

## ECONOMICALLY VIABLE CROPPING SEQUENCE FOR DIVERSIFICATION IN SOUTH-WESTERN REGION OF PUNJAB

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### ABSTRACT

A field experiment was conducted during 2010-2013 at Punjab Agricultural University, Regional Station, Bathinda to study the feasible option for diversification of existing cotton-wheat cropping system for limited irrigation water conditions. Various nine crop sequences viz., cotton-wheat, cotton-barley, cotton-*raya*, *guar* (cluster bean)-wheat, *guar*-barley, *guar*-*raya*, *moong* (green gram)-wheat, *moong*-barley, *moong*-*raya* were tested. Amongst all the cropping sequences the cotton equivalent yield of *guar*-wheat system (3035 kg ha<sup>-1</sup>) was statistically at par with cotton-wheat system (3226 kg ha<sup>-1</sup>) and significantly higher than other crop sequences. The highest water productivity, production efficiency, net returns and benefit : cost ratio was found under *guar* based crop sequences. This sequence also maintained soil health with higher organic carbon, available nitrogen, available phosphorus and available potassium content in surface soil (0-15 cm) than other crop sequences.

(Key words: Diversification, water productivity, profitability, cotton equivalent yield)

### INTRODUCTION

The south-western zone of Punjab is at the tail end of the canal irrigation system. The uncertainty and meagerness of canal water is the major apprehension to the farmers. Water management in field crops is the major concern, which can be looked upon by choosing an appropriate cropping sequence. The decreasing income of the farmer due to increase in cost of cultivation of traditional crop rotation cotton-wheat is another important issue to ponder upon other cropping sequences with higher economic returns. Consequently, the crops chosen in the sequence should have lower demand for water as well as inputs. The prominent cropping sequence of this region is cotton-wheat. It is well known fact that farmers of the cotton belt have been facing the problem of severe debt, forcing the distraught farmers to take extreme step (Sidhu *et al.*, 2011). As the input cost in terms of seed, labour, fertilizers and pesticides is comparatively higher in cotton than other crops and for this reason it has been named as the largest chemical consuming crop in the state. Also, cotton is a labour intensive crop, as the picking and weeding operations are being done manually (Singh *et al.*, 2013). The mono culture of cotton-wheat crops in rotation extracts similar kind of nutrients from the soil over the years resulting in adverse effects on chemical, physical and biological soil health. Therefore, inclusion of leguminous crop in the sequence can solve the problem of soil deterioration to much extent. This can bring diversification as well as sustainability with high monetary returns. Crop rotations

with legumes are believed to be energetically favorable to those without legumes due to reduced N fertilizer inputs (Varvel and Wilhelm, 2003). The option for leguminous crop in this region due to its climate and soil type is between cluster bean (*guar*) and green gram (*moong*) during *kharif* season. *Guar* is a drought-tolerant summer annual legume. It is grown for use as vegetable, fodder, green manuring and as seed for production of *guar* gum. It requires 1-2 irrigations depending upon rainfall. It fits well into crop-rotating program with wheat in *rabi* season. Similarly, *moong* (green gram) is one of the important *kharif* pulse crops. Being leguminous crop, it adds nitrogen to the soil. But due to unpredictable weather conditions at flowering, pod formation and pest infestation its productivity is low as expected.

Wheat is most important crop of *rabi* season as it is directly consumed by the masses. Barley is also useful cereal due to its use in malt and beer industry. *Raya* is also significant oilseed crop of south-western region of Punjab. Therefore, a study with nine crop sequences viz., three each of cotton, *guar* and *moong* based crop sequences during *kharif* season in combination with three crops (wheat, barley and *raya*) in *rabi* season was undertaken to find out the feasible cropping sequence for system productivity, under semi arid conditions of south-west Punjab.

### MATERIALS AND METHODS

A field experiment was carried out for three years at research farm of PAU Regional Station, Bathinda during

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2010-2013 in semi arid region of south-west Punjab to study the feasibility of different crop sequences viz., *Bt* cotton-wheat/barley/*raya*, *guar*-wheat/barley/*raya* and *moong* bean-wheat/barley/*raya* in permanent plots. The experiment was laid out in randomized block design with three replications. The soil of experimental field was sandy loam in texture having low organic carbon, medium available phosphorus and high available potassium. The physico-chemical characteristics of soil (0-15 cm) are presented in table 1. The sowing of the *rabi* season crops (wheat, barley and *raya*) was done according to the time of harvesting of previous crop (cotton, *guar* and *moong*) in same plots. All the recommended packages and practices were followed according to Punjab Agricultural University. The mean rainfall during *kharif* season was 39.01 cm under cotton, 27.64 cm to *guar* and 26.26 cm to *moong* crop. During *rabi* season (wheat, barley and *raya*) the mean rainfall was 4.55 cm. Profile water was measured in 0-180 cm soil profile by gravimetric method. For calculating the water productivity (WP), the water expense was calculated for different treatment combinations. The water expense is sum total of irrigation water applied, profile water used and rainfall during growing season of crop. For computation of WP, seed yields hectare<sup>-1</sup> was divided by the water expense and expressed as kg m<sup>-3</sup>. Production efficiency values in terms of kg ha<sup>-1</sup>day<sup>-1</sup> were calculated dividing the production of the sequence by total duration of sequence (Singh and Verma, 1998). The economics was worked out on the prevailing prices (mean of three years) for the inputs and outputs during the study period. The benefit : cost ratio (B: C) was calculated by dividing gross returns with cost of cultivation. The mean minimum support price or prevailing market rate of the produce of *kharif* and *rabi* crops (Table 2) was used for computing cotton equivalent yield (CEY) of all the cropping sequences. The three year data were pooled and statistically analyzed by using statistical methods described by Gomez and Gomez (1984) and the software used was CPCS1 developed by the department of Statistics, Punjab Agricultural University, Ludhiana.

## RESULTS AND DISCUSSION

### Cotton equivalent yield :

The economic yield of cropping system (*rabi* + *kharif*) of every year (Table 3) were converted into the cotton equivalent yield (CEY). During the first year (2010-11) the CEY of cotton-wheat crop sequence (3182 kg ha<sup>-1</sup>) and *guar*-wheat system (3352 kg ha<sup>-1</sup>) was statistically at par and significantly higher than all other crop sequences. During second year of study (2011-12) same trend was noticed. However, during third year (2012-13) the CEY of cotton based crop sequences were significantly higher than both the *guar* and *moong* based crop sequences. However, in the pooled data of all the years, the CEY of cotton-wheat (3276 kg ha<sup>-1</sup>) was statistically at par with the *guar*-wheat (3035 kg ha<sup>-1</sup>) crop sequence and significantly higher than all the other cropping systems under study. The comparable CEY in *guar*-wheat and cotton-wheat may be attributed to higher market price of *guar* than cotton during the period of study. Moreover, the higher yield in wheat after *guar* may be

ascribed to *guar* being leguminous crop which resulted in nitrogen fixation in soil. Usadadiya and Patel (2013) also reported higher yield of succeeding wheat where legumes (soya bean and green gram) were taken as preceding crop than previous maize. But, lower CEY of moong bean based crop sequence may be due to lower yield potential of moong bean in the sequence. Similar findings has been reported by Kadian *et al.* (2009) at Hisar, while working on various cotton, moong, soybean, pearl millet and sorghum crop sequences under sandy loam soil conditions. The production efficiency (11.32 kg ha<sup>-1</sup>day<sup>-1</sup>) was also found to be the highest in the *guar*-wheat system (Table 3) as during *kharif* season cotton is long duration crop than *guar* and *moong*.

### Water expense components and water productivity :

The information on various water components of different crop sequences are given in table 4 reveals that the maximum irrigation water applied (IWA) was in cotton-wheat sequence (67.5 cm) followed by cotton-barley and cotton-*raya*, which came out to be 60 cm. The minimum water applied through irrigation (45 cm) was under *guar*-wheat, *moong*-barley and *moong*-*raya* crop sequences. As evident to the figures given in the table 4, profile water use by various crop sequences, the cotton-wheat, cotton-*raya* and the entire *moong* based sequences added water to the profile. Whereas all the *guar* based sequences extracted water from the soil profile. The highest water expense was under cotton-wheat crop sequence (100.18 cm) and lowest in *moong*-*raya* (74.21 cm) sequence. The data on water productivity of the system computed from water expense reveal that the water productivity was the highest (0.358 kg m<sup>-3</sup>) of *guar* based crop sequences compared to all other crop sequences. Lowest water productivity was found in *moong*-barley sequence. Higher water productivity in *guar* based sequence may be attributable to lesser number of irrigations to *guar* crop (2 irrigations) than cotton (5 irrigations) and *moong* (3 irrigations). Chauhan (2011) also reported highest water use efficiency (79.51 Rs ha<sup>-1</sup>mm<sup>-1</sup>) of *guar*-wheat as compared to *guar*-gram (74.0 Rs ha<sup>-1</sup>mm<sup>-1</sup>) and *guar*-mustard (59.48 Rs ha<sup>-1</sup>mm<sup>-1</sup>) crop sequences.

### Soil fertility status :

The soil fertility status was analyzed after completion of the experiment on 3<sup>rd</sup> year (2012-13). The data enumerated in table 5, revealed that the pH was maintained under various crop sequences, whereas electric conductivity (EC) was maintained under *guar* and *moong* based crop sequences in surface layer of soil (0-15 cm). The increase in EC was observed in the entire cotton based cropping sequences. The values were higher in cotton-wheat, followed by cotton-*raya* and lowest in cotton-barley. The highest organic carbon (OC) was obtained under *guar*-barley (0.38 %) closely followed by *guar*-wheat (0.37%) cropping system. This could be due to addition of large amount of biomass in the form of leaf fall and nitrogen fixation through nodulated roots of the crop. Consequently, the available N was highest in *guar*-barley and *guar*-wheat and lowest in cotton-wheat cropping sequence. The available P content was also high in *guar*-wheat followed by *guar*-barley and lowest available P was estimated in cotton-*raya* crop