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Off Season Production of Annual Moringa (*Moringa oliefera* Lam.) cv. PKM 1 through Canopy Management and Chemical Manipulation Practices

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Abstract
A field experiment was conducted on annual moringa (*Moringa oliefera* Lam.) cv. PKM 1 to elucidate the influence of canopy management and chemical manipulation to induce off season flowering and fruiting. Among the various treatments, the plants mulched with 50 micron polyethylene mulch, pruned during the month of July and sprayed with 50 ppm Uniconazole (one and two months after pruning) combination resulted in early induction of off season flowering and subsequent fruit set. The result indicated that the plants grown with above mentioned produced more number of flowers per panicle, more number of panicle per plant, higher fruit set (%) and fruit yield per tree when compared with other treatments during off season.

Keywords: Off season flowering, Mulching, Growth retardant, Pruning, Annual Moringa, Yield

Introduction
Moringa (*Moringa oleifera* Lam.) popularly called as the "drumstick tree" which is an indigenous vegetable, has gained its importance due to its neutraceutical values and considered as an indispensable plant for health management. It is one of the most incredible plants to the mankind and its nutritional and medicinal properties have immense potential to manage malnutrition, and prevent and heal any maladies. This fast growing, small to medium sized tree is used as an animal forage, source of nutrition, medicine, water purification, cosmetics even as bio fuel (Anwar *et al*., 2007; Rashid *et al*., 2008; Fuglie, 2001).
India is the largest producer of moringa with an annual production of 1.1 to 1.3 million tonnes of tender fruits from an area of 38,000 ha. Andhrapradesh leads in both area and production (15,665 ha), followed by Karnataka (10,280 ha) and Tamil Nadu (7,408 ha), whereas other states occupying in an area of 4,613 ha only.
Moringa is preferred in the market throughout the year. In south Indian conditions, normally the moringa crop comes to bearing during the month of March –August and the price of pods per kg on an average will be around Rs.5. The farmers get a net profit of Rs.1,50,000 / ha during this period. Further the price of the pods will shoot up to Rs. 15-20 / kg during September and October as the productivity starts declining.
The pods are available in less quantity during November – March, owing to the season which coincides with the heavy rainfall leading to flower drop, which ultimately leads to poor pod set and is considered to be the off season period. During this particular period (November – March), the cost of pods will raise even up to Rs.60 -100 / Kg, which is higher than the profit obtained during the glut period of production (April –August). So the tree crop characterized by inconsistent yield behaviour and is highly influenced by seasons. Since Moringa does not produce flowers during winter and it loves dry climate and less water during flowering and fruit set; the dry period favours flowering and fruit set. So altering the flowering mechanism of moringa through management practices will help the off season production of moringa. Plastic mulches are used in the cultivation of horticultural crops to modify the soil temperature, moisture regimes, prevent the entry of rain water and possibly alter the photobiology of the plant. Plastic mulches primarily affect the field microclimate by modifying the radiation budget of the surface which in turn may influence plant growth and productivity (Liakatas *et al*., 1986). It has great potential that can be fully exploited only if the crop is pruned in the right season. The pruning can be adjusted in such a way that the flowering is manipulated and the yield is obtained during off season when there is premium price in the market. The growth retardants are known for their effects of suppressing vegetative growth and inducing flowering in crop plants. Hence, the present investigation was carried out with a view to study the influence of canopy management and chemical manipulation on off season flowering and

fruiting in annual moringa.

Materials and Methods

A field experiment was conducted at Krishi Vigyan Kendra, Veterinary College and Research Institute Campus, Namakkal, Tamil Nadu from June 2012 to March 2014 with a view to study the influence of canopy management and Chemical manipulation to induce off season flowering and fruiting in annual moringa (*Moringa oleifera Lam*) cv. PKM 1. The soil type was red sandy loam with a pH of 7.16 and EC of 0.134 dSm^{-1} with a fertility status of low available nitrogen (187.8 kg/ha), low available phosphorus (10.6kg / ha) and medium Potassium (132kg / ha).

The experiment was laid out in a Factorial Randomized Block Design (FRBD) with two replications and consisted of 18 treatments, with each treatment comprising of six plants spaced at 2.5 x 2.5 m. The treatments comprised of two levels of mulching *viz.*, without mulching (M_1), Mulching with 50 micron black polyethylene mulch (M_2), three levels of pruning *viz.*, July pruning (P_1), August Pruning (P_2) and September pruning (P_3) and three levels of growth retardant application at one month after pruning and two months after pruning *viz.*, water spray (S_1), Uniconazole 50 ppm (S_2) and Mepiquat chloride 50 ppm (S_3).

All the recommended agronomic practices and crop husbandry were followed to have a good crop stand. The growth attributes days taken for first flowering, number of panicles / tree, number flowers/ panicles, Pod set %, number of fruits / panicle were recorded and the mean data were statistically analysed and the results were discussed hereunder.

Results and Discussion

Days taken for first flowering

Number of days to first flowering is an important criterion that governs the earliness of a crop. Influence of mulching, pruning and chemical spray on number of days taken for first flowering showed highly significant effect during off season (Table1). The number of days taken for first flowering exhibited significant difference with regard to mulching. Among the mulching treatments studied, M_2 (black polyethylene mulch) recorded the lowest days taken for first flowering (72.78 days), followed by M_1 (without mulch) which registered 90.21 days. This might be due to higher soil temperature under black polyethylene mulch that might have improved the plant micro climate which led to early growth and development and advanced the flowering during off season. Tressen (1983) recorded earliness and more yield with the 1-2 ^{0}C increase in soil temperature by use of black polyethylene mulch in tomato. Mulching increases the soil temperature which enables favourable conditions for nutrients, metabolite mobilization and energy. This in accordance with the findings of Splittoesser (1990); Chiazor (2008) in okra: Pinjari *et al.* (2009) in sweet corn; Ekwu *et al.* (2012) in cucumber and Mochiah *et al*. (2012) in capsicum.

Among the months of pruning compared, the days taken for first flowering showed the significant difference. The P_3 (September pruning) recorded the lowest days for first flowering (78.10 days), followed by P_1 (July pruning) with 81.88 days. While P_2 (August pruning) registered maximum days for first flowering (84.50 days). The present study revealed that pruning during September recorded early flowering possibly due to the environmental condition that prevailed during vegetative stage which is a pre-requisite for onset of early flowering (Balakrishnan, 1986). This could be due to higher level of endogenous IAA as well as assimilates at flowering stage resulting earliness. Flowering in many plants was not the result of a series of autonomous processes determined by the genetic constituent but determination of environmental factors like temperature, relative humidity and rainfall (Zeeavaert, 1964). This is in conformity with the finding of Wurster and Nganga (1971); Jeanine Davis and Edmund Estes (1993); Carlton *et al*. (1994); Levent Arin and Sozer Ankara (2001); Bielinski Santos *et al*. (2007); Ekwu *et al.* (2012) and Hidayatullah *et al.* (2013).

The effect of chemical spray had the significant difference for number of days taken for first flowering during off season. The lowest days taken for flowering (80.38 days) was recorded in S_2 (uniconazole 50ppm spray) followed by S_1 (water spray) with 81.22 days. The highest days taken for flowering (82.88 days) was observed in S_3 (mepiquat chloride 50 ppm spray). This would be a result of uniconazole which enhanced mobilization of photosynthates from leaves to productive organs (Hala *et al*., 2008). Keever ad Foster (1991) also found that UCZ on geranium has resulted in early flowering when height control was optimum. The cytokinin effect observed with uniconazle appeared to be an indirect one. Similar results were also reported by Banno *et al*. (1985), they found that supplying cytokinins to auxillary buds initiated flowering in Japanese pear. This is in conformity with the findings of Silva *et al*. (2010) in Mango.

The two way interaction effect between mulching and pruning showed highly significant influence on number of days taken for first flowering. M_2P_1 (black polyethylene mulch and July pruning) recorded the lowest days for first flowering (68.88 days). It was followed by M_2P_2 (black polyethylene mulch and August pruning) which recorded 71.30 days for first flowering. The highest number of days taken for flowering (97.70 days) was registered in M_1P_2 (without mulch and August pruning).

Significant difference was noticed on number of days taken for first flowering under the interaction of pruning and chemicals used in the present study. The lowest days taken for first flowering (76.05 days) was in P_3S_2 (September pruning and uniconazole 50 ppm spray). The highest value (85.02 days) was noticed in P_2S_1 (August pruning and water spray). The combined effect of mulching and chemicals on days taken for first flowering showed significant difference. The result revealed that M_2S_2 (black polyethylene mulch and uniconazole 50 ppm spray) recorded the lowest days for first flowering (70.91 days). It was followed by M_2S_3 (black polyethylene mulch and mepiquat chloride 50 ppm spray) with 72.45 days. The highest days taken for first flowering (93.31 days) were recorded in M_1S_3 (without mulching and September pruning).

The combined effect of mulching, pruning and chemical spray indicated the significant influence on days taken for first flowering. Among the three different combinations studied, the combination $M_2P_1S_2$ (black polyethylene mulch + July pruning + uniconazole 50 ppm spray) registered the lowest days taken for first flowering (66.25 days) followed by $M_2P_1S_3$ (black polyethylene mulch + July pruning + mepiquat chloride 50 ppm spray) (69.35 days). The highest value for this trait (99.75 days) was recorded in $M_1P_1S_3$ (without mulch + July pruning + mepiquat chloride 50 ppm spray). It may be due to the influence of diverse factors like genetic, environmental, physiological, nutritional, hormonal and cultural

Table 1: Influence of canopy management and chemical manipulation on days to first flowering of annual moringa (*Moringa oleifera* Lam.) cv.PKM 1.

Treatments	S_1	S_2	S_3	Mean
M_1	87.46	89.85	93.31	90.21
M_2	74.98	70.91	72.45	72.78
Mean	**81.22**	**80.38**	**82.88**	**81.49**
P_1	80.22	80.87	84.55	81.88
P_2	85.02	84.22	84.25	84.50
P_3	78.42	76.05	79.85	78.10
Mean	**81.22**	**80.38**	**82.88**	**81.49**
M_1P_1	89.40	95.50	99.75	94.88
M_1P_2	97.00	97.90	98.20	97.70
M_1P_3	76.00	76.15	82.00	78.05
M_2P_1	71.05	66.25	69.35	64.88
M_2P_2	73.05	70.55	70.30	71.30
M_2P_3	80.85	75.95	77.70	78.16
Mean	**81.22**	**80.38**	**82.88**	**81.49**
Source	**SEd**		**CD (0.05)**	
M	0.40620		0.85703	
P	0.49749		1.04964	
S	0.49749		1.04964	
MP	0.70356		1.48441	
PS	0.86168		1.81803	
MS	0.70356		1.48441	
MPS	1.21860		2.57108	

Number of panicles per plant

The influence of canopy management and chemical manipulation on number of panicles per tree of annual moringa (*Moringa oleifera* Lam.) cv.PKM 1.were presented in Table 2. The number of panicles produced per tree was significantly influenced by the mulching, pruning and growth retardant application. Moringa plants mulched with 50 micron black polyethylene mulch (M_2) registered the highest number of panicles (46.47) and the lowest number of panicles was observed in unmulched (M_1) plant (31.40). This might be due to the maximum soil temperature prevailed under black polyethylene which was 2.2 to 3.4^{0}C more than the bare soil at 10 cm depth. Black polyethylene mulch is more effective in increasing soil temperature due to a greater net radiation under the mulch compared to bare soil (Streak *et al.*, 1994). Consequently; the soil heat flux is substantially greater under mulch. The effect of mulching material on soil temperature obtained in this study is in agreement with those reported by other researchers (Haynes, 1987).

Among the different months of pruning, July pruning (P_1) registered the highest number of panicles (43.02) followed by August pruning (P_2) (38.79) and the lowest number of panicles were observed with the trees pruned during the month of September (P_3) with 34.99 numbers of panicles. In the present study, the highest number of panicles per tree and flowers per panicle was recorded in July pruning, followed by August pruning. This might be due to induction and emergence of maximum number of primary, secondary and tertiary branches. The time of pruning determines the vegetative growth, tree canopy, advancement of bud sprouting, flowering and fruiting (Azam *et al.*, 2006). The conducive climatic condition would also have improved the panicle production (Vijayakumar, 2001).

Likewise among the chemicals tried, the plants sprayed with uniconazole 50ppm (S_2) produced more number of panicles (41.22) and Mepiquat chloride 50 ppm (S_3) (40.92) and these two treatments were on par. The least number of panicles were observed under control (S_1) (34.65).The magnificent of increased number of panicles per tree could be explained by the following reasons. First, uniconazole enhanced the photosynthetic ability of plants by increasing chlorophyll contents in the leaves. The stimulation of cytokinin synthesis caused by triazole compounds could be the reason for the increase of chlorophyll contents as it enhances chloroplast differentiation, chlorophyll biosynthesis and prevents chlorophyll degradation (Fletcher *et al.*, 2000). The abundant carbohydrate synthesis supported the reproductive growth. The photosynthetic ability was also enhanced by the delay of leaf senescence in response to uniconazole treatment. Second, uniconazole is well known for its anti – gibberellins effect which is efficient in reducing growth of leaves and stems and facilitating carobohydrates accumulation in sink organs. It is in accordance with many reports on positive effect of uniconazole in sink organs (Yim *et al.*, 1997). Third, the increased sink strength presumably enhanced photosynthesis and improved translocation of photo-assimilates to the sink organ.

The interaction effect between mulching and months of pruning showed highly significant influence on number of panicles per tree. M_2P_1 (Black polyethylene x July pruning) recorded the highest number of panicles per tree (54.58). It was followed by M_2P_2 (Black polyethylene x August pruning) which showed 44.56 number of panicles. M_1P_1 recorded the lowest number of panicles per tree (31.46). Significant difference was noticed on number of panicles per tree under the interaction of pruning and chemicals involved in the present investigation. The lowest number of panicles (38.77) was in P_2S_1. The highest number of panicles (45.05) was obtained in P_1S_2. This might be due to pruning along with chemical spray reduced percentage of vegetative growth and increased percentage of flower panicle compared to control. Similar results were reported by Mass (1989). The combined effect of mulching and chemical spray on panicles / tree showed significant difference. The results revealed that M_2S_2 registered the highest panicles / tree (52.98). It was followed by M_2S_3 with a value of 52.05. The lowest number (31.03) was recorded in M_1S_1.

The combined effect of mulching, months of pruning and chemical spray indicated the significant influence on number of flowers per panicle. Among the three combinations, $M_2P_1S_2$ registered the highest number of panicles (59.15) followed by $M_2P_2S_3$ (55.85). The lowest number (27.35) was recorded in $M_1P_1S_1$.

Table 2: Influence of canopy management and chemical manipulation on Panicles per tree of Annual moringa (*Moringa oleifera* Lam.) cv.PKM 1.

Treatments	S_1	S_2	S_3	Mean
M_1	25.40	32.08	36.71	31.40
M_2	43.91	50.36	45.13	46.47
Mean	**34.65**	**41.22**	**40.92**	**38.93**
P_1	38.10	44.67	46.30	43.02
P_2	32.75	42.07	41.55	38.79
P_3	33.12	36.92	34.92	34.99
Mean	**34.65**	**41.22**	**40.92**	**38.93**
M_1P_1	27.20	27.25	39.95	31.46
M_1P_2	22.95	36.15	39.95	33.01
M_1P_3	26.05	32.85	30.25	29.71
M_2P_1	49.00	62.10	52.65	54.58
M_2P_2	42.55	48.00	43.15	44.56
M_2P_3	40.20	41.00	39.60	40.26
Mean	**34.65**	**41.22**	**40.92**	**38.93**
Source	**SEd**		**CD (0.05)**	
M	0.72026		1.51965	
P	0.88213		1.86118	
S	0.88213		1.86118	
MP	1.24753		2.63211	
PS	1.52790		3.22366	
MS	1.24753		2.63211	
MPS	2.16078		4.55895	

Number of flowers per panicle

Influence of canopy management and chemical manipulation on number of flowers / panicle showed highly significant effect during off season (Table 3).

The number of flowers per panicle exhibited significant difference with regard to mulching. Among the mulching treatment studied, M_2 recorded the maximum number of flowers per panicle (72.05), followed by M_1 which recorded 60.68. This might be due to increased root zone temperature in mulched plant. The soil temperature under a mulch depends on the thermal properties (reflectivity, absorptivity or transmittancy). A large proportion of the energy absorbed by the black mulch can be transferred to the soil by conduction (Schales and Sheldrake, 1963).

Among the three months of pruning compared, there was significant difference on the number of flowers per panicle. The P_1 recorded the highest number of flower per panicle (67.90) Compared to P_3 which registered the lowest number of flowers per panicle (65.02). This is in conformity with the findings of Voon *et al.*, 1991, he found that number of panicles borne on a shoot in July pruning was the highest, followed by those pruned in August and September in Mango. Panicle length was higher on new shoots produced after July-August pruning. Likewise the chemical spray showed the significant difference for number of flowers per panicle. The highest number of flowers per panicle (71.14) was recorded in S_2 followed by S_3 with the value of 68.44. The lowest number of flowers per panicle (59.53) however was recorded in S_1. This might be due to inhibition gibberellin biosynthesis. It suppresses cell elongation, but not cell division and can promote flowering and flower expression. In general, triazole, owing to its anti - gibberellin activity, could induce or intensify flowering by blocking the conversion of kaurene to kaurenoic acid (Voon *et al.*, 1991).

The interaction effect between mulching and pruning showed highly significant influence on number of flowers per panicle. M_2P_1 recorded the highest number of flowers (76.13). It was followed by M_2P_2 which recorded 71.30 numbers of flowers per panicle. The lowest number of flowers (59.64) was registered in M_1P_1.

Significant difference was noticed on number of flowers per panicle under the interaction of different months of pruning and chemical spray employed in the present study. The highest number of flowers per panicle (74.22) was recorded in P_1S_2 followed by P_1S_3 which recorded 71.39. The lowest number (58.09) was observed in P_1S_1. This might be due to the accumulation of sufficient carbohydrates in plants and synthesis of proteins during early stages for improved fruit characters and yield. The higher rate of photosynthesis in pruned shoots has been reported to be associated with greater chlorophyll content, mesophyll cell enlargement, lower starch and alteration in activity of cytokinin like substances (Tayler and Ferree., 1986). These findings are in conformity with that of Kandolia and Bhuva (1996) in Phalsa, Gupta and Godara (1989) in Ber.

The combined effect of mulching and chemical spray on number of flowers per panicle showed significant difference. The result showed that M_2S_2 exhibited the highest number of flowers per panicle (73.57). It was followed by M_2S_3 with a value of 72.73. The lowest value for the trait (49.18) was recorded in M_1S_1. The combined effect of mulching, different months of pruning and chemical spray indicated the significant influence on number of flowers per panicle. Among the three different combinations studied, the combination $M_2P_1S_2$ registered the highest number of flowers per panicle (79.30) followed by $M_2P_1S_3$ (77.72). The lowest number of flowers per panicle (44.74) however was recorded in $M_1P_1S_1$.

Table 3: Influence of canopy management and chemical manipulation on number of flowers per panicle of Annual moringa (*Moringa oleifera* Lam.) cv.PKM 1.

Treatments	S_1	S_2	S_3	Mean
M_1	49.18	68.72	64.14	60.68
M_2	69.87	73.57	72.73	72.05
Mean	**59.53**	**71.14**	**68.44**	**66.37**
P_1	58.09	74.22	71.39	67.90
P_2	59.68	72.19	66.72	66.19
P_3	60.82	67.03	67.21	65.02
Mean	**59.53**	**71.14**	**68.44**	**66.37**
M_1P_1	44.74	69.13	65.06	59.64
M_1P_2	48.62	72.70	61.95	61.09
M_1P_3	54.20	64.33	65.42	61.32
M_2P_1	71.43	79.30	77.72	76.15
M_2P_2	70.74	71.68	71.48	71.30
M_2P_3	67.44	69.72	68.99	68.72
Mean	**59.53**	**71.14**	**68.44**	**66.37**
Source	**SEd**		**CD (0.05)**	
M	0.43178		0.91099	
P	0.52882		1.11573	
S	0.52882		1.11573	
MP	0.74786		1.57788	
PS	0.91594		1.93251	
MS	0.74786		1.57788	
MPS	1.29533		2.73298	

Pod set per cent

Influence of canopy management and chemical manipulation on pod set per cent revealed highly significant effect during off season. (Table 4).

The pod set per cent exhibited significant difference with regard to mulching treatments. Among the two treatments, M_2 recorded the highest pod set per cent (2.84), followed by M_1 which recorded (2.18). This may be due to better moderation of soil hydrothermal regimes by the black polythene mulch which consequently increased the availability of nutrients. This is accordance with findings of Sharma and Kathiravan, 2009. According to Downs and Hellermers (1975) root zone temperature affects both physical and metabolic processes within plants, by altering the reaction rates of enzyme systems, since the optimum temperatures for enzymatic reactions are enzyme specific, and only vary between enzymatic systems. The highest growth rates are only achieved once the environmental temperature coincides with the requirements of these enzymatic reactions. As the enzymatic reactions responsible for the processing of photosynthates are temperature sensitive, growth and development are a function of the growing temperature.

Among the chemicals sprayed, the pod set per cent showed a significant difference. The S_2 recorded the highest fruit set per cent (2.71) and S_1 registered the lowest fruit set per cent (2.41). This may be due to the cytokinin effect observed with uniconazole appeared to be an indirect one and reduced abscission of reproductive parts ultimately that increased the pod set per cent. This is in close conformity with the findings of Zaman (1988) in sunflower, Banno *et al.* (1985) in Japanese pear, Luckwill (1970) and Abbott (1984) in apple.

The interaction effect between mulching and month of pruning showed significant influence on fruit set per cent. M_2P_1 recorded the highest fruit set per cent (3.09). It was followed by M_2P_2 which exhibited 2.77 fruit set per cent. The

lowest fruit set per cent (2.10) was registered in M_1P_1. This might be due to optimum temperature and adequate sunshine hours would have facilitated good photosynthetic activity (Ravichandran, 2004) and also favourable metabolic process, availability of photosynthates to fruit development and adequate hormonal balance to augment fruit setting. Pruning also modify the microclimate within the canopy (Chouliaras *et al*., 1995). The results are in agreement with those reported by Lal *et al.* (2003).

Significant difference was observed on fruit set per cent under the interaction of different months of pruning and chemical spray employed in the present experiments. The highest fruit set per cent (2.89) was in P_1S_2 followed by P_2S_3 which recorded 2.53 per cent. The lowest value of 2.19 per cent was recorded in P_3S_1. The combined three way interaction effect of mulching, pruning and chemical spray indicated the significant influence on fruit set percentage. Among the three different combinations studied, the combination $M_2P_1S_2$ registered the highest fruit set per cent (3.59). Where the lowest value (1.79 per cent) was recorded in $M_1P_1S_2$.

Table 4: Influence of canopy management and chemical manipulation on Pod set percentage of Annual moringa (*Moringa oleifera* Lam.) cv.PKM 1.

Treatments	S_1	S_2	S_3	Mean
M_1	2.18	2.31	2.05	2.18
M_2	2.63	3.10	2.80	2.84
Mean	**2.41**	**2.71**	**2.43**	**2.51**
P_1	2.52	2.89	2.37	2.59
P_2	2.51	2.34	2.53	2.46
P_3	2.19	2.89	2.38	2.49
Mean	**2.41**	**2.71**	**2.43**	**2.51**
M_1P_1	2.16	2.19	1.95	2.10
M_1P_2	2.42	1.79	2.25	2.15
M_1P_3	1.96	2.95	1.96	2.29
M_2P_1	2.89	3.59	2.79	3.09
M_2P_2	2.59	2.90	2.81	2.77
M_2P_3	2.42	2.83	2.80	2.68
Mean	**2.41**	**2.71**	**2.43**	**2.51**
Source	**SEd**		**CD (0.05)**	
M	0.08391		0.17704	
P	0.10277		0.21682	
S	0.10277		0.21682	
MP	0.14533		0.30663	
PS	0.17800		0.37555	
MS	0.14533		0.30663	
MPS	0.25173		0.53111	

Yield per tree

Influence of canopy management and chemical manipulation on yield per tree had highly significant effect during off season. (Table 5). The yield per tree exhibited significant difference with regard to mulching. Among the mulching treatment studied, M_2 recorded the maximum yield per tree (15.67), followed by M_1 which registered 14.62. This is in agreement with the observations of Decoteau *et al.* (1989), who obtained higher tomato yield with black plastic mulch than with bare soil. Black plastic mulch increased pod yield of okra by 29.65 % over non mulching (Patel *et al*., 2009). The difference in yield of moringa tree in the present study appears to be related to the differences in far-red/red (FR/R) ratios received by the plants. Nevertheless, the change in FR/R ratio is not the only factor determining photosynthate partitioning and yield. Higher soil temperature, efficient water utilization, fertilizers and reduction in the competition with weeds are other reasons which might also be responsible for increasing the yield (Clarkson, 1960). Black plastic mulch affects the nitrate leaching which is indirectly related to the yield. Some researchers noticed that black plastic mulch is an enduring and impermeable material which protects the bed from nitrate leaching in the early rainy season. When the highest nitrate leaching normally occurs on uncovered soil (Romic *et al*., 2003). The result of the present findings are in accordance with those of the earlier researchers who reported significantly higher yield under black plastic mulch as a result of effective soil temperature, weed control and conservation of soil moisture (Singh *et al*., 2005 ; Mehta *et al*.,2010)

Among the months of pruning compared, yield per tree showed the significant difference. The P_1 recorded the highest fruit yield per tree (16.63) while P_3 registered the lowest yield (14.28). In the present study, the highest number of panicles per tree and flowers per panicle were recorded in July pruning, followed by August pruning. The highest number of primary branches in July pruning might have contributed to this phenomenon. The conducive climatic condition would also have improved the flower and panicle production (Vijayakumar, 2001). Durand (1997) inferred that if tree is managed to facilitate light penetration in the canopy, the photosynthetic activity during fruit growth period might be augmented to increase yield. Similar results were also referred by Yeshitela *et al*. (2005) in mango.

The chemical spray effect observed a significant difference for yield per tree. The maximum yield (16.10 Kg / tree) was recorded in S_2 followed by S_3 with 15.24 Kg / tree. The lowest yield (14.10 Kg / tree) was registered in S_1. The highest number of fruits per plant might be because of higher fruit set and reduced abscission of reproductive parts (Chandra and Das, 2007).

The interaction effect between the mulching and pruning showed highly significant influence on yield per tree. M_2P_1 recorded the highest fruit yield per tree (17.84 Kg / tree). It was followed by M_1P_1 which recorded 15.41 kg of fruits per tree. The lowest yield (14.03 Kg / tree) was registered in M_1P_3. Significant difference was noticed on yield per tree under the interaction of pruning and chemical spray employed in the present study (17.03 Kg / tree). The lowest yield (13.43 Kg/tree) was recorded in P_3S_1 and this could be attributed to inhibition of vegetative growth and thus making available food reserves for developing fruits (Ma and Smith., 1992), which was evident from significantly increased number of fruits per plant.

Table 5: Influence of canopy management and chemical manipulation on yield per tree (Kg / tree) of Annual moringa (*Moringa oleifera* Lam.) cv.PKM 1.

Treatments	S_1	S_2	S_3	Mean
M_1	13.59	15.41	14.87	14.62
M_2	14.62	16.79	15.60	15.67
Mean	**14.10**	**16.10**	**15.24**	**15.14**
P_1	14.88	17.96	17.03	16.63
P_2	13.99	15.30	14.31	14.53
P_3	13.43	15.04	14.37	14.28
Mean	**14.10**	**16.10**	**15.24**	**15.14**
M_1P_1	13.99	16.60	15.65	15.41
M_1P_2	13.62	15.12	14.53	14.42
M_1P_3	13.15	14.50	14.44	14.03
M_2P_1	15.78	19.33	18.42	17.84
M_2P_2	14.36	15.47	14.08	14.64
M_2P_3	13.71	15.57	14.31	14.53
Mean	**14.10**	**16.10**	**15.24**	**15.14**
Source	**SEd**		**CD (0.05)**	
M	0.16544		0.34906	
P	0.20263		0.42751	
S	0.20263		0.42751	
MP	0.28656		0.60459	
PS	0.35096		0.74047	
MS	0.28656		0.60459	
MPS	0.49633		1.04719	

On the basis of result and discussion it may be indicated that moringa loves dry climate and less water for flowering and fruiting during off season.

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