Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5573

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (5):** 879-887 (2017)

International Journal of Pure & Applied Bioscience

Research Article

OPEN ACCESS

Effect of Fertilizer and Organic Manures on Growth and Yield Attributes of Wheat and Paddy Variety under Casuarina (*Casuarina equisetifolia*) Based Agrisilviculture System

Neeraj Kumar[1*], O. P. Rao[2], Manjeet Singh[1], Pradyuman Singh[1] and Shahroon Khan[1]

[1]N. D. University of Agriculture and Technology, Kumarganj, Faizabad -224229 (U. P.), India

[2]CCS Haryana Agricultural University, Hisar-125 004 (Haryana), India

*Corresponding Author E-mail: 2013a63d@gmail.com

Received: 31.08.2017 | Revised: 29.09.2017 | Accepted: 7.10.2017

ABSTRACT

Casuarina equisetifoliais the most widely planted species in India having multiple utility and suitability in agrarian ecosystem. Present study was carried out fifteen –year –old Casuarina equisetifolia (Jhau) trees, planted at10 x 3m distance with wheat variety NW-1067 and paddy variety Sarjoo-52 was taken in RBD experimental design with four replications in five treatments along with using cultivated in Agri-silviculture system and open area. Findings revealed that maximum growth of C. equisetifolia (tree height 14.75m and dbh 28.10 cm etc at end of experiment) was measured in T_2 (NPK 120:60:40 kg ha^{-1}). The signifcantly highe grain yield(27.6 q ha^{-1} and 29.20 q ha^{-1}) of wheat variety NW-1067 has been achieved due to T_2 (NPK 160:60:40 kg ha^{-1}) treatment in agri-silviculture system and open area respectively, whereas signifcantly higher grain yield (38.40 q ha^{-1} and 40.70 q ha^{-1}) of paddy variety Sarjoo-52 has been achieved due to T_2 (NPK 160:60:40 kg ha^{-1}) treatment in agri-silviculture system and open area respectively. It may be concluded that additionalincome of the farmers can be generated by successful utilization of vacant land under C. equisetifolia based agri-silviculture system as inter crops of wheat computed with enhancing fertility status of soil.

Key words: *Casuarina equisetifolia, Agri-silviculture, Grain yield, Fertility and Sarjoo-52*

INTRODUCTION

Agroforestry is a system of land use, where woody perennials are deliberately used on the same land management unit as annual agricultural crops and/or animals either sequentially or simultaneously with the aim of obtaining greater output on a sustained basis. India has developed self-sufficiency in food grain production but the production of fodder for live-stock and fuel wood is far less than required level in the present time. Agri-silviculture system of agroforestry is one of the dominant agroforestry systems in Eastern UP, in which woody plants such as tree species are deliberately planted in association with annual crops on the same piece of land.

Cite this article: Kumar, N., Rao, O.P., Singh, M., Singh, P. and Khan, S., Effect of Fertilizer and Organic Manures on Growth and Yield Attributes of Wheat and Paddy Variety under Casuarina (*Casuarina equisetifolia)* Based Agrisilviculture System, *Int. J. Pure App. Biosci.* **5(5):** 879-887 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5573

However, no comprehensive scientific information is available on the effect of crops and woody trees on each other when grown in association. Farmers of our country integrate fast growing trees on their farm land in association with agricultural crops. The role of trees in soil erosion control and productivity maintenance on a sustained basis has been proved[32].

The increasing deforestation for human habitation, developmental activities and intensive agriculture resulted in ecological imbalance. Therefore, need has been realized for conservation of natural resources and protection of the deteriorating environment so that the required growth in agriculture is maintained with sustainability[5]. It requires optimization and sustained management of available resources in a given area rather than their over exploitation [7]. It is increasingly seen as a promising approach for improving food security[8], largely because the trees are associated with enhancing and sustaining soil health and crop yield[2]. Realizing the importance of agroforestry Government of India has pronounced a National Agroforestry Policy (2014) and its implementation, is in progress.

Casuarina equisetifolia is a very good source of fuel wood in the Phillipines[9]. The merit of planting *Casuarina* for fuel wood lies in its high tolerance to salinity and nutrient poor sodic land conditions. Apart from a fuel wood species, it is an efficient Nfixer and also allows tremendous nutrient return to soil through litter input. Relying on its tolerance to unusually high pH range (8.5-9.5), it has been introduced in agroforestry systems on problem sodic soil[17]. Casurina is also used on pulp and rayon production. It is fast growing, multipurpose and actinorhizal tree species.

The main advantage of planting casuarinas is the fixation of atmospheric nitrogen due to its association with Frankia, in the root nodules, thus enriching the soil with nitrogen. Marcolin *et al*.[13] have shown that Casuarinas are very efficient at carbon sequestration due to their fast growth rate and adaptability. Agri-silviculture system which is gaining ground in most developing countries, which ensures an intensive utilization of the land. It provides employment means of subsistence to people. This system provides the basic requirement of fodder, fuel, pulp and green manure for agricultural crops[23]. Farmers of our country integrate fast growing trees on their farm land in association with agricultural crops. The higher income from agroforestry unlike monocropping of agricultural crops is a major reason for farmer to plant more trees in association with agricultural crops. The role of trees in soil erosion control and productivity maintenance on a sustained basis has been proved[30].

Casuarina equisetifolia is the most widely planted species in India. It is regarded as the farmer's favourite tree in southern states of the country because of its multiple utility and suitability in agrarian ecosystems. Apart from the traditional uses as fuel wood poles and small timber, casuarinas wood is also used for making paper[29]. This nitrogen fixing species has proved to be an excellent soil condition and finds its inevitable role in salt affected soils. Component interaction refers to the influence of one component of a system on the performance of the other components as well as the system as a whole. In an ideal relationship, production of trees as well as crops in combination could be comparable to their sole performance. Agroforestry could be even more advantageous, if the production of associated components is increased due to influence of tree. This is possible because trees are capable of improving productivity of soil in many ways. "Multipurpose trees are of great significance in agroforestry systems, as they not only yield numerous products such as timber, fuel wood, fruits, fodder, but also provides medicines, fibres, rubber, tanning agents, N_2 fixation protective soil amelioration functions. The soil quality and its production capacity can be restored and improved by adopting a kind of agroforestry system called agri-silvi-horti system, which provides a way to sustain agricultural productions[28]. Therefore the present study was undertaken to study the effect of fertilizer and organic manures on

growth and yield potential of Wheat and Paddy Variety under Casuarina (*Casuarina equisetifolia)* based agrisilviculture system.

METHOD AND MATERIALS

The present study was conducted during 2012-2013 in already established 15 years old casuarina plantation spaced at 10 m x 3 m at N. D. University of Agriculture and Technology, Kumarganj, Faizabad ($26^0$27' N latitude and 82^0 12' E longitude at an elevation 113 m above mean sea level). The experimental site is located under sub-tropical climatic conditions, which possesses three climatic seasons, *i.e.* summer (March to mid-June), rainy (mid- June to September) and winter (October to February). The annual rainfall during 2012-2013 was 1148 mm. The mean monthly maximum temperature ranged from 18.4^0C (January) to 33.1^0C (may) and mean monthly minimum temperature varied from 7.6^0C (December) to 25.1^0C (June) during the study period. The soil of experimental site is partially improved salt affected soil (pH=8.5). It was medium in available nutrient (NPK) and organic matter. The paddy variety-Sarjoo-52 and wheat variety NW-1067 were taken in RBD experimental design with four replications in 5 treatments: T_1.Control (Open area) T_2. NPK (120:60:40 kg ha^{-1}) T_3.FYM (24 t ha^{-1}) T_4.Paddy straw (24 t ha^{-1}) T_5.Press mud (10t ha^{-1}).The trees at random on in 10 × 3 m spacing was measured for their top height and girth at breast height (GBH). The total height was measured from ground to top of the trees. The girth at breast height (1.37 m above the ground level) was taken. For soil sampling, surface (0-20 cm depth) soil was sampled from four random spots. Paddy variety (Sarjoo-52) seedlings which were raised in well prepared nursery beds during 30th May to 29th June, 2012, were transplanted on 30th June at the distance of 20 cm from row to row and 10cm from hill to hill. Before transplanting of seedlings, half dose of nitrogen (60kg) and full dose of phosphorus (60 kg) and potash (40 kg) were applied (at the rate of 120 + 60 + 40+ kg, N + P + K/ha). Remaining 60 kg nitrogen was used twice *i.e.* after 30 and 60 days of transplanting. Other treatment such as FYM (24 t ha^{-1}), Pressmud (10 t ha^{-1}), Paddy straw (24 t ha^{-1}) were applied whole amount at the time of field preparation and Control (Open area), where no any manures and fertilizer were applied under agrisilviculture system.Wheat variety (NW-1067) was sown during the 15th November, 2013. Keeping a row to row distance of 22.5 cm with a seed rate of 100 kg ha^{-1}. One half of the nitrogen and whole of the phosphorus was applied at the time of sowing and remaining N was applied to wheat crop under 10 m x 3 m spacing of casuarina plantation and open area after the first irrigation. Other treatment such as FYM, Pressmud, and Paddy straw were applied whole amount at the time of field preparation. Paddy and wheat crops were estimated in terms of growth and yield parameters (plant height, No. of panicles/ hill, effective tillers, grains/ear and 1000 grain weight and grain and straw yield (q/ha) by quadrate method at time of harvest. Five quadrates of 1 m^2 were selected per replication between rows of casuarina. The yield of produce (grain) was extrapolated to be expressed in q ha^{-1}. All cultural practices were adopted as per recommended for cultivation of paddy and wheat.All cultural practices were adopted as per recommended for cultivation of paddy and wheat crops.The experiment was laid out in a Randomized Block Design with three replications. Data were analysed statistically as per method given by Panse and Sukhatme[18] and results were expressed at 5% levels of significance. The critical difference (CD) was calculated using following formula:

$$C.D. = \sqrt{\frac{2MS_E}{r}} \times \text{t value of error degree of freedom at 5\% of significance.}$$

RESULTS AND DISCUSSION

Tree performance: The results showed in (Table 1) clearly indicated that the height, dbh and canopy width of casuarina after 15 years of plantation found significant difference among the different treatment (T_1-control, T_3-FYM (24 t ha^{-1}), T_4-paddy straw (24 t ha^{-1}) and T_5-pressmud (10 t ha^{-1})). The casuarina showed maximum height (14.75 m), dbh (28.10 cm) and canopy width (4.8 m) in T_2 – treatment in final year as compared to initial year. This might be attributed to addition of fertilizer in surface soil layer. Similar results were also obtained by Dar and Ram Niwaj[6] (2007) With *Albizia procera* tree grown in agrisilviculture system.

Productivity of crops: The plant height of wheat differs significantly under casurina and in open (sole wheat). In agri-silviculture system plant height and No. of tillers/m^2 of wheat was found lesser as compared to control. This might be due to advanced germination under casurina. Maximum plant height (67.4 cm) was recorded in open area (Table 2). Less height of crops under casurina may be primarily due to reduced light intensity under casurina. The growth of wheat and paddy crops under *Casuarina equisetifilia* based agrisivicultural system was lower than open area cultivation. The results are in conformity with Rana *et al.*[20] who have also found similar results for different species based agrisilvicultural systems. Thus, when a crop is grown in association with trees, there is a competition for light, moisture, nutrients *etc*., and a positive or negative interaction might be expected to develop between them[10].

Data presented in Table 2 clearly shows that the growth characters of wheat variety NW -1067 and paddy variety Sarjoo-52 was significantly affected by perennial tree *Casuarina equisetifolia*. In wheat variety, the maximum plant height (71.70 cm) was found in T_2 treatment NPK (120:60:40 kg ha^{-1}) which was significantly higher than other treatments under *Casuarina equisetifolia*based agri-silviculture system. The plant height of 71.70 cm and 92.5 cm for wheat and paddy was maximum under T_2 treatment and was closely followed by T_3, T_4 and T_5 in both the agricultural crops. However, also number of tillers m^{-2} was observed greater in T_2 treatment in wheat (248.5) and paddy (355.0) as compared to other treatment. This might be due to the fact that in agri-silviculture system, crops got the benefits of fertilizer applied to intercrops that resulted in higher crop growth. Sharma *et al.*[25] reported that single and combined application of nitrogen and phosphorus led to substantial increase in crop growth, relative growth rate and photosynthetic efficiency at various stages of crop growth in greengram crop. Mishra[14], Bhilare and Patil[3] and Sharma and Jat[23] in cowpea and Khalid *et al.*[11] and Angadi *et al.*[1] in sorghum have reported similar findings.

Yield attributing characters

The data related to No. of ears m^{-2}, Grains $ear^{-1}$and Test weight (g) of wheat was (5.6, 39.8 and 38.8) in T_2 treatment are presented in fig 1. In wheat, the No. of ears m^{-2} (5.6), Grains ear^{-1}(39.8) and Test weight (38.8 g) were found significantly maximum under T_2 treatment as compared to other treatments. On the other hand the paddy crop was also significantly higher No. of panicles/ hill, No. of grains $panicle^{-1}$and Test weight (g) (8.1, 175 and 24.2) in T_2 treatment and it was closely followed by T_3, T_4 and T_5 in treatments (fig 2). Thereafter, Yield attributing characters increased with added fertilizer dose in wheat and paddy crop. Increase in growth and yield attributes of green gram with the application of N and P has also been reported by Kumar[12] and Singh *et al*[27]. Among all the different treatments, in open area showed significantly higher Yield attributing characters in wheat and paddy crops as compared to casurina based agroforestry system. Nandal and Singh[15] have also reported reduced branching in lentil and munbean under all spacings of shisham as compared to control.

Yield

The data on grain yield (q/ha), straw yield (q/ha) are presented in table 3. In general, the grain yield and straw yield of wheat and paddy increased with increase in fertility levels. Grain yield was more in T_2 treatment in wheat

and paddy crops. Theobservation recorded with respect to grain and straw yield of wheat and paddy were significantly influenced by different treatment of casuarina has been shown in Table-3 in control, the maximum grain yield (29.2 and 40.7 q/ha) and straw yield (43.6 and 59.6q/ ha) were recorded in wheat and paddy crops in T2 treatment. The grain and straw yield which are reflection of all the growth and yield attributes characters increased significantly with increase in fertilizer level up to recommended dose of fertilizer in both the crops (wheat and paddy) (Table 3). Favorable response of wheat and paddy to nitrogen and phosphorus application might be attributed to the fact that nitrogen application helps to meet the nitrogen requirement of plant until the time it fixes its own nitrogen and beneficial effect of phosphorus on nodulation[26]. The combined application of these nutrients resulted in better vigour and superior yield attributes which ultimately produced more yields of green gram. Sharma *et al*.[14] observed increase in test weight, biological yield and harvest yield of green with the application of fertilizer upto 20 kg N + 60 kg P_2O_5 ha^{-1}.

The grain and straw yields of both the crops under casurina decreased significantly as compared to open field (crops without casurina) and 56.8 % grain yield reduction was observed in wheat (Table 3). The decrease in the straw yield of paddy and wheat was of the order of 35.3 % and 56.8 %, respectively. Yield reduction in wheat and paddy indicated that higher tree density had more suppressing effect on crops, reduced solar radiation on crop canopy and lower availability of moisture and nutrients. Light intensity in wheat and paddy under casurina reduced as compared to sole crop. Reduced yield of groundnut under teak due to reduced PAR availability has also been recorded by Venkatarao *et al*.. Reduction in yield of wheat and paddy crop under system may be because of fact that shade negatively affects grain yield. Yield reduction depends on the light intensity. Similar findings were also reported by Bisaria *et al.*[4] in wheat crops. The findings are in conformity to Puri *et al*. [18], Nadal and Hooda[16]. The yield of wheat crop under *Casuarinaequisetifilia* based agri-sivicultural system was lower than paddy crop. Results revealed (fig 3) that the average grain yield reduction under shade of tree canopy was noticed 53.0 % for wheat and 38.2 % paddy crop. The results are in conformity with Rana *et al.* [20] who have also found similar results for different species based agri-silvicultural systems. In fact the paddy crop is more tolerant to the sodic soils Rana *et al.*[19].

Table 1: Performance of casurina trees growth under agri-silviculture system

Treatments	Tree growth initial year			Tree growth final year		
	Tree height (m)	**Dbh (cm)**	**Canopy width (m)**	**Tree height (m)**	**Dbh (cm)**	**Canopy width (m)**
T_1 Control (Open area)	11.8	21.6	2 .0	12.75	22.65	2.1
T_2NPK (120:60:40)	12.9	26.5	4.4	14.75	28.10	4.8
T_3 FYM (24 t ha^{-1})	12.5	24.2	3.6	13.75	25.68	3.9
T_4 Paddy straw (24 t ha^{-1})	12.1	22.2	3.2	13.30	23.53	3.5
T_5Pressmud (10t ha^{-1})	12.4	23.9	3.4	13.63	25.35	3.7
CD at 5%	**0.63**	**1.79**	**0.21**	**0.85**	**2.19**	**0.25**

Table 2: Effect of INM on growth of wheat and paddy crop under *Casuarina equisetifolia* based agri-silviculture system and open area

Treatments	Wheat growth parameters				Paddy growth parameters			
	Plant height (cm)		No. of tillers/m2		Plant height (cm)		No. of tillers/m2	
	Agrisilviculture system	Open area	Agrisilviculture system	Open area	Agrisilviculture system	Open area	Agrisilviculture system	Open area
T_1 Control (Open area)	60.8	58.2	161.0	157.4	65.6	67.1	230.0	233.0
T_2 NPK (120:60:40)	71.7	73.2	248.5	251.7	92.5	94.3	355.0	359.0
T_3 FYM (24 t ha^{-1})	67.5	70.4	224.7	231.2	82.9	83.6	321.0	322.0
T_4 Paddy straw (24 t ha^{-1})	65.4	66.7	213.5	215.4	80.5	82.7	305.0	306.0
T_5Pressmud (10t ha^{-1})	66.3	68.5	217.0	216.9	81.4	83.1	310.0	314.0
Mean	66.3	67.4	212.9	214.5	80.6	82.2	304.2	306.8
CD at 5%	**4.506**	**5.16**	**13.971**	**18.38**	**5.822**	**5.15**	**20.906**	**21.55**

Table 3: Effect of INM on yield of wheat and paddy crop under *Casuarina equisetifolia* based agri-silviculture system and open area

Treatments	Wheat yield characters				Paddy yield characters			
	Grain yield (q ha^{-1})		Straw Yield (q ha^{-1})		Grain yield (q ha^{-1})		Straw Yield (q ha^{-1})	
	Agrisilviculture system	Open area	Agrisilviculture system	Open area	Agrisilviculture system	Open area	Agrisilviculture system	Open area
T_1 Control (Open area)	21.5	22.7	30.8	31.4	26.5	26.8	35.2	36.3
T_2 NPK (120:60:40)	27.6	29.2	40.2	43.6	38.4	40.7	55.7	59.4
T_3 FYM (24 t ha^{-1})	25.7	26.9	38.6	39.2	33.6	34.1	46.5	51.2
T_4 Paddy straw (24 t ha^{-1})	24.9	25.4	35.8	37.5	32.2	32.5	44.2	45.8
T_5Pressmud (10t ha^{-1})	25.2	27.6	36.6	39.8	33.0	35.8	45.1	49.3
Mean	25.0	26.4	36.4	38.3	32.7	34.0	45.3	48.4
CD at 5%	**1.677**	**1.74**	**2.648**	**2.79**	**2.056**	**2.28**	**3.202**	**3.03**

Fig. 1: Effect of INM on yield attributing of wheat crop under *Casuarina equisetifolia* based agri-silviculture system and open area

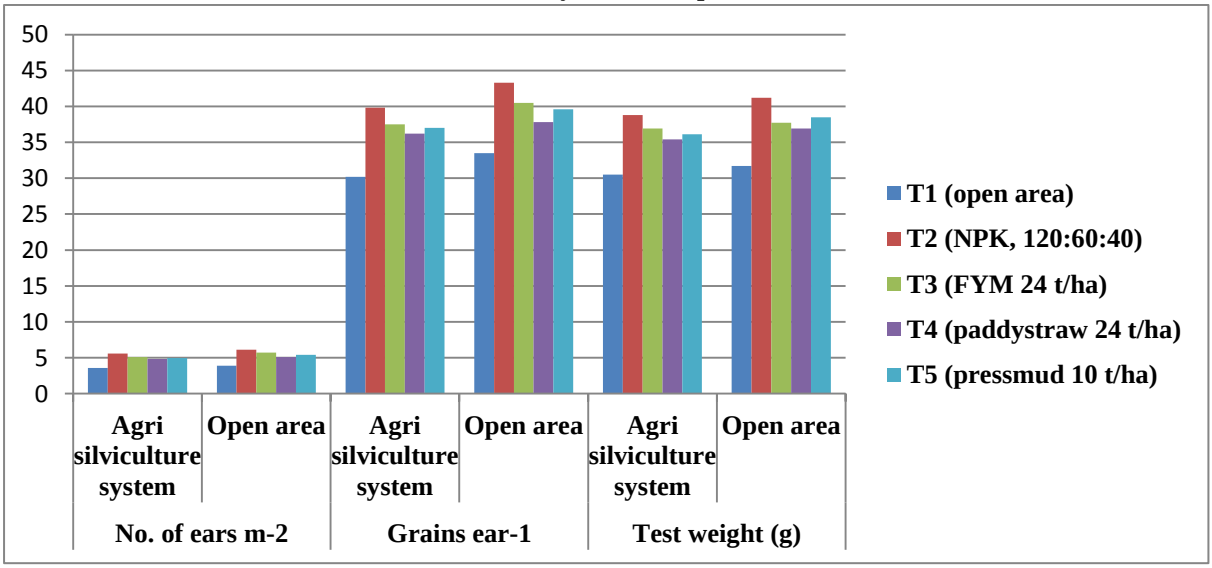


Fig. 2: Effect of INM on yield attributing of paddy crop under *Casuarina equisetifolia* based agri-silviclture system and open area

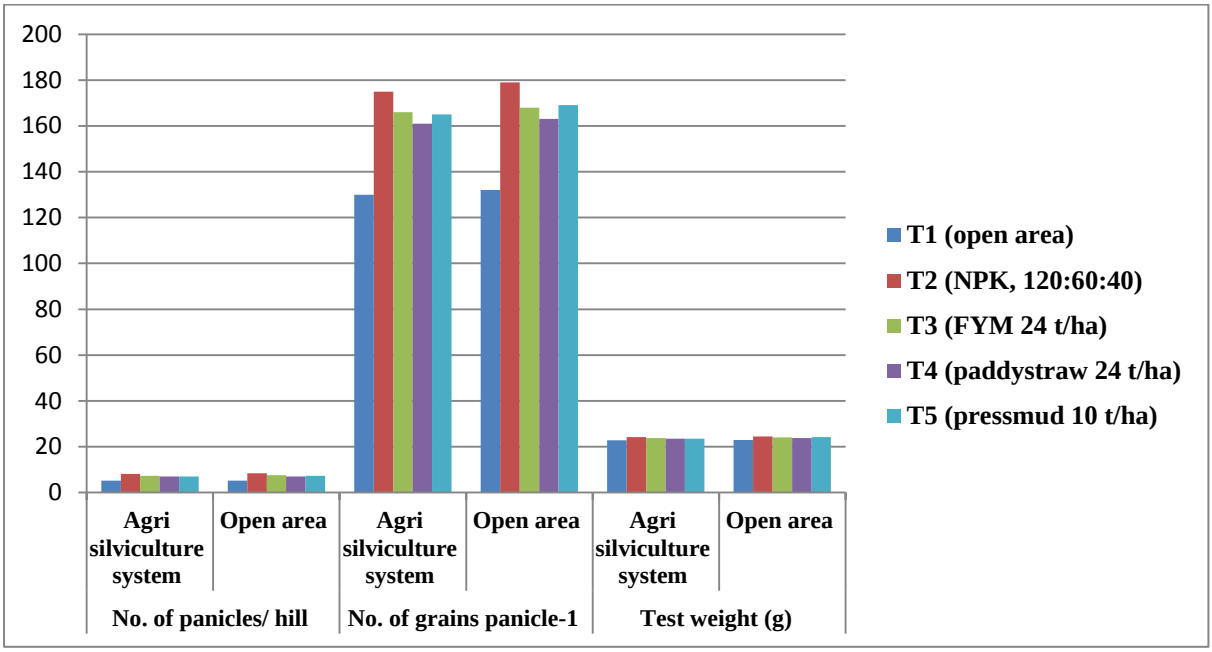
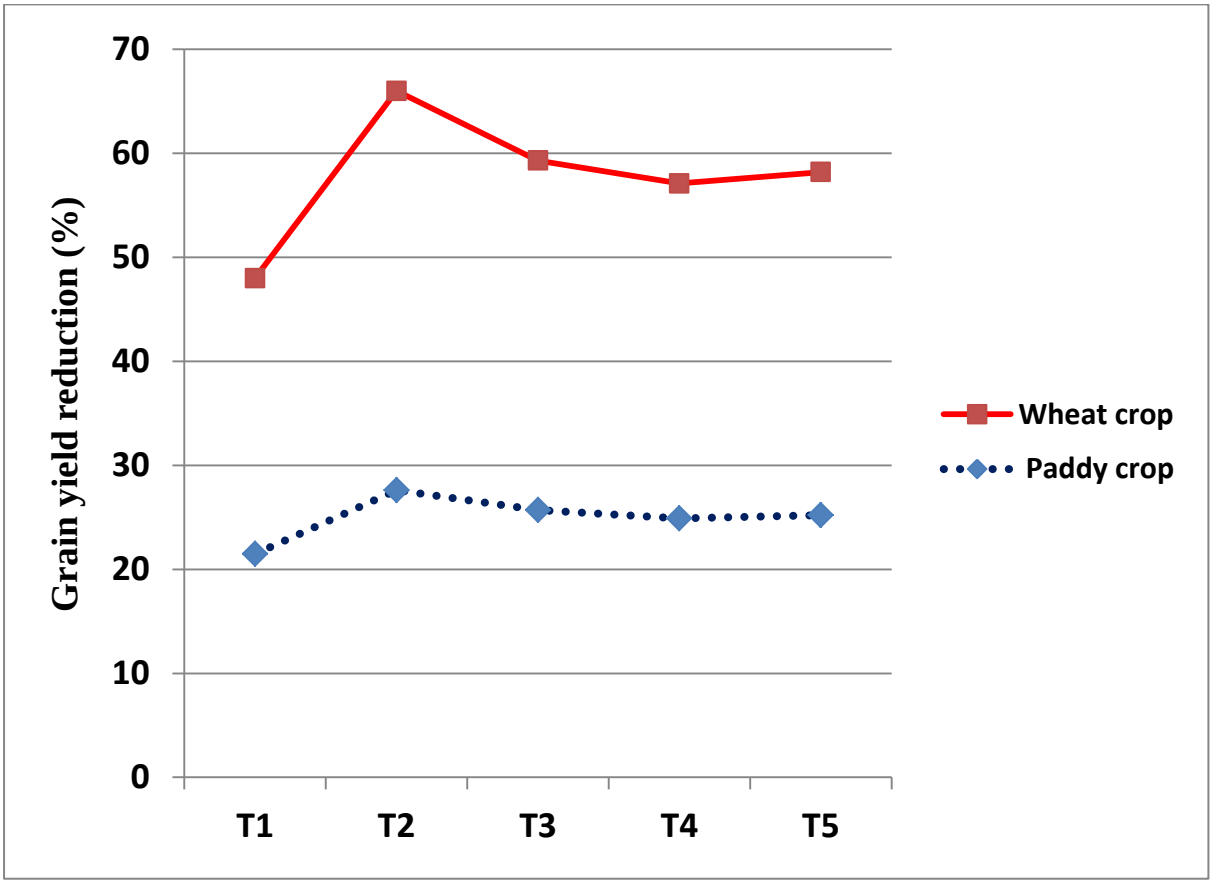


Fig. 3: Grain yield reduction of wheat and paddy under *Casurina equisitifolia* based agri-silvicultural systems in different treatments



CONCLUSION

Growth and yield parameters of wheat and paddy were higher in T_2 treatment as compared to T_3, T_4 and T_5 treatments in both the systems. Therefore, Growth and yield of wheat and paddy were lower in crop grown under casurina compared to open field. The yield of wheat and paddy were recorded 2.7 and 5.7 times higher in open field as compared to casurina based agroforestry system. Paddy crop was found more suitable for cultivation under casurina.

REFERENCES

1. Angadi, V. V., Hugar, A. Y. and Basavaraj, B., Evaluation of promising kharif sorghum genotypes for their yield potential and fertility response.*Karnataka J. Agril. Sci*. **17 (3):** 539-541 (2004).
2. Barrios, E., Sileshi, G.W., Shepherd, K. and Sinclair, F., Agroforestry and soil health: linking trees, soil biota and ecosystem services. *Soil Ecological Ecosystem Services,* pp. 315–330 (2012).
3. Bhilare, R. L. and Patil, V. S., Response of forage cowpea varieties to phosphorus application.*Forage Res*. **28 (3):** 179-180 (2002).
4. Bisaria, A.K., Gill, A.S., Lal, B., Handa, A.K. and Ajit., Agri-silvicultural studies: establishment, growth and production of multipurpose trees and their effect on the growth and production of crops and vice-versa. *Annual report*. NRCAF, Jhansi, U.P., pp. 10-22 (1995-96).
5. Chauhan, S. K., Brar, M. S. and Sharma, R., Performance of poplar (*Populus deltoides* bartr.) and its effect on wheat yield under agroforestry system in irrigated agro-ecosystem, India. *Caspian Journal of Environmental Science,* **10(1):** 53-60 (2012).
6. Dar, S. A. and Newaj, R., Tree growth and biomass productivity of herbaceous layer under different pruning regimes in *Albliziaprocera* based agrisilviculture system. *Range Management and agroforestry*, **28**: 108-110 (2007).
7. Dhyani, S. K., Ajit and Handa, A K., Agroforestry potential and scope for development across agro-climaic zones in India.*Indian Journal of Forestry,* **32(2):** 181-190 (2009).
8. Glover, J. D., Reganold, J. P. and Cox, C. M., Agriculture: plant perennials to save Africa's soils. *Nature,* **489 (7416):** 359–361 (2012).
9. Halos, S. C., Casuarinas in Phillipines forest development. pp. 89-98. *In*: S.J. Midgley, J.W. Jurnbull& R.D. Johston (eds.) *Casuarina EcologyManagement and Utilization*. CSIRO, Melbourne, Australia (1983).
10. Hocking, D., Some principles of crop complementarily in agroforestry systems. In: *Agroforestry systems- A new challenge*. (P.K. Khosla, S. Puri and D.K. Khurana, eds.), ISTS, Solan.pp.39-42 (1986).
11. Khalid, M. Ijaz, A. and Muhammad, A., Effect of nitrogen and phosphorus on the fodder yield and quality of two sorghum cultivar (*Sorghum bicolor* L.).*International Journal of Agricultural and Biology* **5** (1): 61-63 (2003).
12. Kumar, M., *Effect of various methods of weed control and fertility levels on growth, yield and quality of mungbean(Vignaradiata (L.) Wilczek).*M.Sc Thesis, CCS HAU, Hisar, Deptt. of Agronomy (1996).
13. Marcolin, M., Santos, A. and Salati, A., Emissoesremocoes de dioxide, de carbon posomudancansnosestoques de florestaseplantadas Brazilian foundation of sustainable Development, *The Brazilian ministry of science and Technology* .pp -47 (2002).
14. Mishra, S. K., Effect of nitrogen, phosphorus and seed inoculation of vegetable cowpea (*Vignasinensis*Savi.).*AnnalsAgric. Res*. **20** (3): 308-312 (1999).
15. Nandal, D. P. S. and Singh, R. R., Productivity of different cropping sequences in *Dalbergiasissoo* Roxb. based agro-silviculture system. *Indian Journal of Forestry*. **24 (4):** 433-436 (2001).

16. Nandal, D. P. S. and Hooda, M. S., Production potential of some agricultural crops under different spacing of poplar. *Indian Journal Agroforestry*,**7 (1):** 16-20 (2008).
17. Parihar, A. K. S., and Rana, B. S., Soil physico-chemical properties in agroforestry systems developed on sodic soil. In: *Wasteland development :challenges and oppurtunities.*(A.K. Singh, K.S. Bhatia and J.P. Yadav, eds.), Deptt. Of planning, Yojana Bhawan Lucknow.pp.213-219 (1999).
18. Panse, V.C. and Sukhatme, P.V. 1989. Statistical Methods for Agricultural Workers. 4th Edition, ICAR Publication, New Delhi, India.
19. Puri, S, Sao., B. and Nair, S. L., Growth and productivity of wheat varieties in an agri-silviculture system. *Indian Journal Agroforestry*, **3 (2):** 134-138 (2004).
20. Rana, B. S., Parihar, A. K. S. and Singh, B. P., Periodic changes in crop yield and certain characteristics of *Casurina equisitifolia*based agrisilvicultural system developed on sodic wasteland. In: *Agroforestryin 21st Century.* (S.K. Chauhan, S.S. Gill, S.C. Sharma and RajniChauhan, eds.), P.A.U., Ludhiana. pp 97-101 (2005).
21. Rana, B. S., Saxena, A. K. and Verma, S. K., Agroforestry research on sodic wasteland in eastern part of Uttar Pradesh. *Indian Forester*, **137(12):** 1410-1422 (2011).
22. Sanchez, P. A., Science in agroforestry. Agroforestry Systems, 30:5-55 (1995).
23. Sharma, S. K. and Jat, N. L., Effect of phosphorus and sulphur on growth and nutrient uptake in cowpea. *Haryana J. Agron*. **18** (1 & 2): 168-169 (2002).
24. Sharma, S., Daramwal, N. S., Sharma, C. R., Upadhyay, R. G. and Sharma, S., Influence of various doses of nitrogen and phosphorus on protein content, yield and its attributes of mungbean (*Vignaradiata* (L.) Wilczek) *Res. Crops*.**2 (2):** 108-111 (2001).
25. Sharma, S., Upadhyay, R. G, Sharma., C R and Rameshwar., Response of various levels of nitrogen and phosphorus application on growth, physiological parameters and yield of *Vignaraiata* (L.)Wilczek under rainfed and mid-hill conditions of Himachal Pradesh.*Indian J. Agric. Res*. **37 (1):** 52-55 (2003).
26. Singh, D. K., Effect of moisture regimes and fertility levels on yield of green fodder of *Trifoliumalexandrium* L. under *Eucalyptus* and *Leucaena* based sustainable land use system. *Bionotes*. **1(2):** 42-43 (1999).
27. Singh, M., Sekhon, H. S. and Singh, J., Response of summer mungbean (*Vigna radiata* L. Wilczek) genotypes to different phosphorus levels. *Environmental and Ecology*. **22:** 13-17 (2004).
28. Thakur, P.S and Kumar, R., Growth and production behavior of medicinal and aromatic hurbs grown under hedge grows of Leuceana and Morus. *Indian Journal of Agroforestry,* **8:** 12- 21 (2006).
29. Varghees M, Nicodemus and Ravi N., Genetic and ecological variation in wood properties of Casuarinaequisetifolia species.In casuarina improvement and utilization (Gurumurthi K. A. Nicodemus and Siddappa Eds.). Institute of Forest Genetics and Tree Breeding Coimbature, India, pp.29-37 (2001).
30. Viswanath, S., Peddappaiah, R.S., Subramoniam, V., Manivachakam, P. and Gerogre, M., Management of *Casuarina equisetifolia* in wide-row intercropping systems.*Indian Journal of Agroforestry,* **6 (2):** 19-25 (2005).
31. Young, A., The environmental basis of agroforestry. In T. Darnhofer and W.E. Rcifsnyder, eds. Meteorology and agroforestry: proceedings of an international workshop on the application of meteorology to agroforestry systems planning and management. Nairobi: ICRAF. 29-48 (1989).