academicJournals

Vol. 12(23), pp. 3669-3675, 5 June, 2013
DOI: 10.5897/AJB12.2079
ISSN 1684-5315 ©2013 Academic Journals
http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Calcium carbide (CaC_2): Effect on fruit set and yield of mango (*Mangifera indica* L.) cv. Langra

Waqas Akram[1], Saeed Ahmad[1], Muhammad Yaseen[2], Waqas Ahmad[1*], Waqar Ahmad[1], C.M.Ayub[1] and Muhammad Asif Shehzad[3]

[1]Institute of Horticultural Sciences, University of Agriculture, Faisalabad-38040, Pakistan.
[2]Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad-38040, Pakistan.
[3]Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan.

Accepted 8 May, 2013

Application of slow release calcium carbide (CaC_2) to the soil are thought to improve plant growth and yield through the generation of acetylene, which inhibits nitrification, thereby reducing nitrogen losses which may be converted to physiologically significant concentrations of the plant growth regulator ethylene. The effects of different application rates of slow release of CaC_2 on the growth and development of mango (*Mangifera indica* L.) cv. Langra were studied in a field trial in 2009. The rates were 0, 5, 10, 20 and 30 g of CaC_2 per tree. The NPK was applied at the rate of 2 kg: 1 kg: 1 kg per plant respectively in the form of Urea, DAP and SOP. Half dose of N with whole P and K was applied before flowering, along with the application of CaC_2. Results show that number of leaves per flush, leaf area, leaf area index, transpiration rate, photosynthetic rate, final fruit drop, yield per plant, fruit weight, fruit volume, pulp weight, peel weight, juice weight and fruit skin color were significantly affected by the calcium carbide treatment while number of new flushes per branch, number of flowers, flower drop percentage, fruit percentage and stone weight remained unaffected. It was also concluded that cv. Langra showed positive response to different doses of wax-coated CaC_2. However, T_4 (30 g CaC_2 plus NP and K fertilizers) was the most effective treatment with respect to yield and other growth parameters.

Key words: Calcium carbide, *Mangifera indica* L., stomatal conductance, physiological attributes, total soluble solids, fruit set.

INTRODUCTION

Mango (*Mangifera indica* L.) is an important tropical fruit, which is being grown in more than 100 countries of the world (Sauco, 1997). It has been a major fruit owing to its particular climatic requirements, however, its delicious taste, unique flavor with high nutritive value has made it equally popular across the globe and its demand and trade is expanding rapidly in other parts of the world. It has high vitamin A (4016 IU/100 g) contents and is a good source of vitamin-C or ascorbic acid (28.5 mg/100 g) (Meadows, 1998). Pakistan is bestowed with good agro-climatic conditions needed for successful production of mango. Depending upon cultivar and climatic conditions, development of vegetative shoots from initiation of growth to full elongation takes 3 to 6 weeks (Whiley et

*Corresponding author. E-mail: uaf_waqas@yahoo.com. Tel: (+92) 3326613478.

Abbreviations: DAP, SP etc

al., 1989). The vegetative growth of tree which takes place in periodic cycles is termed as flushesgrowth. Vegetative growth through flushes continues from April to October, and few of these bloom during the following year. However, this industry is particularly facing such challenging problems like alternate bearing, mango malformation, fruit drop, poor cropping, insect-pest and diseases which appear mainly due to enigmatic blooming and vegetative growth behavior (Chacko, 1991).

Unimpressive yield is one of the major problems which could be due to non-availability of nutrients from the soil. Inefficient use of fertilizers especially Nitrogen Use Efficiency (NUE) which is not more than 60% of the main cause of low yield (Ahmad and Rashid, 2003). Various ways are considerable to increase nitrogen use efficiency. One of them is the use of ammonium nitrate that contains nitrogen in both the ammonium and nitrate form, less subject to volatilization losses than urea but ammonium nitrate does not work well on sandy soils. So, there is a need to control nitrogen losses by means of economical and work well in all types of soil. Calcium carbide which may cause slow release of nitrogen to avoid losses by leaching, nitrification and denitrification may serve as a possible solution. Calcium carbide when applied to the soil reacts with soil water to produce calcium ion and acetylene (C_2H_2).

The soil micro-organisms reduce acetylene with the help of enzyme (nitrogenase) to ethylene C_2H_4. Calcium carbide (CaC_2), previously known to release acetylene (C_2H_2) gas upon its reaction with water has recently been reported to increase the concentration of the plant hormone ethylene (C_2H_4) in soil air as a result of microbial reduction of C_2H_2 (Bibik et al., 1995; Arshad and Frankenberger, 2002; Khalid et al., 2006). Ethylene is a simple, readily diffusible gaseous hormone which regulates multiple developmental processes including seed germination, fruit ripening, abscission and senescence (Abeles et al., 1992). It has stimulatory effect on growth and development of plants. Being a gas, ethylene is difficult to be used for agricultural production and also inhibits the activity of ammonia-oxidizing enzyme involved in the nitrification process (Chen et al., 1994; Arshad and Frankenberger, 1998), which leads to inhibition of nitrification and denitrification processes, causing increase in N fertilizer use efficiency (Thompson, 1996; Aulakh et al., 2001). Taking into consideration the role of calcium carbide, as a potent source of acetylene and ethylene, the study was undertaken to evaluate the effects of different doses of wax- coated CaC_2 on vegetative and reproductive growth of mango.

MATERIALS AND METHODS

The present study regarding the effects of different levels of CaC_2 on vegetative and reproductive growth, yield and fruit quality of Mango (*M. indica* cv. Langra) was initiated on February, 2009 at the experimental Orchard Square No. 9, Institute of Horticultural Sciences, University of Agriculture, Faisalabad. The experiment was planned in randomized complete block design with triplicate run containing one tree per replication. Treatments comprised of T_0 = Control (2 kg: 1 kg: 1 kg) NPK, T_1 = CaC_2 at 5 g + (2 kg: 1 kg: 1 kg) NPK, T_2 = CaC_2 at 10 g + (2 kg: 1 kg: 1 kg) NPK, T_3 = CaC_2 at 20 g + (2 kg: 1 kg: 1 kg) NPK, T_4 = CaC_2 at 30 g + (2 kg: 1 kg: 1 kg) NPK. 15 trees of mango (cv. Langra) having an age of 14 to 15 years planted in square system (planting distance = 15 × 15 m) were selected for the research purpose.

The experimental trees received similar cultural practices for irrigation and plant protection during the investigation. The NPK was applied at the rate of 2 kg: 1 kg: 1 kg per plant, respectively, in the form of urea, diammonium phosphate (DAP) and sulphate of potash (SOP). Half of N and full dose of P and K (1 kg) was applied at the end of January, along with treatments just before flowering. Second dose of N was applied after fruit setting in April. Calcium carbide was grinded with mortar and pestle into small grains or powdered. Then, wax was poured into the pan in which powdered calcium carbide was placed and then properly mixed until whole powdered calcium carbide was coated with wax.

Powdered CaC_2 coated with wax was applied along with half dose of Nitrogen, according to the rates aforementioned, placed 6 cm deep, and followed by immediate irrigation. CaC_2 was applied in a circle inside 1 m range along the border of the canopy area, for there are maximum feeder roots in this area.

Observations

Data on vegetative attributes (number of new flushes /branch and number of leaves/flush); reproductive attributes (flowers/panicle, flower drop (%), fruit set, initial fruit drop (%), final drop (%) and fruit yield/tree (kg); physical attributes (fruit weight (g), fruit volume (cc), peel weight (g), pulp weight (g), juice weight (g), stone weight (g) and fruit color); physiological attributes (leaf area (cm^2), leaf area index, transpiration rate, photosynthetic rate, stomatal conductance and water use efficiency); biochemical attributes (total soluble solids, titratable acidity (%), vitamin C (mg/100 ml) and total sugars (%) were collected by using standard procedures during the course of study.

Statistical analysis

Data collected was statistically analyzed using the computer software MSTAT- C. Analysis of variance techniques were employed to test the overall significance of the data, while the least significant difference (LSD) test ($P \leq 0.05$) was used to compare the differences among treatment's means (Steel et al., 1997).

RESULTS AND DISCUSSION

Vegetative attributes

The data was collected and analyzed to determine the effects of different levels of wax-coated CaC_2 along with recommended dose of N, P and K fertilizer on number of new flushes/branch of cv. Langra. Results clearly show that application of different rates of wax-coated CaC_2 with recommended doses of NPK affected it non-significantly (Table 1). Maximum number of new flushes (17.65) was observed in treatment T_3 where 20 g/plant wax-coated CaC_2 along with recommended dose of fertilizers (NPK at1000, 500, 500 kg $acre^{-1}$ respectively) was applied which was followed by T_4 (17.07); while minimum new

Table 1. Effect of different levels of wax-coated CaC_2 with NPK on vegetative, reproductive, physical, physiological and biochemical attributes of mango (*Mangifera indica* L.).

Parameter	Treatment				
	T_0	T_1	T_2	T_3	T_4
Vegetative					
New flushes /branch	13.27^{c}	15.4^{b}	15.66^{b}	17.65^{a}	17.07^{a}
Leaves/flush	9.23^{c}	11.5^{bc}	13.1^{ab}	13.9^{ab}	14^{a}
Reproductive					
Flowers/panicle	965.9^{b}	851.7^{c}	923.8^{b}	1083.4^{a}	1166.1^{a}
Flower drop (%)	82.92^{a}	81.14^{a}	79.85^{a}	79.96^{a}	79.74^{a}
Fruit set (%)	19.08^{ab}	18.86^{b}	21.81^{a}	20.08^{a}	20.26^{a}
Initia lfruit drop (%)	30.49^{a}	30.09^{a}	29.73^{a}	22.43^{b}	19.82^{c}
Final drop (%)	99.85^{a}	99.42^{ab}	99.5^{ab}	98.76^{bc}	98.25^{c}
Fruit yield/tree (kg)	41.83^{c}	41.87^{c}	44.17^{bc}	48.83^{ab}	52.73^{a}
Physical					
Frui tweight (g)	176.24^{b}	177.65^{b}	178.34^{b}	201.25^{ab}	216.67^{a}
Fruit volume (cc)	181.18^{c}	187.78^{c}	189.16^{c}	205.72^{b}	226.5^{a}
Peel weight (g)	23.17^{c}	24^{bc}	25^{bc}	28^{ab}	32.33^{a}
Pulp weight (g)	104.67^{b}	110^{b}	108^{b}	120^{b}	144.67^{a}
Juice weight (g)	89.49^{b}	90^{b}	98^{b}	101^{b}	119.98^{a}
Stone weight (g)	43.33^{a}	40.83^{a}	41.5^{a}	42.5^{a}	39.67^{b}
Fruit color	1.75^{c}	1.8^{c}	2.2^{c}	2.9^{b}	3.83^{a}
Physiological					
Leaf area (cm^2)	49.58^{c}d	43.03d	70.78^{bc}	80.36^{ab}	84.50^{a}
Leaf area index	621.25^{b}	472.00^{b}	701.21^{b}	1056.87^{a}	1210.50^{a}
Transpiratio nrate	10.97^{c}	11.85^{c}	14.32^{bc}	17.29^{ab}	19.77^{a}
Photosynthetic rate	32.61^{c}	30.04^{c}	38.48^{b}	45.65^{ab}	48.11^{a}
Stomatal conductance	77.78^{c}	76.43^{c}	78.8^{c}	84.14^{b}	90.13^{a}
Water use efficiency	3.36^{a}	2.63^{c}	2.97^{b}	2.54^{c}	2.49^{c}
Biochemical					
Total soluble solids	14.73d	15.77^{c}	16.37^{bc}	17.2^{ab}	18.07^{a}
Titratable acidity (%)	0.35^{a}	0.34^{b}	0.35^{a}	0.33^{b}	0.36^{a}
Vitamin C (mg/100 ml)	12.55^{c}	15.32^{b}	14.89^{b}	16.70^{b}	19.59^{a}
Totalsugars (%)	7.03^{bc}	7.53^{ab}	8.16^{a}	6.68^{c}	7.80^{a}

Any two means not sharing same letters ignificantly differ at 5% level of significance; T_0 = Control (2 kg: 1 kg: 1 kg) NPK; T_1 = CaC_2 at 5 g + (2 kg: 1 kg: 1 kg) NPK; T_2 = CaC_2 at 10 g + (2 kg: 1 kg: 1 kg) NPK; T_3 = CaC_2 at 20 g + (2 kg: 1 kg: 1 kg) NPK; T_4 = CaC_2 at 30 g + (2 kg: 1kg: 1kg) NPK.

flushes growth (13.27) was observed in T_0 treatment where no CaC_2 was applied. Analysis of variance at 5% level of significance of different levels of wax-coated calcium carbide indicated that number of leaves per flush increased consistently with increasing dose of wax-coated calcium carbide (5, 10, 15, 20 and 30 g). Maximum number of leaves were observed in T_4 (14.53 leaves) where 30 g of CaC_2 was applied along with recommended dose of NPK fertilizers. Minimum number of leaves (9.23) was observed in T_0 (control) where no CaC_2 was applied (Table 1).

Ethylene triggers the formation of adventitious roots and also increases the N use efficiency of plants (Keerthisinghe et al., 1996). With the extension of roots and increase in N use efficiency, various growth parameters including number of leaves/ plant were also enhanced due to better nitrogen availability.

Reproductive attributes

Statistical analysis regarding number of flowers/panicle of cv. Langra exhibited non-significant differences among different levels of CaC_2 (Table 1). Maximum number of flowers was observed in T_4 (1166.1) where 30 g of CaC_2 was applied along with recommended dose of NPK fertilizers. Similarly, minimum number of flowers was observed in T_1 (851.7). The results of average flower drop percentage revealed non-significant results. Mean flower drop percentage was reduced in all treatments where we applied wax-coated CaC_2 as a slow releasing source of ethylene. With the increase in dose of calcium carbide, flower drop percentage decreased non-significantly. Maximum flower drop percentage was observed in T_0 (82.92%) which was the control, where no CaC_2 was applied. Similarly, minimum flower drop percentage was observed in T_4 (79.74%) where 30 g CaC_2 was applied along with the recommended dose of N, P and K (Table 1). CaC_2 along with recommended dose of fertilezers non-significantly affected number of fruit set percentage. Minimum fruit set percentage was observed in T_1 (18.86%) where 5 g of wax-coated calcium carbide was applied along with recommended dose of NPK. While, maximum fruit set percentage was observed in T_2 (21.81%) where 10 g of wax-coated calcium carbide was applied (Table 1).

Analysis of variance at 5% level of significance of different levels of wax-coated calcium carbide on initial fruit drop showed non-significant results. Minimum initial fruit drop was observed in T_4 (19.82%) where 30 g of wax-coated calcium carbide was applied along with recommended dose of NPK. While, maximum fruit set percentage was observed in T_0 (30.49%) where no wax-coated calcium carbide was applied (Table 1). Final drop percentage of cv. Langra exhibited significant differences among different levels of CaC_2. Mean final fruit drop percentage was reduced in all treatments where we applied wax-coated CaC_2 as a slow releasing source of ethylene. With the increase in dose of calcium carbide, final fruit drop percentage decreased significantly. Maximum final fruit drop percentage was observed in T_0 (99.85%) which was control, where no CaC_2 was applied. Similarly, minimum final fruit drop percentage was observed in T_4 (98.25%) where 30 g CaC_2 was applied along with the recommended dose of N, P and K (Table 1). Fruit yield increased with the increase in dose of calcium carbide along with the recommended dose of N, P and K significantly. Maximum yield 52.73 kg per plant was observed in T_4 where calcium carbide was applied at the rate of 30 g per plant along with recommended dose of NPK fertilizer followed by T_3 (48.83 kg) where calcium carbide was applied at rate of 20 g per plant. Among all treatments, T_0 (41.83 kg) which was control showed minimum fruit yield where only recommended dose of NPK fertilizer was applied. Trees applied with 30 and 20 g calcium carbide showed 26 and 16% increase in yield more than control, respectively (Table 1).

Application of calcium carbide in the presence of N fertilizer significantly increased the yield and yield contributing factors. CaC_2 application significantly improves the N uptake resulting in higher nitrogen use efficiency of applied N fertilizer. This may be mainly due to the suppressing effect of C_2H_2 gas released from CaC_2 on the oxidation of NH_4^+ to NO_3^{-1}. Moreover, better root growth in response to C_2H_4 might have also contributed in greater uptake of nutrients including N. Improvement in growth and yield is through bi-facet mechanisms of action of calcium carbide, that is, as a source of the plant hormone C_2H_4 as well as the nitrification inhibitor, C_2H_2. Although, both the aforementioned phenomena are involved in plant growth promotion but the increased N availability as a result of C_2H_2 release from calcium carbide seems to be having greater effect. Any formulation of calcium carbide (such as coating with compost, wax or paint, etc.) which leads to slow and gradual release of C_2H_2 and C_2H_4 gases in soil air could be useful in improving the nutrient-use efficiency as well as growth and yields of crops. In general, the results indicate that total yield was significantly increased because of the increased photosynthesis rate and leaf area of the trees. It can also be attributed to the enhanced nutrient uptake as a result of increased adventitious roots (Rao and Fritz, 1987) stimulated by ethylene release (Chaiwanakupt et al., 1996) and it may also occur owing to the ability of ECC to inhibit nitrification (Hazzrika and Sarkar, 1996), thus reducing N losses and assuring its availability for a long period.

N cannot be stored in leaves (Bronson and Mosier, 1993) and its continuous supply is needed (Zhang et al., 1992). These results are in conformity with those of Yaseen et al. (2006) who also obtained higher yield in treatments in which calcium carbide was applied.

Physical attributes

Analysis of variance at 5% level of significance clearly demonstrated that fruit weight was significantly affected by calcium carbide application with NPK. The maximum (216.67 g) was observed in T_4 (recommended dose of NPK and calcium carbide at the rate of 30 g plant^{-1}) as compared to recommended NPK fertilizer alone (T_0), followed by T_3 (20 g), T_2 (10 g) and T_1 (5 g). Application of NPK (T_o), taken as control, gave minimum average fruit weight. Trees applied with 30 and 20 g revealed about 27 and 13% increase in peel weight in contrast with control, respectively (Table 1). Statistical analysis data regarding fruit volume of cv. Langra exhibited non-significant differences among different levels of CaC_2 as compared to the control. Maximum fruit volume was observed in T_4 (226.50 cc), where 30 g wax-coated calcium carbide was applied along with recommended dose of NPK followed by T_3 (205.72 c.c). Minimum fruit volume was observed in T_0 (181.18 cc) where no wax-coated calcium carbide was applied (Table 1). Maximum peel weight (32.33 g) was observed in T_4 where 30 g/plant of wax-coated CaC_2 was applied along with recommended dose of NPK fertilizers. Minimum peel weight was observed in T_0 (23.17) which was the control. 30 and 20 g calcium carbide application to trees caused 39.5 and 23% increase in peel weight, respectively (Table 1).

Statistical results of average pulp weight by use of wax-coated calcium carbide as a slow releasing source of ethylene revealed significant results. Pulp weight in treatments of wax-coated calcium carbide consistently increased with increase in quantity of wax-coated calcium carbide. Maximum pulp weight was recorded in T_4 (144.67 g) where wax-coated calcium carbide at the rate of 30 g $plant^{-1}$ was applied, along with recommended dose of NPK fertilizer. Minimum pulp weight was observed in T_0 (104.67 g) which was the control, where only NPK fertilizer was applied (Table 1). Trees applied with 30 and 20 g calcium carbide showed about 39 and 17% increase in weight as compared to trees applied with NPK only, respectively. These results are in line with the previous findings of Abbasi et al. (2009). Statistical analysis data regarding juice exhibited significant differences among different levels of CaC_2 when applied along with recommended NPK fertilizers compared to recommended fertilizer alone. The maximum juice weight was observed in T_4 (119.98 g) where 30 g per plant of calcium carbide was applied along with recommended dose of NPK while minimum juice weight was observed in T_0 (89.49 g), taken as control where only NPK fertilizer was applied with no calcium carbide application (Table 1). Mean stone weight was found to be non-significant when CaC_2 was applied along with recommended dose of N, P and K as compared to the control.

The higher stone fruit weight was observed in T_4 (39.67 g) where no wax-coated calcium carbide was applied, while the maximum fruit volume was observed in T_0 (43.33 g) where no wax-coated calcium carbide was applied (Table 1). Different levels of wax-coated calcium carbide as a precursor of ethylene on fruit color showed significant results when applied along with recommended NPK fertilizers compared to recommended fertilizer alone ($P \leq 0.05$). The maximum fruit color (3.83) was observed in T_4 where 30 g/plant of wax- coated CaC_2 was applied along with recommended dose of NPK fertilizers. Minimum fruit color was observed in T_0 (1.75) which was the control (Table 1). Color of skin and its appearance is one of the most important features to attract consumer's acceptability. The impact of calcium carbide was noted excellent. Data presented indicates that the fruit was free of blemishes and generated good color as compared to calcium carbide untreated trees. These results are in strong agreement with the findings of Mukherjee (1997).

Physiological attributes

Data show that leaf area was increased with higher doses of CaC_2. Maximum leaf area (84.50 cm^2) was observed in T_4 where CaC_2 was applied at the rate of 30 g $plant^{-1}$ along with recommended dose of N, P and K fertilizers. Similarly, minimum leaf area (43.03 cm^2) was observed in T_1. Thus, it is obvious that CaC_2 significantly increased leaf area of the tree (Table 1). Data regarding leaf area showed a significant difference among treatments. Thus, calcium carbide produces acetylene which decreases the nitrification process and enhances the N use efficiency in the plants, ultimately resulting in more vegetative growth. In the control and T_1 treatment where no acetylene or very less acetylene was produced, less leaf area was observed; possibly the result of a lower photosynthesis rate and lower metabolic process (Arshad et al., 1993). Maximum leaf area index (1210.5) was observed in T_4 where CaC_2 was applied at the rate of 30 g $plant^{-1}$ along with recommended dose of N, P and K fertilizers. Similarly, minimum leaf area index (472.0) was observed in T_1. Thus, it is obvious that CaC_2 significantly increased leaf area index (Table 1). Data regarding leaf area index showed a significant difference among treatments. Thus, calcium carbide produces acetylene which decreases the nitrification process and enhances the N use efficiency in the plants, ultimately resulting in more vegetative growth. In the control and T_1 treatment where no or less acetylene was produced, less leaf area index was observed; possibly the result of a lower photosynthesis rate and lower metabolic process (Arshad et al., 1993). The increase in the level of wax- coated calcium carbide along with NPK fertilizers, transpiration rate was also increased (Table 1). Maximum transpiration rate (19.77) was observed in T_4 where CaC_2 was applied at the rate of 30 g $plant^{-1}$ along with recommended dose of N, P and K fertilizers. Similarly, minimum transpiration rate (10.97) was observed in T_0 (control).

Mean photosynthetic rate was increased in all treatments where we applied wax-coated CaC_2 as a slow releasing source of ethylene except T_1. The higher photosynthetic rate was observed in T_4 (48.11) where 30 g CaC_2 was applied along with the recommended dose of N, P and K. Similarly, minimum photosynthetic rate was observed in T_1 (30.04) (Table 1). This high photosynthetic rate is obviously because of increased vegetative growth resulting in more availability of N in plants applied with calcium carbide. The higher photosynthetic rate may be the result of higher ethylene production in the rhizosphere of the plant which increased vegetative growth (Keerthisinghe et al., 1993, 1996); while in treatments where no CaC_2 was applied or applied at very low rate, there was less vegetative growth and hence, less photosynthetic rate was observed. T_1 and T_0 showed minimum vegetative growth possibly reason for less photosynthetic rate. These results are similar to the finding of Porter (1992).

The higher stomatal conductance ($P \leq 0.05$) was observed in T_4 (90.13) where 30 g of wax-coated calcium carbide was applied along with recommended dose of NPK. Stomatal conductance was observed minimum in T_1 (76.43) (Table 1). Water use efficiency was not affect-ted significantly with the application of CaC_2. Maximum water use efficiency was observed in T_0 (3.36) where no CaC_2

was applied in parallel to minimum efficiency which was observed in T_4 (2.49) (Table 1).

Analogous findings were also observed by Sahrawat (1989).

Biochemical attributes

Statistically, the maximum total soluble solids (TSS) were observed in T_4 where 30 g of CaC_2 was applied along with recommended dose of NPK fertilizers. Minimum was observed in control where only NPK fertilizer was applied. Application of 30 and 20 g calcium carbide was found to increase 23 and 16.77% more TSS than control, respectively (Table 1). Total soluble solids contains 75% sugars and are considered important as they are determinant of the quality of fruits when forming a good blend with acidity which ultimately leads to good taste and flavor to the fruit. Calcium carbide treated trees gave fruit better in TSS compared to control. Our results were supported by the findings of Shah et al. (2002). There were non-significant results on titratable acidity among the different levels of CaC_2 along with recommended dose of NPK as compared to control ($P \leq 0.05$). The trees applied with 30 g/plant showed the highest (0.36%) acidity fallowed by T_0 (0.35%) and the lowest acidity was recorded in case of T_3 treatment (0.33%) where 20 g of calcium carbide was applied (Table 1). The highest ascorbic acid contents (19.59 mg/100 ml) of mango fruit cv. Langra was found in case of T_4 trees followed by the trees applied with 20 g of calcium carbide (16.70 mg/100 ml) and the lowest ascorbic acid was (12.55 mg/100 ml) from the trees applied with NPK fertilizer only. An increase in 56 and 33% vitamin C was observed in fruits obtained from trees applied with 30 and 20 g calcium carbide as compared to control, respectively (Table 1). Significant amount of total sugars were observed in the treatment T_2 (10 g CaC_2) along with recommended dose of NPK fertilizers. Similarly, minimum total sugars were observed in T_3 applied with 20 g CaC_2 and fertilizer. The major sugars identified in mango are glucose, fructose and sucrose.

All three increase during ripening; sucrose is in the greatest concentration throughout, with fructose the predominant reducing sugar. Our findings are also supported by those of Maan and Dhillon (1974) who also found better color and sugars in calcium carbide treated mangoes.

Conclusions

Results of this study show that wax-coated CaC_2 as a slow releasing source of ethylene has a positive correlation in relation to vegetative, reproductive, physical, biochemical and physiological attributes of mango (*M. indica* L.) cv. Langra. However, wax-coated CaC_2 at 30 g along with NPK fertilizers was proved to be the most effective treatment in terms of growth and yield of mango (*M. indica* L.) cv. Langra.

REFFERENCES

Abbasi NA, Hussain A, Maqbool M, Hafiz IA, Qureshi AA (2009). Encapsulated calcium carbide enhances production and post-harvest performance of potato (*solanum tuberosum*) tubers. New Zealand J. crop. Hort. Sci. 37: 131-139.

Abeles FB, Morgan PW, Saltveit ME (1992). Ethylene in Plant Biology. 2nd Ed. Academic Press, Inc., CA, USA.

Ahmad N, Rashid M (2003). Fertilizers and their use in Pakistan. Extension Bulletin. Third Edition. NFDC, Islamabad.

Arshad M, Frankenberger WT (2002). Ethylene: Agricultural Sources and Application. Kluwer Academic/Plenum Publisher. New York. USA.

Arshad M, Frankenberger WT (1998). Plant growth regulating substances in rhizosphere: Microbial production and functions. Adv. Agron. 62: 145-151.

Arshad M, Hussain A, Javed M, Frankenberger WT (1993). Effect of soil applied L-methionine on growth, nodulation and chemical composition of Albezia lebbeck L. Plant and Soil. 148: 129-135.

Aulakh MS, Singh K, Doran J (2001). Effects of 4-amino 1,2,4-triazole, dicyandiamide and encapsulated calcium carbide on nitrification inhibition in a subtropical soil under upland and flooded conditions. Biol. Fertil. Soils. 33: 258-263.

Bronson KF, Mosier AR (1993). Effect of nitrogen fertilizer and nitrification inhibitors on methane and nitrous oxide fluxes in irrigated corn. pp. 278-289. In: R.S. Oremland (ed.), Biogeochemistry of global change: radioactively active trace gases. Chapman & Hall, New York.

Bibik ND, Letunova SV, Druchek EV, Muromtsev GS (1995). Effectiveness of soil-acting ethylene producer in obtaining sanitized seed potatoes. Russian Agri. Sci. 9: 19-21.

Chacko EK (1991). Mango flowering still on enigma. Acta Horti. 291: 12-21.

Chen DL, Freney JR, Mosier AR, Chalk PM (1994). Reducing denitrification loss with nitrification inhibitors following pre-sowing application of urea to a cotton field. Aust. J. Exp. Agri. 34(1): 75-83.

Chaiwanakupt P, Freney JR, Keerthisinghe DC, Phongpan S, Lakeley RL (1996). Use of urease, algal inhibitors and nitrification inhibitor to reduce nitrogen loss and increase the grain yield of flooded rice. Biol. & Fert. Soils. 22(1-2): 89-95.

Hazzrika S, Sarker MC (1996). Effect of integrated nutrient management on the recovery of fertilizer nitrogen by rice. J. Nucl. Agri. & Biol. 25: 32-37.

Keerthisinghe DG, Lin XJ, Lou QX, Mosier AR (1996). Effect of encapsulated calcium carbide and urea application methods on denitrification and N loss from flooded rice. Nutri. Cyc. Agroeco. 45(1): 31-36.

Keerthisinghe DG, Freney JR, Mosier AR (1993). Effect of wax coated calcium carbide and nitrapyrin on nitrogen loss and methane emission from dry seeded flooded rice. Nutri. Cyc. Agroeco. 16(1): 71-75.

Khalid A, Arshad M, Zahir ZA (2006). Phytohormones: microbial production and applications. In: N. Uphoff et al., Editors, Biological Approaches to Sustainable Soil Systems, Taylor & Francis/CRC Press, Boca Raton , pp. 207-220.

Meadows J (1998). Florida food fair. Cooperative Extension Service for Sarasota Country. University of Florida: Extension Institute of Food and Agriculture Sciences.

Maan SS, Dhillon S (1974). Effect of ethrel and calcium carbide on ripening of mango. Prog. Hort. 61: 59-62.

Mukherjee SK (1997). Introduction: Botany and Importance. In: R. E.

Litz. The Mango: Botany, Production and Uses. CAB International, Wallingford, U.K. pp: 5.

Porter LK (1992). Ethylene inhibition of ammonium oxidation in soil, Soil Sci. Soc. Am. J. 56, pp. 102-105.

Rao KP, Fritz DC (1987). Effects of ethephon plant growth regulator on rice yield. Proceedings of 14th Annual Meeting, 2-6 August 1987. Honolulu, Plant Growth Regulator Society of America. pp. 489.

Sahrawat KL (1989). Effects of nitrification inhibitors on nitrogen transformations, other than nitrification, in soils, Adv. Agron. 42: 279-309.

Sauco V (1997). Mango World Production. Acta Hort. 455: 15-20.

Shah HRA, Chatta GA, Hafiz IA, Ahmad S, Khan M (2002). Nitrogen

concentration at various growth stages of mango and effect of calcium carbide on fruit quality. Asian J. Plant Sci. 1(2): 164-166.
Steel RGD, Torrie JH, Dickey DA (1997). Principles and procedures of statistics, 3rd edition McGraw-Hill, New York.
Thompson RB (1996). Using calcium carbide with the acetylene inhibition technique to measure denitrification from a sprinkler irrigated vegetable crop. Plant Soil 179: 9-16.
Whiley AW, Rasmusen TS, Saramib JB, Walstcnholmc BN (1989). Effect of temperature on growth, dry matter production and starch accumulation in ten mango (*Mangifera indica* L.) cultivars. J. Hort. Sci. 64: 753-765.
Yaseen M, Arshad M, Khalid A (2006). Effect of acetylene and ethylene gases released from encapsulated calcium carbide on growth and yield of wheat and cotton. Pedobiologia. 50: 405-411.
Zhang S, Cai LGX, Wang XZ, Xu YH, Zhu ZL, Freney JR (1992). Losses of urea-nitrogen applied to maize grown on a calcareous fluvo-aquic soil in North China plain. Pedosphere 2: 171-178.