.96
NPKS+Zn	82.25	79.08	80.66	73.13	69.24	71.19	155.38	148.32	151.85
S.Em.±	0.42	0.61	0.37	0.19	0.17	0.13	0.47	0.62	0.39
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of weed management and nutrient management on weed dry matter at harvest

Treatments	Weed dry matter (g m^{-2})								
	Narrow-leaved weeds			Broad-leaved weeds			Total weeds		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Weed management									
Weedy check	246.33	239.82	243.08	238.56	231.49	235.03	484.90	471.32	478.11
Hand weeding 15 & 35 DAS	69.37	70.08	69.72	65.97	65.28	65.62	135.34	135.36	135.35
Tembotrione	121.93	117.86	119.89	118.98	113.36	116.17	240.91	231.22	236.06
Alachlor *fb* hand weeding	94.68	88.82	91.75	91.56	86.65	89.11	186.24	175.48	180.86
Atrazine *fb* hand weeding	89.42	85.29	87.36	88.06	82.29	85.18	177.48	167.58	172.53
Tembotrione *fb* hand weeding	102.48	99.14	100.81	98.36	95.89	97.12	200.84	195.03	197.93
Alachlor+atrazine *fb* hand weeding	75.73	74.28	75.01	73.35	67.02	70.19	149.08	141.30	145.19
Alachlor *fb* Tembotrione	69.82	69.43	69.62	64.80	64.88	64.75	134.62	134.31	134.38
Atrazine *fb* Tembotrione	68.98	68.88	68.93	64.63	64.49	64.64	133.31	133.36	133.57
S.Em. ±	2.29	2.24	1.60	2.35	2.63	1.76	3.60	4.71	2.96
C.D. (P = 0.05)	6.85	6.71	4.61	7.05	7.89	5.08	10.81	14.11	8.54
Nutrient management									
NPK	104.29	101.49	102.89	100.46	96.79	98.62	204.75	198.28	201.51
NPK+Zn	104.35	101.55	102.95	100.52	96.88	98.70	204.87	198.44	201.65
NPKS+Zn	104.27	101.49	102.88	100.45	96.78	98.62	204.72	198.27	201.50
S.Em.±	0.88	0.74	0.57	0.78	0.78	0.55	1.23	1.51	0.97
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of weed management and nutrient management on weed control efficiency at harvest

Treatments	Weed control efficiency (%)								
	Narrow-leaved weeds			Broad-leaved weeds			Total weeds		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Weed management									
Weedy check	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hand weeding 15 & 35 DAS	71.58	70.76	71.27	72.33	71.77	72.05	72.07	71.26	71.67
Tembotrione	50.40	50.84	50.62	50.11	51.01	50.56	50.29	50.93	50.61
Alachlor *fb* hand weeding	61.47	62.97	62.22	61.63	62.56	62.09	61.57	62.77	62.17
Atrazine *fb* hand weeding	63.60	64.42	64.01	63.07	64.40	63.74	63.37	64.42	63.89
Tembotrione *fb* hand weeding	58.29	58.65	58.47	58.76	58.52	58.64	58.54	58.59	58.57
Alachlor+atrazine *fb* hand weeding	69.21	69.00	69.11	69.23	71.00	70.12	69.24	69.99	69.61
Alachlor *fb* Tembotrione	71.79	71.06	71.32	72.85	71.98	72.45	72.26	71.51	71.88
Atrazine *fb* Tembotrione	71.93	71.29	71.61	72.92	72.17	72.51	72.42	71.73	72.07

Table 5: Effect of weed management and nutrient management on plant height of QPM

Treatment	Plant height (cm)					
	30 DAS			At harvest		
	2015	2016	Pooled	2015	2016	Pooled
Weed management						
Weedy check	55.50	58.28	56.89	157.63	161.18	159.40
Hand weeding 15 & 35 DAS	72.21	76.53	74.37	204.92	208.70	206.81
Tembotrione	62.40	63.49	62.95	171.57	178.93	175.25
Alachlor *fb* hand weeding	69.90	71.18	70.54	182.45	189.73	186.09
Atrazine *fb* hand weeding	70.08	71.87	70.97	186.96	192.51	189.73

Tembotrione *fb* hand weeding	65.40	68.79	67.10	178.03	181.52	179.77
Alachlor+atrazine *fb* hand weeding	71.60	75.04	73.32	199.34	202.35	200.84
Alachlor *fb* Tembotrione	73.50	78.87	76.18	207.43	210.57	209.00
Atrazine *fb* Tembotrione	74.22	80.68	77.45	209.08	212.16	210.62
S.Em. ±	1.62	0.81	0.81	5.16	5.07	2.58
C.D. (P = 0.05)	4.84	2.43	2.33	15.48	15.21	7.44
Nutrient management						
NPK	66.31	70.40	68.36	185.52	190.13	187.83
NPK+Zn	69.12	71.19	70.16	188.33	192.85	190.59
NPKS+Zn	69.50	73.32	71.41	191.95	196.23	194.09
S.Em.±	0.68	0.56	0.34	1.77	1.69	0.88
CD (P=0.05)	1.95	1.61	0.96	5.06	4.85	2.49

Table 6: Effect of weed management and nutrient management on dry matter of QPM

Treatments	**Dry matter accumulation (g plant^{-1})**								
	30 DAS			**60 DAS**			**At harvest**		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Weed management									
Weedy check	9.67	9.89	9.78	54.31	56.01	55.16	139.10	140.58	139.84
Hand weeding 15 & 35 DAS	25.22	27.39	26.30	78.48	79.43	78.95	190.18	191.63	190.91
Tembotrione	17.51	18.13	17.82	70.06	71.44	70.75	175.27	178.75	177.01
Alachlor *fb* hand weeding	21.95	22.41	22.18	74.13	75.51	74.82	183.48	186.30	184.89
Atrazine *fb* hand weeding	22.72	22.89	22.81	74.99	76.38	75.69	185.28	186.94	186.11
Tembotrione *fb* hand weeding	19.46	20.34	19.90	72.33	73.31	72.82	180.01	183.63	181.82
Alachlor+atrazine *fb* hand weeding	23.35	25.12	24.23	76.00	77.44	76.72	187.73	192.79	190.26
Alachlor *fb* Tembotrione	25.71	26.92	26.31	79.02	80.23	79.63	200.94	198.68	199.81
Atrazine *fb* Tembotrione	26.47	28.02	27.24	82.06	83.98	83.02	193.76	200.10	196.93
S.Em. ±	0.53	0.46	0.35	2.26	1.74	1.43	6.15	3.73	3.60
C.D. (P = 0.05)	1.58	1.37	1.01	6.78	5.21	4.11	18.43	11.18	10.36
Nutrient management									
NPK	20.54	21.35	20.95	71.52	73.65	72.59	173.97	182.29	178.13
NPK+Zn	21.51	22.61	22.06	73.65	74.91	74.28	181.40	182.72	182.06
NPKS+Zn	21.96	23.07	22.52	75.29	76.02	75.65	189.89	188.13	189.01
S.Em.±	0.28	0.24	0.18	0.74	0.64	0.49	3.45	1.75	1.93
C.D. (P=0.05)	0.80	0.70	0.52	2.11	1.84	1.38	9.88	5.01	5.45

Table 7: Effect of weed management and nutrient management on yield and harvest index of QPM

	Grain yield			**Stover yield**			**Biological yield**		
	2015	**2016**	**Pooled**	**2015**	**2016**	**Pooled**	**2015**	**2016**	**Pooled**
Weed management									
Weedy check	2521	2735	2628	4482	4857	4669	7002	7592	7297
Hand weeding 15 & 35 DAS	4420	4580	4500	7241	7463	7352	11660	12043	11852
Tembotrione	4001	4083	4042	6991	7030	7011	10992	11113	11053
Alachlor *fb* hand weeding	4129	4230	4179	7096	7169	7132	11224	11400	11312
Atrazine *fb* hand weeding	4268	4312	4290	7118	7206	7162	11386	11518	11452
Tembotrione *fb* hand weeding	4091	4110	4100	7008	7144	7076	11099	11254	11176
Alachlor+atrazine *fb* hand weeding	4300	4330	4315	7159	7283	7221	11459	11613	11536
Alachlor *fb* Tembotrione	4454	4540	4497	7302	7595	7448	11755	12135	11945
Atrazine *fb* Tembotrione	4466	4567	4516	7338	7581	7459	11804	12147	11976
S.Em. ±	142	128	95	214	152	131	296	226	186
C.D. (P = 0.05)	425	383	275	641	456	378	888	677	537
Nutrient management									
NPK	3894	4058	3976	6614	6873	6743	10508	10931	10719
NPK+Zn	4034	4177	4105	6674	7072	6873	10708	11249	10978
NPKS+Zn	4288	4261	4275	7290	7164	7227	11578	11425	11502
S.Em.±	70	38	40	70	74	51	100	85	66

CD (P=0.05)	201	110	112	201	213	144	287	242	185

CONCLUSION

On the basis of two years investigation on Quality Protein Maize under the influence of Weed and Nutrient Management, it emerged out that weed management by atrazine 0.5 kg ha^{-1} as PE *fb* tembotrione 0.125 kg ha^{-1} at 20 DAS gave the highest weed control efficiency (72.07 %) and grain yield (4516 kg ha^{-1}). Under nutrient management conjoint application of 120 kg N +60 kg P_2O_5+ 30 kg K_2O along with 40 kg S and 5 kg Zn ha^{-1} gave highest grain yield (4275 kg ha^{-1}).

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