Development of Bed-Furrow Intervention in the Rice-Wheat Cropping System in Punjab, Pakistan

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***Abstract*-**The successful implementation of bed-furrow, a resource conservation intervention (RCI), for rice-wheat cropping system has become the prime goal for researchers and cultivators by developing bed-seeded crops in South Asia. The paper reviews the output, need, methods, merits, demerits and constraints for adopting bed-furrow RCI in Pakistan. The potential of this intervention and the issues of adopting permanent raised beds have also explored in the study. The application of Bed-furrow is only limited to few hectares for field demonstrations and research in Pakistan. The findings of research reveal substantial enhancement in output and profitability by including residue straw mulching on bed-furrow. The strategies that enhance the adoption, merits and output of bed-furrow for Pakistan in particular are as follows: i) selection of rice germ-plasm in aerobic circumstances gives improved output, ii) Provision of accurate and efficient seed and fertilizer at economical cost by improving the design etc. of four wheel tractors, iii) The scope and use of bed-furrow should be further enhanced by taking onboard all the state holders including farmers, agronomist, engineers, machine operators and manufacturers. Data collection and monitoring should be properly carried out for its sustainable usage within the region of South Asia and iv) to enhance the areas of farms where bed-furrow is suitable for their growing cops, soil and topographic conditions, thus offers economic profit and output/productivity.

The participation and consultation of all the stakeholders including farmers, researchers, equipment operator is utmost important to manage hurdles for acquiring potential benefits, productivity and sustainability of bed-furrow intervention.

***Keywords*-**Indo-Gangetic Plains, Rice-Wheat Cropping System, Machinery Operators, Productivity, Economic Benefits

I. INTRODUCTION

The rice and wheat systems are exercised on 12 million hectares annually in South Asia and thus characterize main food supplies. The initial studies on conserving agriculture in rice wheat system in South Asia were started by researchers belonging to National Agriculture Research System (NARS) Consultative Group of International Agriculture Research (CGIAR) and other institutions. Several studies and researches have concluded considerable saving of water and other inputs including monetary and time benefits [i-vi]. In the low-lying areas having poor drainage, the bed-furrow planting intervention is more favorable than the zero tillage [i-vi].

Due to less output and agriculture yields, there is great potential available of on-farm irrigation management interventions including laser land leveling (LLL), zero tillage (ZT) and especially bed-furrow for rice wheat system of crops developed by Cornell University, Mexico International Maize and Wheat Improvement Center and Australian Center for International Agriculture Research (ACIAR). In Pakistan, the bed furrow was first introduced and practiced by sowing wheat crop followed by rice. Now rice-wheat cropping system has been successfully exercised on thousands of acres of land in Pakistan. Easy accessibility of farming equipment at relative rates and tractors has also made ploughing conservation successful in Pakistan.

The definition along with few merits and de-merits of bed-furrow intervention is presented in Table 1.The use of bed furrow technique for sowing of wheat has now improved for South Asia for augmenting water-use efficiency. Several researchers have also recommended bed furrow in addition to laser land levelling and zero tillage under different soil and climate conditions [vii].

TABLE I
SUMMARY OF DEFINITION, MERITS AND DE-MERITS OF BED-FURROW INTERVENTION [VIII]

Intervention	Definition	Advantages	Disadvantages
Bed-furrow (BF)	It is a process in which the field is divided into narrow strips of raised beds / ridges separated by furrows. The crops are planted on the bed surface and irrigation water is applied through the furrows.	Saving of approximately 30% irrigation water. Less reduced chances of plant submergence due to excessive rain or over-irrigation. Lesser crusting of soil around plants and therefore, more suitable for saline and sodic soils. Adaptable for various crops without changing basic design / layout of farm. Increased fertilizer use efficiency due to local application.	It needs land grading so as water can travel the entire length of furrow without ponding. It needs continual slope by removing low and high spots. It is not suitable to all crops.

Reference [viii] discussed that agriculture output mainly depends on net revenue. The cost and benefits of bed-furrow along with other resource conservation interventions (RCIs) for rice-wheat cropping zone of Punjab, Pakistan is shown in Table II.

TABLE II
COST AND BENEFITS OF WHEAT BY VARIOUS INTERVENTIONS INCLUDING BED-FURROW (RS PER HECTARE) [VIII]

Interventions	Traditional	Zero tillage	Laser land levelling	Bed-furrow
Levelling	-	-	3457	-
Ploughing	9876	-	5926	5926
Planking	3951	988	988	1975
Sowing	1481	1975	1728	3333
Seeds	5920	4840	5120	4920
Irrigation	4716	3501	3975	3390
Fertilizer	19086	15975	17765	16198
Herbicide	3778	3037	3383	2765
Harvesting/ threshing	7931	7802	7778	7631
Total Cost of Production	56739	38118	50120	46138
Gross benefits	143552	161948	171534	150734
Net benefits	86813	1238302	121414	104596
Increase in net benefits	-	37017	34601	17783

The comparison of water productivity, fertilizer use efficiency and wheat yield of Pakistan has been compared with other regional and developed countries (Table III). The results indicate that the water productivity and fertilizer use efficiency of Pakistan are compatible with India and less than developed countries like Mexico and China. It indicates that there is great potential for Pakistan to enhance these parameters and make it compatible with developed countries by adopting RCIs.

This paper highlights the errors and experiments conducted in the study and execution of bed furrow resource conservation intervention in Pakistan paving way for its future sustainability.

TABLE III
COMPARISON OF RESULTS WITH OTHER STUDIES [VIII]

Output parameters	Pakistan	India	Mexico	China
Water Productivity (kg/m^3)	1.6	1.75	2.3	2.16
Wheat yield (kg/ha)	4450	4758	5591	5137
Fertilizer use efficiency (%)	20	25	30	28

II. THE KEY FEATURES OF THE BED-FURROW INTERVENTION SYSTEM

The idea of growing wheat crop on bed was initiated with prototype bed planter machinery connected to wheel tractor developed in Mexico CIMMYT with instantaneous efforts on POTS. However, bed planter machinery connected to wheel tractor which can provide seeds and fertilizers has not still developed even after three years of concentrated efforts, developments, participation and research comparable to POTS. To date with latest developments beds can be developed easily. The size of beds are generally kept 50cm to 70cm having two rows for direct transplanted / seeded rice and 2-3 rows for wheat on bed top (Fig. 1).

III. SOIL PREPARATION FOR BED-FURROW INTERVENTION

When preparing the land for seeding crop in a bed

system, several observations from the on-farm trials are important:

1. Weeds present in the fields must be eradicated earlier to making beds for sowing crop.
2. The soil must be accurately leveled where a bed-furrow intervention is to be implemented. This permits uniform water application to confirm that the beds will continue dry. When the fields are not level, water application efficiency will be curtailed and irrigation water will flow over the beds, consequentially in excessive vegetative growth and finally decreasing the crop yield.
3. Land moisture should be low sufficient to allow the beds-furrows intervention to be made to uniform depth.
4. Well-pulverizedland is required to an equal depth through the field to ensure that beds-furrows sustain the same dimensions.

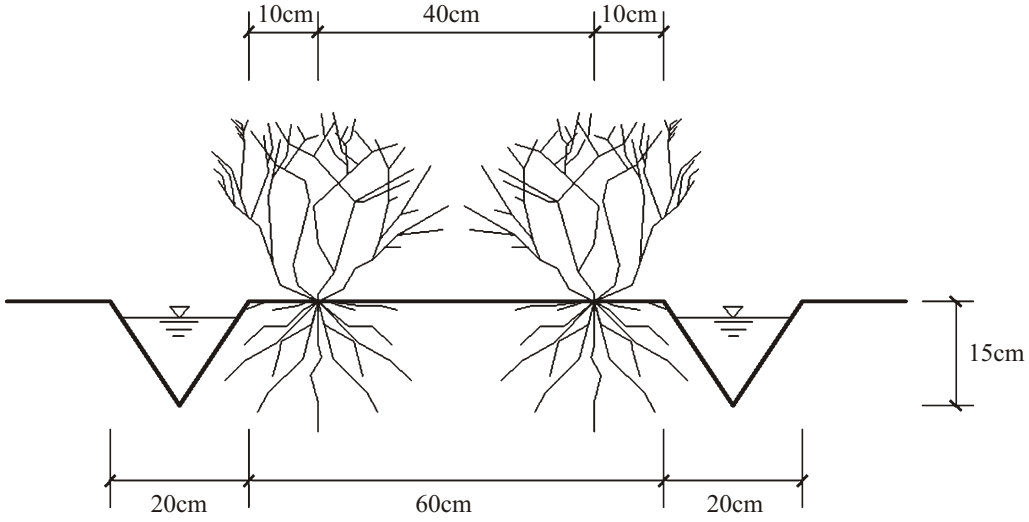

Fig. 1. Bed size developed by farmers in Pakistan

IV. Soil Preparation for Bed-furrow Intervention

A furrow and bed shaper is normally used for making the beds-furrows but a ridge can also be used. An regular bed outfit makes one bed and two furrows at a time, and in one day beds-furrows easily be completed over an area of 4-5 ha. An outfit can make parallel beds with a width of 50-60-cm and furrows of same height, and the usage of a rope can be more useful to keep the furrow straight. The machinery tractor has to be driven very slow however for making the beds; the shaper desires to be lifted at the end of the field while turning around. The rear wheel of the tractor machinery on its way back is followed in the earlier made furrow. The link between the ridge/shaper, the tractor can be adjusted to make furrow at a desire depth, e.g.30cm for sowing crop. When irrigating furrows and beds, the irrigation watercourse should be adjusted accordingly that it does not disturb the soil.

V. Issues Concerned with Adoption of Permanent Raised Beds

The following issues are concerned with growing crops on permanent raised beds need to be considered:

1. To develop multipurpose bed planter is necessary to increase the adoption of permanent raised beds. The different sizes of cotton and wheat increase the difficulty to grow both the crops on permanent raised beds and desire re-sizing of beds among crops. Moreover, a multipurpose PRB planter also needs to be developed. Besides width, technology and equipment are also required to adjust the height of beds according to the crop sown on higher beds but this height may not suit wheat or other crops which replace cotton in a rotation system.
2. The tractors are owned by most of farmers having medium size (upto 65 hp); however available bed-shapers are heavier / larger and cannot be comfortably operated by medium to small sized tractors. Thus, modification of the bed-shaper is required for the easy use. On-farm water management has developed prototype bed-shaper suited to local conditions of Pakistan on the basis of one developed by Punjab Agriculture University in Ludhiana, India. Recently, the University of Agriculture, Faisalabad, developed a bed-planter for establishing beds of suitable height and width for growing wheat and cotton. It is expected that more precise bed-planter/shaper will be available at low cost in near future for farmers of Pakistan.
3. Exclusion of carry-over cotton sticks from beds

core issue of permanent raised beds. These sticks provide safety for forthcoming crop from insects and at the same time causes shading problems including hampering spray and harvest operation and impairing productivity. It is utmost important to develop machinery/equipment to triumph these hurdles.

4. Invasion of weeds is enhanced by the permanent weeds. Manual process of cultivation is easy among the beds but requires more labor and time. Moreover, neither the mechanical equipment nor chemical method for controlling of weeds in sowing crops on beds is available.

Further studies are therefore desired to develop techniques for crops growing on PRB.

VI. Bed-furrow Intervention in Pakistan

Pakistan is a very important country regarding the production of rice-wheat crop. In Pakistan, yields of rice crop have been decreasing year by year. In order to test the raised beds with or without straw retentions about their situations, a bed presented of 0.6 hectare was placed on four farms in Gujranwala (Punjab, Pakistan) by the authors in 2010. A bed planter machine (manufactured in Pakistan) was used to shape the bed of size 60cm. The samples were taken from those four farms. The four samples of each crop on rice and wheat copping system in two years were taken. Besides, the observations constituted by both growers and authors are mentioned below.

In research areas, the soils are commonly silty clay. The yield of wheat crop that obtained from bed-furrow intervention was pretty different. It has come to know that bed-furrow intervention resulted the spike numbers per square meter and plant population significantly high as compared to common seeding method. However, it was observed that height did not change considerably between bed-furrow intervention and conventional method. In addition to these, forty percent irrigation water was saved by bed-furrow intervention compared to conventional seeding and there was less weed infestation. The wheat crop yield was considerably higher during bed-furrow intervention due to decline of weed infestation through the years and normally lower in conventional tillage as shown in Table IV.

In case of rice crops, it was revealed that the height and population of the plant, particle length, and particle numbers per square meter did not change considerably between bed-furrow and traditional intervention. But, some weeds were found in bed-furrow intervention. However, it was found that the yields of basmati rice (paddy) were significantly highest during conventional seeding as compared to that of bed-furrow intervention (Table V). It should be detected that the paddy varieties were only chosen about puddle and expectedly flooded conditions. By author, it is doubtful that the yield would be quite different, if paddy variety was selected under aerobic condition.

TABLE IV
Wheat Crop Yield in t/ha During Two Interventions of Seeding/ Tillage in Punjab, Pakistan [VIII]

Intervention	2010-11	2011-12	Mean
Bed-furrow	3.80	4.25	4.0
Traditional	3.45	3.97	3.21

TABLE V
Paddy Yield in t/haover Two Interventions of Seeding/ Tillage in Punjab, Pakistan [XVI]

Intervention	2011	2012	Mean
Bed-furrow	3.60	3.42	3.51
Traditional	3.72	3.75	3.74

Further, there was some limitations which causes crop yield on bed-furrow intervention. These limitations involved struggle in transplanting rice crop on hard beds, more rodent attack and defective equipment for bed-furrow intervention which causes poor crop stand. Therefore, it need more research expansion and availability of good equipment that are capable of shaping bed in hard soil (for both wheat and rice crop) during more residue for earlier crop.

VII. Conclusion

In Pakistan, the tasks for employing and doing research for bed-furrow cropping system consist of:

Supplying fertilizer and seed accurately. In order to get this, improvement in manufacture and design of machine is required. It is more inexpensive and trustworthy to use four wheel tractors in Pakistan.

Expansion and enhancement in the practice of bed-furrow intervention in Pakistan. Relevant stake holders, i.e. agricultural engineers, manufacturers, agronomist, farmers and machinery operators play a vital role in this regard. However, continuing to collect and monitor data on how its usage can be sustained within the Pakistan environment.

Selecting rice germ-plasm during aerobic conditions i. e. bed-furrow intervention that performs well.

Up scaling the awareness of cultivators where bed-furrow intervention appropriate their cropping system and soil and offer advantageous in economic pays as well as yield.

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