Effect of tree spacing, organic manures and PGPR on flowering parameters of *Dianthus barbatus* L under *Grewia optiva* Drummond-based agroforestry system

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ABSTRACT

The investigations were carried out to study the effect of tree spacing, organic manures and PGPR on flower parameters of *Dianthus barbatus* L (sweet william). It was found that flower parameters like days taken to flowering, cluster size and duration of flowering were more under the agroforestry system except number of flowers per plant. Organic manures like FYM and vermicompost enhanced the flower parameters both in open condition and within agroforestry system. Alone PGPR was not much effective with regard to the flower parameters. Study also revealed that tree-based farming system can be one of the viable alternative land use systems to prevent further degradation of land due to soil erosion and obtain production on sustainable basis.

Keywords: PGPR; vermicompost; agroforestry system; FYM; land use system

INTRODUCTION

Land use options that increase livelihood security and reduce vulnerability to climate and environmental change are necessary. Traditional resource management adaptations such as agroforestry systems may potentially provide options for improvement in livelihoods through simultaneous production of food, fodder and firewood as well as mitigation of the impact of climate change (Pandey 2007). Reframing the challenge in another way, agroforestry systems may provide part of the answer to a central challenge for sustainability on how to conserve forest ecosystems and farmland biodiversity as well as the services that they provide while simultaneously enhancing food production for an increasing population under the condition of land and water scarcity (Lambin and Meyfroidt 2011). Livelihoods improvement is not just about the positive change towards better quality of life and human well-being but it takes into account the local and global change which determines livelihoods. The adverse impact of climate change may be more severely felt by poor people who are more vulnerable than rich. Appropriate policy responses combining the agro-ecosystems as key assets can strengthen adaptation and help build the resilience of communities and households to local and global change (Kareiva et al 2007). There is thus a need for intensified management and governance efforts to generate products and services in agro-ecosystems. Tree growing in combination with agriculture as well as numerous other vegetation management regimes in cultural landscape including in farms, watersheds and regional landscape can be integrated to take advantage of services provided by adjacent natural, semi-natural or restored ecosystems (Pandey 2002).

Tree-based farming system can be one of the viable alternative land use systems to prevent further degradation of land due to soil erosion and obtain production on sustainable basis. Among various trees used in agroforestry, *Grewia optiva* Drummond is an important multipurpose tree. It belongs to family Tiliaceae and is one of the most important fodder trees of northwestern Himalaya. According to Brandis (1972)

G optiva is distributed throughout the sub-Himalayan tract found up to an altitude of 1,800 m. It is sparingly found in forest area and is mostly raised along agriculture fields and is heavily lopped for palatable fodder. It is very popular among the farmers of western Himalayas for feeding their productive cattle during the winter period when no other green fodder is available.

India is comparatively well placed with regard to floriculture business being a large tropical country and able to produce variety of flowers all round the year. Due to favourable climatic conditions India can supply fresh flowers. Government of India gives incentives to floriculture. Himachal Pradesh is the state where temperature varies from 0 to 39ºC and often produces off-season flowers in India when there is dearth period for the flower production. Therefore integration of flower crop in the agroforestry system may prove one of the best viable cultural practices to improve the socio-economic status of the small landholding farmers in Himachal Pradesh.

Dianthus barbatus (sweet william) is a species of *Dianthus* native to southern Europe and parts of Asia which has become a popular ornamental garden plant. It belongs to family Caryophyllaceae and is a herbaceous biennial or short-lived perennial plant growing to 30-75 cm tall with flowers in a dense cluster of up to 30 at the top of the stems. The flowers have a spicy, clove-like scent; each flower is 2-3 cm in diameter with five petals with serrated edges. In wild plants the petals are red with a white base.

Organic farming comprises diversified agricultural techniques like intercropping, crop rotation, green manuring, organic manures (FYM and compost), organic residues, biofertilizers etc. Most commonly used organic manure is FYM in which cattle dung constitutes the major source of nutrients and contains 0.72, 0.35 and 0.80 per cent N, P and K respectively. Similarly vermicompost enriches the soil by improving the residual build up of organic carbon and available N, P and K in soil. Vermicompost greatly increases surface area providing more micro-sites for microbial decomposing organisms and strong adsorption and retention of nutrients (Shi-wei and Fu-Zhen 1991). Vermicompost has many outstanding biological properties like bacteria, actinomycetes, fungi and cellulose degrading bacteria (Werner and Cuevas 1996). Therefore integration of flower crop in the agroforestry system may prove one of the best viable cultural practices to improve the socio-economic status of the small landholding farmers in northwestern Himalaya.

MATERIAL and METHODS

The study was conducted at the experimental field of Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2012-2013. An agroforestry system comprising *G optiva* + *D barbatus* was developed to study the effect of different tree spacings, organic manures and PGPR on growth parameters of winter flower annual (*D barbatus* L). *G optiva* was planted in July 2004 at different spacings (plant to plant 1, 2 and 3 m and rows 8 m apart). *D barbatus*, an important winter annual flower was sown as intercrop and applied with eight organic doses viz 5.00 kg FYM (T_1), 3.00 kg vermicompost (T_2), 5.00 kg municipal solid waste (T_3), PGPR (T_4), 5.00 kg FYM + PGPR (T_5), 3.00 kg vermicompost + PGPR (T_6), 5.00 kg municipal solid waste + PGPR (T_7) and control (T_8 no manure) per plot. Size of the plot was 1 × 1 m. Seed treatment was done with 250 ml PGPR. Nursery-raised seedlings of *D barbatus* were transplanted in the system during the month of November 2012. The study was undertaken in the year 2012-13. Experiment was laid out in a split plot design and data were recorded for various growth parameters from December 2012 to April 2013.

RESULTS and DISCUSSION

Flowering parameters of *D barbatus* were significantly affected by tree spacing and organic treatments. Among different tree spacings, minimum days (128.23) were taken for flowering in S_1 and maximum (131.64) in S_0. Among different doses of organic treatments minimum days (127.65) taken for flowering were recorded in T_6 and maximum (133.57) in T_8. Cumulative effect of treatment and spacing (T × S) registered a significant effect on the days taken for flowering with minimum days (125.65) recorded in the treatment combination T_6S_1 which was found statistically at par with the treatment combination T_2S_1 (126.55) and maximum days (135.42) were recorded in the treatment combination T_8S_0. It showed that the closer spacing of trees influenced the days taken to flower and closer spacing initiated early flowering in *D barbatus*. This may be due to the higher temperature and higher moisture content under tree canopy in winter season as compared to the open conditions. These results are in the line with the work of Swaroop (1967) in which it was reported that half sunny location and higher moisture content initiated early flowering in moist soil. Among organic treatments it was found that vermicompost @ 3.0 kg/plot initiated early flowering in *D barbatus*. The findings of the present investigations are in line with the results of Hidalgo and Harkess (2002) who reported that plants grown in (50%) vermicompost had an early flower development in chrysanthemum cv Mirmar.

Tree spacing and organic treatments significantly affected the cluster size. Maximum (10.78 cm) cluster size was recorded in S_1 which was found to be statistically at par with the S_2 and S_3 whereas minimum (9.63 cm) was recorded in S_0 ie open conditions. Among different doses of organic treatments maximum (10.83 cm) cluster size was recorded in T_6 which was statistically at par with the T_2, T_3, T_1, T_5 and T_7 whereas minimum (8.86 cm) was recorded in T_8. Combined effect of treatments and spacing (T × S) showed a significant effect on the cluster size. Maximum (11.64 cm) cluster size was recorded in T_6S_1 which was statistically at par with the treatment combinations T_1S_1, T_1S_2, T_2S_1, T_2S_3, T_2S_0, T_3S_1, T_3S_2, T_3S_3, T_5S_1, T_5S_2, T_5S_3, T_6S_3 and T_7 S_3 whereas minimum (7.59 cm) was recorded in T_8S_0. Results of the present investigations showed that cluster size of *D barbatus* was found to be more under tree canopy in comparison to open conditions. Although studies on adverse radiation effect on understory species have been reported from other agroforestry systems (McMurtie and Wolf 1983, Sinoquet and Bonhomme 1992) but no such reports are available for flower size in flowering winter annuals. Prakash (2011) reported that flower size of *Calendula officinalis* was more under *G optiva* canopy at a spacing of 3 m from tree to tree as compared to the open conditions. Applications of different doses of organic treatments had positive effect on the flower size. The treatment vermicompost @ 2.00 kg + PGPR followed by FYM @ 5.00 kg + PGPR were numerically found better with respect to flower size as compared to other treatments. The greater flower size in these treatment doses might be due to an optimum nutrient availability. Similar results were reported by Ajitkumar (2002) in marigold.

Under tree spacing maximum (89.19) number of flowers per plant was recorded in S_0 and minimum (84.24) in S_1. Among different doses of organic treatments T_6 resulted in maximum (90.85) number of flowers per plant and minimum (79.38) was recorded in T_8. Combined effect of treatments and spacing (T × S) showed significant effect on the number of flowers per plant. Maximum (94.28) number of flowers per plant was recorded in treatment combination T_6S_0 which was found to be statistically at par with the T_2S_0 (93.05) and minimum (77.00) was recorded in treatment combination T_8S_0. It reveals that lower number of flowers per plant was recorded in S_1 under *G optiva* whereas higher number of flowers per plant was recorded in open conditions (S_0) which may be due the lower production of photosynthates under low light conditions for a longer period. It has been reported that where soil nutrients and moisture are not limiting, crop growth and yield are dependent on total solar radiation intercepted (Bellow and Nair 2003). Probably reduced flower number under canopy in present study was also mainly due to reduced light available to the crop when moisture and nutrients were not limiting. Application of organic treatments such as vermicompost @ 2 kg/plot + PGPR was found to be the best manure dose for the production of maximum number of flowers per plant. Similar results were reported by Sreenivas et al (1998) in China aster where they reported that more number of flowers per plant was recorded with the application of FYM (15 tonne/ha) + NPK at the recommended level. Similarly Yadav and Singh (1997) also reported significant improvement in the yield of marigold with the application of FYM. Similar results were reported by Hidalgo and Harkess (2002) as plants grown in vermicompost had more number of flowers per plant in chrysanthemum cv Mirmar.

Duration of flowering was significantly affected by both tree spacing and organic treatments. Perusal of the data reveals that all tree spacings, organic treatments and interaction effect registered a significant effect on the duration of flowering. The higher (38.25 days) duration of flowering was recorded in S_1 and lesser (35.97 days) in S_0. Among different doses of organic treatments higher (38.77 days) duration of flowering was recorded in T_6 and lesser (33.46 days) in T_8. Interaction effect (T × S) showed that maximum duration (39.83 days) of flowering was recorded in T_2S_1 while it was minimum (32.03 days) in T_8S_0 showing thereby that irrespective of spacing and organic treatments, agroforestry prolonged flowering in *D barbatus* in comparison to open conditions. Prolonged duration of flowering in agroforestry system may be due the continuous shade to the flower crop which had adverse affect on vegetative growth like plant height, number of side shoots, plant spread etc. The findings of the present investigations are in line with Li et al (2008) who reported that variation in the amount of

Table 1. Effect of tree spacing and organic manures on flowering parameters of *Dianthus barbatus* L under *Grewia optiva* Drummond-based agroforestry system

Treatment	Flowering parameters under different spacing																			
	Days taken to flowering					Cluster size (cm)					Number of flowers/plant					Duration of flowering (days)				
	S_1	S_2	S_3	S_0	Mean	S_1	S_2	S_3	S_0	Mean	S_1	S_2	S_3	S_0	Mean	S_1	S_2	S_3	S_0	Mean
T_1	128.29	129.57	129.94	131.50	129.83	11.32	10.80	10.44	9.72	10.57	82.18	83.33	85.33	90.33	85.29	38.83	38.08	37.42	36.92	37.81
T_2	126.55	127.90	129.80	129.83	128.52	11.61	10.28	10.61	10.58	10.77	84.52	86.72	88.67	93.05	88.24	39.83	37.75	37.90	36.27	37.94
T_3	129.07	130.17	130.11	132.35	130.43	10.69	11.44	10.83	9.89	10.71	88.00	85.17	88.96	88.39	87.63	38.55	37.66	37.00	35.17	37.10
T_4	128.83	130.53	131.15	133.00	130.88	10.13	10.44	10.02	8.90	9.87	81.85	82.59	84.55	87.81	84.20	37.85	37.50	36.50	35.55	36.85
T_5	127.79	128.10	128.28	130.17	128.58	11.08	10.66	10.61	9.85	10.55	84.00	85.74	87.68	91.87	87.32	38.92	38.50	38.00	37.52	38.23
T_6	125.65	126.92	128.18	129.85	127.65	11.64	10.33	10.89	10.45	10.83	88.41	89.77	90.94	94.28	90.85	39.75	38.57	38.75	38.00	38.77
T_7	127.76	129.38	130.55	131.00	129.67	10.16	10.22	10.97	10.08	10.36	85.59	87.66	89.18	90.76	88.30	38.25	37.50	36.89	36.33	37.24
T_8	131.85	133.33	133.67	135.42	133.57	9.60	9.24	9.00	7.59	8.86	79.39	81.40	79.72	77.00	79.38	34.00	33.80	34.00	32.03	33.46
Mean	128.23	129.49	130.21	131.64	129.89	10.78	10.43	10.42	9.63	10.31	84.24	85.30	86.88	89.19	86.40	38.25	37.42	37.06	35.97	37.17

T_1: 5 kg farmyard manure (FYM), T_2: 3 kg vermicompost (VC), T_3: 5 kg municipal solid waste (MSW), T_4: Plant growth promoting *Rhizobacteria* (PGPR), T_5: PGPR + 5 kg FYM, T_6: PGPR + 3 kg VC, T_7: PGPR + 5 kg MSW, T_8: No manure, S_1: 1 m tree spacing, S_2: 2 m tree spacing, S_3: 3 m tree spacing; S_0: open

$CD_{0.05}$	Days taken to flowering	Cluster size	Number of flowers/plant	Duration of flowering
T	0.49	0.97	0.52	0.31
S	0.35	0.69	0.37	0.22
T x S	0.99	1.94	1.05	0.63

PAR intercepted by the crop canopy during a week prior to anthesis can explain 97 per cent of the variation in seed yield inside and outside the cropping system. Delaying physiological maturity under low light increases flowering period and grain filling duration. Similar observations have been reported by Hadi et al (2006) and Nasrullahzadeh et al (2007).

CONCLUSION

The investigations revealed that flower parameters like days taken to flowering, cluster size and duration of flowering were more under the agroforestry system. Number of flowers per plant increased with the increase in tree spacing. Intercropping of flower crop with *G optiva* can provide an excellent agroforestry system to enhance the socio-economic status of the farmers. This system can be a viable option to replace the traditional agroforestry system.

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