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Response of Watermelon to Different Level of NPK Nutrients on Growth, Yield and Quality Attributes

J.P. Sajitha[1] and R.M. Vijayakumar[2]
Department of Vegetable Crops[1], Department of Fruit Crops[2]
Horticultural College and Research Institute,
Tamil Nadu Agricultural University, Coimbatore - 641 003

Field experiments were conducted at Coimbatore district, Tamil Nadu, during 2012 to 2013. To find the effect of different levels of nutrients applied through fertigation using water soluble fertilizers along with azophosmet and humic acid on growth, yield and quality of hybrid watermelon 'Kiran'. Application of 125% of water soluble fertilizers *viz.,* **250:125:125 kg/ha of NPK, in addition to azophosmet and humic acid showed the best performance in almost all the parameters studied in both seasons as it recorded the highest vine length (379.33 and 437.41cm), higher number of primary branches per plant (4.68 and 4.76).The least days to first flowering (21.67 and 28.72 days), node at which first female flowers produced (8.93 and 5.43), Total no. of female flower(20.82 and 27.65). The highest female and male flower ratio 12. 56: 1 and 15.85: 1 was recorded in T_9 (100% RDF through soil application), single fruit weight (3.45 and 3.99 kg fruit^{-1}) and yield per hectare (45.27 and 46.98 t/ha) was high in T_7 (125% - 250:125:125 NPK kg/ha + Azophosmet (450ml/ha) + humic acid(2ml/lit). Regarding quality characters lycopene (6.07 and 6.38 mg 100g $^{-1}$), Total Soluble Solids (TSS) (10.94 and 8.12 °brix) and ascorbic acid (8.0 and 8.05 mg 100 g^{-1} respectively estimated showed no significant difference.**

Key words: Watermelon, Fertigation , Azophosmet, Humic acid.

The watermelon (*Citrullus lanatus* Thunb) is the most important fruit vegetable crop that belongs to the Fa: Cucurbitaceae. It is a popular dessert fruit, although it is native to tropical Africa due to its taste, flavour and nutritive values, now it is grown extensively all over the world and used as refreshing drink beverage. Its global consumption is greater than that of any other cucurbitaceous vegetables and accounts for 6.8% of the world area (Goreta *et al.,* 2005). In India, it is grown as a common summer season crop. It is estimated that the crop covers an area of about 30,000 ha with an annual production of 3,50,000 metric tonnes (Vigneshwara Varmudy,2012). The fruit consists of 92% moisture, 0.2% protein, 7.0% carbohydrates, 0.3% minerals and vitamin C (8.1mg/100g). It also possesses great antioxidant properties and higher concentration of lycopene.

Increase in watermelon production can be achieved either by bringing more area under cultivation, or by adopting improved varieties and better cultural practices. The second approach is more often preferred ; among various cultural practices, fertilizer application is one of the quickest and easiest ways of increasing the yield per unit area.

Fertigation is the most convenient and effective means of providing optimum nutrients to the plants for higher yields. An attempt was made to study the effect of different levels of nutrients through water soluble fertilizers on the growth and yield of watermelon.

*Corresponding author's e-mail: burserasaji@gmail.com

Materials and Methods

The experiment was conducted at Coimbatore district, Tamil Nadu, during 2012-2013. A Randomized Block Design (RBD) with 9 treatments replicated thrice. The plot size was 8x5m and seeds of watermelon (hybrid Kiran) were sown on raised ridges at a spacing of 1.8x 0.6m. The treatments tested were T_1 (75% - 150:75:75 NPK kg/ha), T_2 (100% - 200:100:100 NPK kg/ha), T_3 (125% - 250:125:125 NPK kg/ha), T_4 (150% - 300:150:150 NPK kg/ha), T_5 (75% - 150:75:75 NPK kg/ha + Azophosmet (450ml/ha) + humic acid(2ml/lit), T_6 (100% - 200:100:100 NPK kg/ha + Azophosmet (450ml/ha) + humic acid(2ml/lit), T_7 (125% - 250:125:125 NPK kg/ha + Azophosmet (450ml/ha) + humic acid(2ml/lit) , T_8 (150% - 300:150:150 NPK kg/ha + Azophosmet (450ml/ha)+humic acid(2ml/lit) and T_9 (100% RDF through soil application). The water soluble fertilizers used were poly feed, mono ammonium phosphate and multi-K. In control, urea, single superphosphate and muriate of potash were used. All the fertilizers, humic acid and azophosmet were given in split doses for 8 weeks. First dose was applied 21 days after sowing, while the remaining doses were applied at weekly intervals. All other cultural practices were adopted to raise the crop as per recommendation (http://agritech.tnau.ac.in/hort).The data in respect of crop growth and yield attributing characters were recorded and statistically analyzed following Panse and Sukhatme (1978).

Results and Discussion

Vine length

The observations on vine length showed that the highest values of 379.33 and 437.71cm were recorded in season I and II, respectively in T_7 which was found to be on par with T_8 in both the seasons. The lowest vine length was recorded in the control (T_9) (during season I 278.21 cm and season II 327.41 cm). The increased vine length may be due to continuous availability of nutrients throughout the crop growth under ideal soil moisture regimes and the result was in agreement with Neary *et al*., (1995), who reported that the better availability of nutrients had helped in protein synthesis, resulting in production of taller plants.

Number of primary branches plant^{-1}

Application of 125 per cent recommended dose of water soluble fertilizers along with azophosmet and humic acid recorded the highest number of primary branches compared to other levels of fertigation. The highest mean number of branches was noticed in T_7, registering 4.68 and 4.76 in season I and II, respectively. The least number of branches was observed in control (T_9) with 3.17 and 3.34 in season I and II, respectively. More number of branches per plant might be due to the higher availability of N, P and K during early stages of crop growth, which would have increased the root activity, besides the synthesis of cytokinin in the roots. The transport of cytokinin from the root would have encouraged auxillary buds resulting in increased number of branches (Pandey *et al*., 1996).

Days for first female flower production

The results indicated that application of 125 per cent of recommended dose of water soluble fertilizers along with azophosmet and humic acid (T_7) had resulted in the earliest female flower production in season I (21.67 days) and season II (28.96 days) and was found to be on par with 150 per cent recommended dose of water soluble fertilizers along with azophosmet and humic acid (T_8) in season I and II. Soil application of recommended dose of fertilizers registered late female flower production with 29.32 and 38.01 days, respectively in season I and II. Early flowering under drip fertigation had been documented by Prabhakar *et al.* (2001), Meenakshi and Vadivel (2003) and Kavitha (2005). This indicated that nutrient availability at regular intervals in water soluble form and judiciuous water availability might have helped in earlier flowering. Better uptake of potassium by fertigation treatment would have also helped in the transport of cytokinin and other metabolites towards the sink development namely, flower buds.

Table 1. Influence of different levels of nutrients on growth attributes of watermelon

Treatments	Vine length (cm)		Number of primary branches per plant		Days for first female flower production	
	Season I	**Season II**	**Season I**	**Season II**	**Season I**	**Season II**
T1	296.23	344.12	3.60	3.42	28.26	35.93
T2	312.47	361.62	3.82	3.66	27.18	35.73
T3	328.32	378.73	4.06	3.9	26.14	33.66
T4	353.21	404.82	4.35	4.27	24.01	31.32
T5	335.73	386.25	4.15	4.01	25.27	33.43
T6	358.01	411.31	4.41	4.41	23.33	31.11
T7	379.33	437.71	4.68	4.76	21.67	28.96
T8	372.61	428.74	4.59	4.67	22.01	29.12
T9	278.21	327.41	3.34	3.17	29.32	38.01
SEd	6.72	7.75	0.09	0.08	0.41	0.93
CD (P=0.05)	14.25	16.42	0.19	0.17	0.86	1.97

Node at which first female flower produced

Application of 125 per cent recommended dose of water soluble fertilizers along with azophosmet and humic acid (T_7) also recorded the lowest node for first female flower production in season I (8.93) and season II (5.43), which was found to be on par with T_8 in both the seasons. Soil application of recommended dose of fertilizers (T_9) registered the highest node at which first female flower produced 14.86 and 8.99cm in season I and II, respectively. Higher levels of available nutrients would have helped the plants for better photo assimilation and hormonal balance. In addition, differentiation of auxiliary buds into reproductive ones would have been accelerated. Takahashi *et al*. (1993) found that high N, P and K rates developed flower buds sooner than lower rates. Abd El and Sorial (2000) had reported that bio-fertilizer treatments significantly enhanced the induction of female flowers and reduced male flowers in Squash plants.

Sex ratio

Observations made on sex ratio showed significant differences among the treatments (Table 2). The ratio between female and male flowers significantly decreased with increased level of nutrients and the lowest 10.06: 1 and 11.07: 1 female and male flower ratio in seasons I and II, respectively were found in T_7. The highest female and male flower ratio 12. 56: 1 and 15.85: 1, respectively was recorded in T_9 (100 per cent recommended dose of nutrients through soil application). Application of 125 per cent recommended dose of nutrients as water soluble fertilizer along with azophosmet and humic acid produced significant difference in female and male flower ratio which decreased with increased level of nutrients. The higher fertilizer doses cause more vegetative growth, thereby accumulate more reserve food material and alter C:N ratio, which in turn may produce more female flowers per vine lowering the female : male ratio in watermelon. A balanced nutrition is utmost necessary to maintain a proper sex ratio in cucurbits, which regulate the number of fruits per vine and total yield per ha. These results coincide with the findings of Hazarika *et al.* (2012).

Table 2. Influence of different levels of nutrients on number of flowers and sex ratio in watermelon

Treatments	Node at first female flower produced		Total no. of female flowers		Sex ratio	
	Season I	**Season II**	**Season I**	**Season II**	**Season I**	**Season II**
T1	14.30	8.69	14.86	15.56	11.98	14.75
T2	13.00	7.70	15.96	18.44	11.39	13.08
T3	11.78	7.04	17.52	21.63	11.06	12.04
T4	10.67	6.42	19.07	23.47	10.60	11.78
T5	12.42	7.41	16.72	18.85	11.25	13.14
T6	11.34	6.78	18.25	22.16	10.75	11.98
T7	8.93	5.43	20.82	27.65	10.06	11.07
T8	9.07	5.63	20.55	26.86	10.16	11.28
T9	14.86	8.99	13.69	14.06	12.56	15.85
SEd	0.28	0.15	0.37	0.43	0.20	0.28
CD (P=0.05)	0.59	0.31	0.78	0.91	0.43	0.59

Number of fruits plant^{-1}

The number of fruits plant^{-1} exhibited significant difference among the treatments. It ranged from 2.00 to 2.67 in season I and 2.85 to 4.0 in season II. The highest number of fruits plant^{-1} was recorded in T_7 (2.67 and 4.00 in season I and season II, respectively). The recommended dose of nutrients as soil application (T_9) recorded the least number in season I (2 fruits plant^{-1}) and season II (2.85 fruits plant^{-1}).

The increased number of fruits under the above treatment might be mainly due to early vigour shown by the crop due to the availability of plant nutrients at adequate level along with sufficient soil moisture for the early development of plant parts and rooting system. Moreover, higher production of dry matter under drip fertigation might have paved way for increased production of photosynthates, which ultimately would have resulted in increased fruit production. This result is in accordance with the findings of Tumbare and Nikam (2004), who observed a positive response with the production of more green fruits per plant in chilli under drip fertigation

Table 3. Influence of different levels of nutrients on yield attributes of watermelon

Treatments	No. of fruits plant^{-1}		Single fruit weight(kg)		Yield (Kg plant $^{-1}$)		Yield (t ha^{-1})	
	Season I	**Season II**	**Season I**	**Season II**	**Season I**	**Season II**	**Season I**	**Season II**
T_1	2.07	2.92	1.463	1.724	5.13	5.28	30.45	32.02
T_2	2.21	3.13	1.890	2.192	5.51	5.81	32.57	33.82
T_3	2.32	3.62	2.395	2.752	6.12	6.51	37.84	39.31
T_4	2.53	3.87	2.882	3.355	6.74	7.18	41.35	42.98
T_5	2.24	3.22	1.962	2.267	5.73	6.13	35.55	36.54
T_6	2.41	3.70	2.447	2.878	6.32	6.74	38.86	40.72
T_7	2.67	4.00	3.452	3.991	7.38	7.92	45.27	46.98
T_8	2.61	4.00	3.325	3.858	7.19	7.65	43.51	45.33
T_9	2.00	2.85	1.017	1.255	4.72	4.86	24.57	25.62
SEd	0.05	0.07	0.20	0.22	0.12	0.16	1.11	1.77
CD (P=0.05)	0.11	0.15	0.42	0.46	0.25	0.35	2.34	3.74

Single fruit weight

The fruit weight ranged from 1.02 to 3.35 kg in first season and 1.25 to 3.99 kg in second season, respectively. The treatment (T_7) recorded the highest fruit weight of 3.35 and 3.99 kg fruit^{-1} in season I and II, respectively which were found to be on par with 150 per cent recommended dose of water soluble fertilizers along with azophosmet and humic acid. The control registered the lowest fruit weight.The higher fruit weight at higher fertilizer level could be attributed to translocation of more carbohydrates because of high potassium levels; which may play a vital role in translocation of metabolites to the developing fruits. This results are in line with Prabhu (2006) and Ciba (2009), who reported that high potassium had increased the fruit weight.

Fruit yield

Fertigation significantly increased the fruit yield over soil application of fertilizers. Application of 125 per cent recommended dose through water soluble fertilizers along with azophosmet and humic acid (T_7) recorded the highest fruit yield in season I (68.27t/ ha) and season II (73.26 t/ ha). Soil application of recommended dose of fertilizers registered the lowest fruit yield in season I (43.66 t/ha) and season II (44.96 t/ha). Different levels of water soluble fertilizers along with Azophosmet and humic acid have a significant effect on yield ha^{-1}, as fertilizer treatment T_7 produced higher yield, which might be due to more fruit length, fruit girth and maximum weight of fruit. Naeem *et al.* (2002) reported that different doses of NPK behaved significantly different for total yield. Likewise, Jilani *et al.* (2008) reported that, N application @ 100 kg ha^{-1} significantly increased brinjal yield.

Lycopene content

The lycopene content in fruit ranged from 4.17 to 6.07 mg 100g^{-1} in first season and 4.26 to 6.38 mg 100 g^{-1} in second season, respectively. The treatment T_7 recorded the highest lycopene content (6.07 and 6.38 mg 100g^{-1} in season I and season II), which was on par with 150 per cent recommended dose of NPK through water soluble fertilizers along with azophosmet and humic acid (T_8). The control registered the lowest lycopene content. Potassium plays an important role in the process of fruit pigmentation, it increase lycopene and decrease chlorophyll. Fruits from potash deficient plants were low in lycopene content..Robertson *et al*., 1995;Trudel and Ozbun (1970) and lycopene was at the highest level under appropriate amount of phosphorus.

Table 4. Influence of fertigation on quality attributes of watermelon

Treatments	Lycopene (mg 100g^{-1})		Total Soluble Solids (°Brix)		Ascorbic acid (mg 100g^{-1})	
	Season I	**Season II**	**Season I**	**Season I**	**Season I**	**Season I**
T1	4.53	4.6	9	8.56	6.06	6.27
T2	4.84	4.89	9.42	9.03	6.44	6.47
T3	5.17	5.28	9.85	9.51	6.56	6.64
T4	5.64	5.86	10.44	10.03	7.01	7.12
T5	5.34	5.51	10	9.62	6.95	7.01
T6	5.72	5.98	10.66	10.36	7.18	7.46
T7	6.07	6.38	11.25	10.94	8.01	8.05
T8	6.01	6.27	11.16	10.85	7.65	7.75
T9	4.17	4.26	8.53	8.12	0.233	0.234
SEd	0.12	0.10	0.19	0.18	0.007	0.008
CD (P=0.05)	0.25	0.21	0.41	0.38	0.014	0.018

Total soluble solids

Application of 125 per cent recommended dose of NPK through water solublefertilizers along with azophosmet and humic acid recorded the highest TSS content in season I (11.25 °brix) and season II (10.94 °brix). The lowest TSS content was recorded in T_9 in both season I (8.53°brix) and season II (8.12 °brix). The increased TSS might be due to substantial increase in production and accumulation of carbon rich biomass within the plant and better translocation of produced biomass to the fruit combined with the more conversion of organic acids to sugar. The higher fertilizer level might have activated a number of anabolic enzymes within the plant tissues to support better physiological processes leading to increased TSS in fruits. The positive response of nitrogen fertilization by increased TSS has been reported by Hedau *et al*. (2001) in many crops including tomato. Okur and Yagmur (2004) also reported that TSS of the fruit increased in parallel with the increasing doses of K in watermelon.

Ascorbic acid content

The treatments with water soluble fertilizers along with azophosmet and humic acid recorded higher ascorbic acid content than straight fertilizers. Application of 125 per cent recommended dose of NPK through water soluble fertilizers along with azophosmet and humic acid (T_7) recorded the highest ascorbic acid content in first (8.01mg 100 g^{-1}) and second season (8.05 mg 100 g^{-1}). Soil application of 100 per cent recommended dose of RDF (T_9) registered the lowest content in first (5.95mg 100 g^{-1}) and second season (6.14mg 100 g^{-1}). The synthesis of ascorbic acid is closely associated with carbohydrate metabolism (Malex and Baker, 1977). *Azospirillium* produces biologically significant amount of GA, which has the ability to augment biosynthesis of ascorbic acid (Tien *et al*., 1989). This could be attributed to the increased ascorbic acid content due to *Azospirillium* application in the present study.

Conclusion

Application of water soluble fertilizers along with azophosmet and humic acid have positive effect on growth and yield characters of watermelon as it enhanced the fruit yield. Among different levels of water soluble fertilizers, application of 125% of water soluble fertilizers *viz.,* 250:125:125 kg/ha of NPK in the form of poly feed, mono ammonium phosphate, multi-K and Azophosmet (450ml/ha) along with humic acid (2ml/lit) maximise production of watermelon 45.27 to 46.98 t.

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