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Intercropping in Fruit Orchards in Semi-Arid Regions—Options and Influences

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Abstract

The primary productivity in arid/semi arid region, confronted by several bio-physical constraints, is about two times less as compared to humid/sub-humid regions. Aberrant weather condition and deepening water crisis are proving hard impediment in successful production of crop. By putting orchard under intercropping system, there can be assurance against crop failure. Intercropping offers better economic return, hastened yield, efficient use of resources and thus adds in viability of farming venture. For reorienting and revamping farming scenario especially in semi-arid region, there is a need to have a boost to intercropping option. However, while selecting crop, the compatibility of component crop must be taken into account.

Key words : Allelopathy, Economy, Growth, Intercrops, Orchard.

With rising demographic pressure, the land : man ratio is declining sharply. Available land on per capita basis between sixties to nineties restricted to 0.13 hectare only (1). Fruit trees possess long gestation period and commercially comes into bearing after a long waiting period of 3—6 years. During this period orchard land and growers resources can be put forth to best use following intercropping. It has been observed that during initial unproductive phase of the orchard, intercropping is intended to maximize land and space use efficiency to generate supplemental income, protect the inter-space from losses through weeds, erosion, impact of radiation, temperature, wind and water and enriching it by nitrogenous fixing leguminous crops. Integration of annual crops with fruit trees or association of trees with shrubs during juvenile phase in different ecological regions of the country has been reviewed by various workers (2, 3). Incorporation of trees including fruits, shrubs, grasses, crops and their permutations and combination in time and space dimensions can really mitigate the harsh condition of arid/semi- arid region and may produce yields. Suiting to the choice of owner and agro-climatic conditions prevailing in particular domain, different types of intercropping combinations are resorted in orchard crops. However, while selecting crop for intercropping, the compatibility of intercrop in terms of nutrient requirement, water requirement, space requirement and interaction—complementary/ competitive is taken into account. Generally accepting, short term crop being less apt to compete with the primary crop are usually deemed fit in intercropping. The present review is an attempt to highlight different crops combination observed beneficial in orcharding in semi-arid region. The impact of intercrop combinations on growth, yield, economics, besides their allelopathic influence and influence on soil fertility status has also been discussed here suitably under different heads.

Impact On Growth, Yield and Economics of Orchard Crop

Intercrop Combinations

In data palm, provided water facility is available, pulses like lentil, gram, peas can be grown (4). Growing of crops in association with trees and shrubs like khejri (*Prosopis cineraria*) and ber or bordi (*Ziziphus rotundifolia*) in cultivated fields have been a common practice in arid Rajasthan. The alluvial plains in the districts of Jodhpur, Barmer and Nagaur in Rajasthan represents *Ziziphus nummularia-Capparis*

decidua zone. About 120 to 250 shrubs of *Ziziphus nummularia* and 20—25 trees/shrubs of *Capparis decidua* per hectare are maintained in the fields of pearl millet, mung bean, moth bean, cluster bean and sesame. In medium to heavy and moderately saline soils of Jalore and Pali districts of Rajasthan, *Salvadora-Prosopis-Capparis* are common tree species grown in association with rainfed *kharif* and irrigated *rabi* crops (5). The cultivation of cluster bean/ mustard and Indian aloe (*Aloe barbadensis*) as a ground storey crop has been recommended in ber plantation (6). Multi-storey combinations incorporating large trees, small trees and ground crops have been recommended (7). In low rainfall (300—500 mm) zone, combinations such as khejri + ber or drumstick + vegetable (legume or cucurbits) have been suggested. During juvenile phase of aonla, there are ample opportunities for raising annual crops like moth bean (*Phaseolus acontifolius*), brinjal (*Solanum melongena*), gram (*Cicer arietinum*), mustard (*Brassica compestris*) and fenugreek (*Trigonella foenum-graceum*), while perennial crops like ber (*Ziziphus mauritiana*), karonda (*Carissa congesta*), drumstick (*Moringa olerifera*) and pomegranate (*Punica granatum*) as an under storey perennial component crop (3). Among the various multi-tier cropping systems, the best and most appropriate cropping models was a two tier system such as aonla + guava, aonla + ber. Among the three tier system—aonla + guava + matricaria, aonla + ber + lemongrass and aonla + casurina + subabool were found to be productive and remunerative under semi-arid conditions of Faizabad, UP (8). Generally, urd, moong, soybean, groundnut, lentil, gram among pulses; taramira, rapeseed, til and linseed among oilseeds; wheat, barley, oat, jowar and bajra among cereals, senna, ashwagandha, stevia, asparagus, aloe, giloe, palmarosa, vetiver, vinca and marigold among medicinal plants; brinjal, chilli, tomato, onion and okra among vegetables fit well as intercrop combinations in different fruit crops in different seasons in semi-arid region (9). It has been observed that in three year old plantation of ber at a density of 400 plants/ha in association with green gram performed well (10). The inter-planting of ber/ guava and two plants of karonda in aonla based cropping model reported to be useful (11). The suitability of gonda, ber, aonla, drumstick as upper storey crop, and that of karonda, pomegranate and phalsa as lower storey crop and field crops like cowpea, ridge gourd and green gram and chillies, brinjal, green gram and okra as intercrop combination in arid fruit crops has been highlighted (12). In pomegranate plantation upto 4—5 years age, low growing vegetables and pulse crops may be grown (13). In jamun orchard (14) fruit crops like peach, guava, kagzi lime as filler plantation and field crops like gram, peas, mung can be grown successfully. In addition, vegetables like cauliflower, cabbage, knolkhol, radish, brinjal, turnip and carrot can be grown near established market. Under Maharashtra condition (15), along with ber and aonla cowpea, seasamum, gram and mustard were found to be better.

Growth

Supplemental effect in terms of growth of fruit crops and annual crops in association has been reported by various workers. At Pali (Rajasthan), intercropping of cluster bean between the interspaces of ber (16) had no adverse effect on plant growth. Similarly in studies on ber based cropping system under hot arid eco-system of western Rajasthan, It has been observed that the ground storey crops such as cluster bean and Indian aloe did not have any competitive effect on the growth and development of ber trees and vice-versa. Influence of intercropping on vegetative growth of aonla was studied (17) under rainfed condition of Agra, UP. There had been maximum plant height and stem girth of aonla in association with sunhemp (*Crotolaria juncea*) as green menure and cowpea (*Vigna sinensis*) as intercrop. Better growth and yield of ground storey crops in association with sapota has been noted (19). Under semi-arid condition of Godhar, Gujarat, cucurbits can be combined with drumstick (16) as multi-tier cropping system. From the experiment it appeared that interaction of ground crop did not reduce the growth parameters of drumstick.

Yield

Intercropping between fruit trees or mixed multispecies cropping system has been reported to increase the yields of both under and ground storey crops thus imparting greater stability in the production system. For sustainable production and ecologi-

cal restoration, ground storey and mixed multi-storey cropping system integrating perennial fruit trees with annual crops have been suggested by many workers (7, 19). Horti-agri system involving *bordi* + mung bean/moth bean/cluster bean was found environmentally protective and economically viable during the drought years. Under semi-arid condition of Pali (Rajasthan), yields of 4.36 q/ha mung bean, 10.33 q/ha cluster bean and 1.88 q/ha sesame (*Sesamum indicum*) were obtained from ber (cv Seb) based cropping system during *kharif* season while fruit yield in the intercropped orchard increased from 5.2 to 14.2 kg/tree without any adverse effect on plant growth up to five years (16). There is record that under Jodhpur (Rajasthan) condition, a farmer can get an additional production of 7.82 q/ha cluster bean when grown with jujube plantation during *kharif* season (20). Arable crops like pearl millet, cluster bean, raya and chickpea can be grown successfully in association with *Dalbergia sissoo* + *Morus alba.* The grain yield and net return were observed to be higher in intercropping as compared to sole cropping (21). For obtaining higher yield and higher economic returns than sole cropping (22), intercropping of pearl millet, cowpea, cluster bean and mustard in the inter-spaces of well grown khejri trees has been recommended. The recommendation pertaining to better suitability of pulse crop (cluster bean) in a khejri-based agroforestry system (23) has been made. Increased grain yield of cluster bean to the tune of 203.20% was obtained when grown with *Prosopis cineraria* over sole crop. The maximum recorded yield of 8.50, 2.80 and 16.67 q/ha of gram, mustard and wheat have been reported in association with kinnow, bael and ber fruit trees respectively (24). Growing of intercrops in association with kinnow, bael and ber did not hinder the growth and development of the over-storey crops. In aonla based cropping system, among bottlegourd, pumpkin, sponge gourd, cucumber, bitter gourd, the crop of bottlegourd produced better yield (25). Under semi-arid condition of Godhra, Gujarat under drumstick based multi-tier cropping system, incorporation of cucurbits as ground crop had more drumstick equivalent yield and land equivalent ratio was 2.39.

Economics

Many workers have suggested that agri-horticulture system on dry land is possible and this system is desirable in stabilizing income of small farmer by providing food grains, fruits and fuel wood. In arid eco-system, agri-horticulture system involving *Ziziphus rotundifolia* + mungbean/moth bean/cluster bean and *Ziziphus mauritiana* + mung bean/cluster bean have been reported to provide round the year supply of fodder for five goats/sheep/ha and fuel wood for a family of five members besides efficient nutrient recycling and increase in economic viability (26). Under similar condition, in aonla based cropping system, aonla + okra had given net return of Rs 72,505/ha. In crop diversification studies for sustainable production in hot arid eco-system of Rajasthan, during pre-establishment phase of ber orchard, Indian aloe and cluster bean-mustard were identified as low input and high returning crops giving net returns of Rs 65,802 and Rs 26,144/ha, respectively (2). The maximum income (Rs 35,172/ha), net profit (Rs 30,162/ha) and benefit : cost ratio (6:02) under the intercropping system of bael + moth bean have been realized (27). There are references where growing of crop (28) with ber and aonla plantation had been adjudged remunerative than pure cropping. The remunertiveness of the adoption of tree-crop farming collectively over sole cropping has been highlighted by many workers (29, 30). In aonla based cropping system, among bottlegourd, pumpkin, sponge gourd, cucumber, bitter gourd, the crop of bottlegourd was considered more economical (25) under rainfed condition of semi-arid region. On the basis of cost analysis, under Maharashtra condition along with ber and aonla, out of cowpea, sesamum, gram and mustard, the intercrop of cowpea was found beneficial (31). Following intercropping of these crops, the grower got additional income of Rs 5,111 to Rs 9150 per hectare in aonla and Rs 5695 to Rs 14954 per hectare in ber as compared to no intercropping. Under drumstick based multi-tier cropping system (15), incorporation of cucurbits as ground crop reduced the cost of input by 70.1 and 64.0% as compared to bower local systems of supports provided to grow cucurbits, respectively.

Intercrop Combinations and Their Influence on Soil Fertility Status

Allelopathic Influence

Allelopathy influence of aqueous leaf extract of

fruit crops on the vigor of seedlings of annual crops has been observed. The allelopathic effect of aonla (*Emblica officinalis*) and ber (*Ziziphus mauritiana*) on the germination and seedling growth parameters of wheat was studied and found that the germination of wheat seed was not affected significantly (32) whereas shoot length, root length, dry weight and vigor index showed significant differences. The inhibitory effect of *Citrus aurantium* and *Syzygium cumini* on germination of annual crops was observed (33). The allelopathic influence (34) of *Leucaena leucocephala* Lam on seed germination and seedling growth of wheat (*Triticum aestivum*) under laboratory condition was studied. It was exhibited that aqueous extract of fresh leaf, flower and pod, stimulated the germination and seedling growth of *Triticum aestivum* at lower concentrations and inhibited significantly at higher concentrations. Among various ground storey crops, groundnut, cluster bean, mustard and wheat, the water soluble allelochemicals from aqueous leaf extract of ber (*Ziziphus mauritiana*) had maximum inhibitory effect (35) on mustard and minimum in cluster bean with respect to germination, seedling vigor and phyto-mass while other crops showed variable response exhibiting sensitivity in one character and tolerance in another. The aqueous leaf extract of aonla (*Emblica officinalis*) influences (36) the germination and seedling growth characters of moth bean, wheat, gram and mustard. The water-soluble allelochemicals of aonla had maximum inhibitory effect on seed germination and seedling growth characters of mustard and minimum on moth bean and wheat. There is reduction (37) in the growth and yield of four test crops viz. cowpea, sesame, horsegram and sorghum with the neem associated soil media.

Soil Fertility

Intercropping of legumes between fruit trees have been recommended in view of addition of fertility to the soil. Under tree cover buildup of organic matter takes place virtually owing to falling of leaf litter. Under fruit based cropping system, fruit crops, which are deciduous in nature, have an advantage of adding some amount of leaf litter to the growing site every year adding fertility of the soil. While studying the ameliorative effect, reduction in soil pH, electrical conductivity, gypsum requirement, exchangeable sodium percentage and sodium absorption ratio and increase in organic carbon and cation exchange capacity have been reported under different cropping models (38). Guava + phalsa + ber (*Ziziphus mauritiana*) had the best ameliorative effect on chemical properties of sodic soils. The beneficial effects of pulses (39) as intercrops in mandarin orchards owing to their ability to mobilize atmospheric nitrogen to the soil plant system have been recorded. It has been observed that about 20—25% of the total living biomass of the trees is in roots and there is constant addition of organic matter to the soil through dead and decaying roots (40). There was higher level of available nitrogen (41) in the soil under intercropping combination of cluster bean with fruit crops in arid environment.

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