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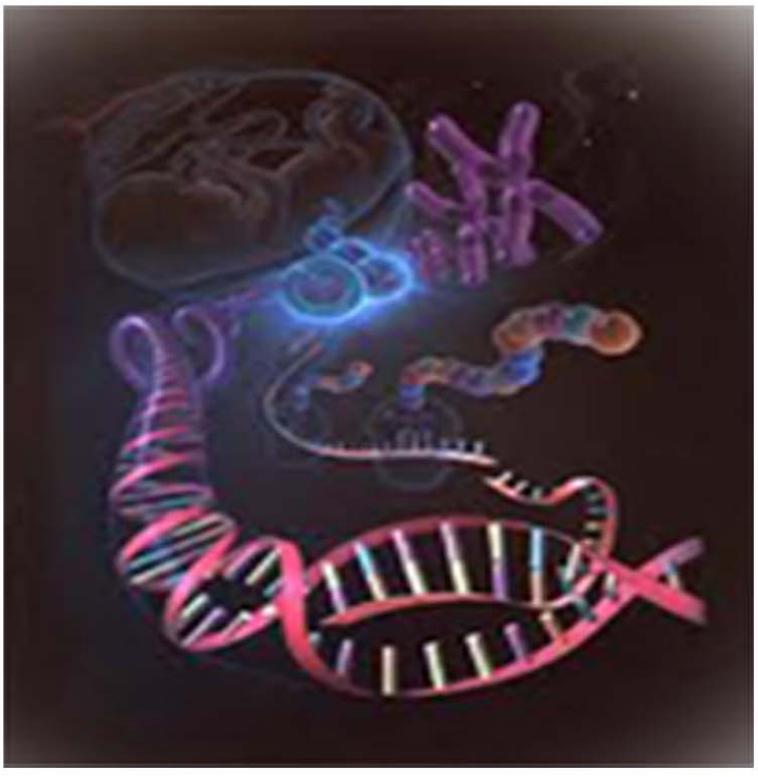

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Research Paper

FURROW IRRIGATED RAISED BED (FIRB) PLANTING TECHNIQUE FOR DIVERSIFICATION OF RICE-WHEAT SYSTEM FOR WESTERN IGP REGION

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A field experiment comparing furrow irrigated raised beds and flat beds under irrigated conditions was started in 2009. In bed planting systems,crops are planted on the raised beds in ridge-furrow system. This system is often considered more appropriate for growing high value crops that are more sensitive to temporary water logging stress. Farmers often raise crops such as cabbage, carrot, radish, okra, onion, brinjal, cauliflower, colocasia, turmeric, cotton, maize and wheat on the raised beds. Results shows that system of raised bed planting of crops may be particularly advantageous in areas where groundwater levels are falling. This tillage and crop establishment option also facilitates crop diversification and intercropping of several vegetables. The experimental results indicated that FIRB technique is not only save the resources like water and nutrients and labour but also facilitates the greater diversification of the rice-wheat cropping systems and improve the physical properties of soil.

Keywords: Crop diversification, Water productivity, Sustanability, Furrow Irrigated Raised Bed (FIRB)

INTRODUCTION

Crop diversification is intended to give a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to lessen risk. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. The crop shift (diversification) also takes place due to governmental policies and thrust on some

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crops over a given time.Some times market infrastructure development and certain other price related supports also induce crop shift. Often low volume high-value crops higher profitability and the resilience/stability in production also induce crop diversification. Furrow Irrigated Raised Bed (FIRB) planting system in which crops are sown on ridges or beds. The height of the beds is maintained at about 12 to 15 cm and having a width of about 37 to 107 cm depending on the crops. In case of cabbage, carrot, okra and cauliflower around 37 to 107 cm bed width is maintained and generally two to four rows having a distance of 30 cm are sown. During the last decade practice of raised bed planting has been emerge with a greater pace in IGP specially in high value crops and vegetables. The major concern of this system is to enhance the productivity and save the irrigation water. There are evidences for the greater adoption of this practice in the last decade in other parts of the world like high-yielding,irrigated, wheat-growing area of north-western Mexico (Connor *et al*., 2003; and Sayre and Moreno Ramos, 1997) where bed planting rose from 6% of farmers surveyed in 1981 to 75% in 1994. Potential agronomic advantages of beds include improved soil structure due to reduced compaction through controlled trafficking, reduced water logging and timely machinery operations due to better surface drainage. Beds also create the opportunity for mechanical weed control and improved fertilizer placement (Singh *et al*., 2002). Permanent beds also provide the opportunity for diversification to water logging sensitive crops not suited to conventional flat layouts, and the ability to respond rapidly to market opportunities (Singh *et al*., 2005). There are several reports of reduced irrigation amounts or time, with similar or higher yields, for vegetable crops on beds compared with conventional tilled vegetable crops, from farmer participatory trials and researcher plots across the IGP. Typical irrigation savings range from 18% to 30-50% (Hossain *et al*., 2001; Naresh *et al*., 2010; and Singh *et al*., 2010).

MATERIALS AND METHODS

The name, abbreviation, brief description, benefits, and limitations of selected RCTs and conventional technologies were presented in Table 1 for crop diversification.

Experiments on different tillage and crop establishment techniques involving permanent beds were conducted under researcher managed trials at the research farm ($29^0 01'$ N, $77^0 45'$ E, and 237 m above mean sea level) of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (Uttar Pradesh), and farmer managed trials in Ghaziabad District of Uttar Pradesh during 2009-10 and 2010-11. The water table depth of the experimental sites were 23 m with very good quality of water. The climate of the area is semiarid,with an average annual rainfall of 805 mm (75-80% of which is received during July to September), minimum temperature of 4^0C in January, maximum temperature of 41 to 45^0C in June, and relative humidity of 67 to 83% throughout the year. The experimental soil (0-15 cm) was silty loam in texture,with a bulk density of 1.42 Mg m^{-3}, weighted mean diameter of soil aggregates 0.71 mm, pH 8.1, EC (saturation extract) 0.4 dS m^{-1}, total C 8.3 g kg^{-1}. The particle size distribution of 0-20 cm soil layer is 68.6 % sand, 17.1 % silt and 14.3 % clay.

Experiment I: The experiment was initiated during monsoon 2009 at SVPUAT, Meerut research farm involving permanent beds systems in cabbage-okra–brinjal rotation. A randomized block design

Table 1: Name, Abbreviation, Brief Description, Benefits, and Limitations of Conventional Technologies and RCTs for Crop Diversification

Name	Abbreviation	Brief Description	Benefits	Limitations
Conventional till broadcast seededcabbage	CT BCC	Seeds are broadcast manually in thoroughly prepared fields with 4-5 plowings/ harrowings by a tractor or a power tiller. After sowing, laddering is practiced to cover seeds.	Traditional; easy crop Establishment	High energy and tillage cost; high seed rate; delay cabbageseeding; low yield.
Reduced till drill seeded vegetables	RT DSV (rotovator)	A single pass tillage is done by a tractor with an attached rotovator or tiller;then, vegetable crops are drill seeded	Faster tillage and seeding; savings on tillage cost; Timely vegetables seeding; high yield.	Tendency to increase tillage frequency; no soil structure maintenance.
Raised bed drill seeded vegetables	Bed DSC	Here, a bed former cum zero till drill is used to form 37 cm/107 cm wide raised beds and 30 cm wide furrows in well prepared, pulverized soil and diversified crops are sown in rows on both sides/four rows of moist beds.	Good drainage; savings inirrigation water; facilitates mechanical weed control.	Variable crop stand; weedpressure.
Conventional till Transplanted vegetables with integrated cropand resource management	CT TPV ICRM	Land is plowed and leveled; young seedlings at 2 to 3 leaf stage are transplanted at an optimal spacing and improved soil, water, nutrient, and weed management.	Reduced inputs, increased yields, and higher resource use efficiency.	Time consuming; needfor skilled labor; difficult to follow wetting and drying irrigation.
Raised bed Transplanted vegetables	Bed TPV	Here, a bed former cum zero till drill is used to form 37 cm/107 cm wide raised beds and 30 cm wide furrows in well prepared, pulverized soil vegetablesare transplanting in rows and irrigation was applied just after transplanting.	Good drainage; savings inirrigation water; facilitates mechanical weed control.	Variable crop stand; Perfect land leveling and early weed cntrol needed.
Conventional till Transplanted vegetables in flat	CT-TPV	2-3 dry tillages followed by planking/ leveling and young seedlings at 2 to 3 leaf stage are transplanted at an optimal spacing and irrigation was applied just after transplanting .	Traditional; easy crop Establishment	High energy and tillage cost early water control needed;variable crop stand; more weeds;

(RBD) was used in the study. A combination of six tillage and crop establishment techniques, [1. direct seeded on narrow beds (DSN Bed) 2. transplanted on narrow beds (TPN Bed) 3. direct seeded on wide beds (DS W Bed) 4. transplanted on wide beds (TPW Bed) 5.direct seeded on flat beds (DS FBed) 6.transplanted on flat beds (TPFBed)]. The changes in soil physical properties were recorded by taking soil samples at 0-15 cm soil layer from top of the beds in permanent beds and within the row in flats. The details of the treatments are depicted in Table 1.

Experiment II: The farmers' participatory trials on tillage and crop establishment techniques were carried in Ghaziabad District for two years on corriander- carrot-tomato, cauliflower- onion and colocassia-garlic cropping systems.Three tillage and crop establishment techniques [1.Direct seeded/ transplanted on narrow beds (DS/ TPNBed), 2. Direct seeded/transplanted on wide beds (DS/TPWBed), 3. Direct seeded/ transplanted on flat beds (DS/TPFBed) with and without FYM were adopted. Each farmer was considered as one replication and data was analysed using randomized block design (RBD)

RESULTS AND DISCUSSION

In the context of diversification, the debate has always focused on what areas, in which season, and how to diversify. Furrow-irrigated raised-bed planting provides additional options to generate alternate sources of productivity growth in wheat

through intercropping of high value vegetable crops. Cabbage, the most important wet season vegetable crop in Western IGP has shown potential for rice crop diversification in IGP. The introduction of direct seeding of cabbage and wide FIRB planting technique in the region has shown tremendous potential for increasing the water productivity and economic growth of the farmers with the limited resources. The results revealed a marked increase in water productivity and net profit under cabbage-based system and the water productivity and net profit was further increased with wide FIRB planting technique compared to flat planting technique (Table 2).

The winter green leafy spices like corriander has been disappeared from the cropping systems due the intensive irrigated cereal and sugarcane dominated production systems during last 2-3 decades. In view of the sustained productivity and nutritional security, the researchers have advocated the inclusion of winter green leafy spices in the cropping systems in this region. Corriander, the potential winter green leafy spices crop of the region have been reintroduced with the availability of the new crop management techniques in general and wide FIRB planting technique in particular. The results of the on-farm trials revealed that under flat planting technique, the water productivity and profitability of corriander-cauliflower-tomato was less but, it was improved with the wide FIRB planting technique (Table 3).

Table 2: Yield, Water Productivity and Profitability of Cabbage, Okra and Brinjal Crop Under Various Tillage and Establishment Techniques

Crop Establishment	Yield t ha^{-1}			Water productivity (kg yield m^{-3} water)			Net profit(Rs ha^{-1})		
	Cabbage	Okra	Brinjal	Cabbage	Okra	Brinjal	Cabbage	Okra	Brinjal
DS N Bed + F	33.6	9.5	24.8	10.182	2.021	5.701	53790.0	42995.0	31510.0
DS N Bed	31.4	8.3	22.3	9.235	1.711	4.901	47210.0	27510.0	25825.0
TP N Bed + F	30.7	9.7	24.6	8.528	1.979	5.467	45100.0	45500.0	29850.0
TP N Bed	27.5	8.4	22.1	7.333	1.750	4.804	35500.0	28500.0	25140.0
DSW Bed + F	38.5	12.5	26.7	13.051	3.012	7.120	66500.0	70748.0	41100.0
DSW Bed	35.6	10.8	23.5	11.672	2.541	5.995	57800.0	55750.0	33110.0
TPW Bed + F	36.7	12.4	26.2	11.651	2.952	6.770	60600.0	69125.0	38650.0
TP W Bed	34.2	11.1	23.3	10.523	2.552	5.854	55110.0	56400.0	32105.0
DS F Bed +F	28.7	7.5	19.7	7.266	1.376	3.696	39120.0	27250.0	18770.0
DS F Bed	26.4	6.8	17.8	6.439	1.214	3.254	32200.0	24500.0	16625.0
TP F Bed + F	25.5	7.7	19.2	5.930	1.400	3.435	29500.0	27500.0	17915.0
TP F Bed	24.3	7.0	17.5	5.283	1.228	3.070	25910.0	25250.0	15310.0
Average	31.1	9.3	22.3	8.598	1.914	4.812	45695.0	41752.0	27159.0

Table 3: Effect of Tillage and Crop Establishment Techniques on Productivity and Profitability of Corriander, Cauliflower and Tomato

Crop Establishment	Yield t ha^{-1}			Net profit(Rsha^{-1})		
	Corriander	Cauliflower	Tomato	Corriander	Cauliflower	Tomato
DS/TPNbed+F	0.9	21.5	24.3	35500.0	45500.0	71200.0
DS/TPNBed	0.8	20.7	21.7	31250.0	45096.0	60810.0
DS/TPWBed+F	1.4	24.7	28.5	52250.0	58910.0	82500.0
DS/TPWBed	1.2	21.6	25.8	46750.0	48620.0	76700.0
DS/TPFBed+F	0.7	18.9	19.8	27250.0	37190.0	52960.0
DS/TPFBed	0.6	17.5	17.9	23750.0	35375.0	45350.0
Average	0.9	20.8	23.0	35250.0	45115.0	64920.0

The effect of crop diversification on colocasia–garlic shown a remarkable increase in the yield and water productivity and profitability of colocasia-garlic system (Table 4). The effect was much more pronounced under wide FIRB planting technique than the flat planting systems. The wide FIRB planting technique have potential for higher productivity of high value cash crops as compared to flat planting conventional system during spring season turmeric-okra cropping system has a marked increase in net income of the farmers through adoption high value cropping systems under FIRB planting technique (Table 5).

FIRB PLANTING SYSTEM AND SOIL PROPERTIES

The soil physical properties (bulk density, AMWD, infiltration rate, cone index) in surface (0-15 cm) layer showed remarkable changes due to tillage and crop establishment techniques (Table 6). The mean weight diameter of aggregates (AMWD)

Table 4: Productivity and Profitability of Colocassica (C) and Garlic (G) Under Permanent Bed Planting In Farmer Managed Plots

Crop Establishment	Yield t ha^{-1}		Total water use mm ha^{-1}		Water productivity (kg yield m^{-3} water)		Net profit (Rs ha^{-1})	
	C	G	C	G	C	G	C	G
DSN Bed+F	11.6	6.5	525	395	2.210	1.646	44905.0	52250.0
DSNBed	9.7	5.2	575	405	1.687	1.284	37300.0	37705.0
DSWBed+F	13.5	9.7	465	365	2.903	2.658	51999.0	78450.0
DSWbed	12.2	7.6	495	385	2.465	1.974	46550.0	63350.0
DSFBed+F	8.4	4.8	585	460	1.436	1.044	32100.0	35300.0
DSFBed	7.6	4.5	605	485	1.256	0.928	28900.0	32250.0
Average	10.5	6.4	541.7	415.8	1.938	1.539	40290.0	49884.0

Table 5: Productivity and Profitability of Turmeric(t) and Okra (O) Crop Under Permanent Bed Planting In Farmer Managed Plots

Crop Establishment	Yield t ha^{-1}		Total water use mm ha^{-1}		Water productivity (kg yield m^{-3} water)		Net profit (Rs ha^{-1})	
	T	O	T	O	T	O	T	O
DS/NBed+F	22.5	9.5	425	470	5.294	2.021	57750.0	42250.0
DS/Nbed	20.8	8.3	445	485	4.674	1.711	52820.0	35155.0
DS/WBed+F	24.7	12.5	385	435	6.416	2.874	63130.0	54490.0
DS/Wbed	21.6	10.8	405	465	5.333	2.323	54390.0	47850.0
DS/FBed+F	18.5	7.5	465	550	3.978	1.364	46150.0	31095.0
DS/Fbed	17.8	6.8	495	575	3.596	1.183	44120.0	26535.0
Average	20.9	9.2	436.7	495.8	4.786	1.856	53060.0	39563.0

Table 6: Physical Properties in Different Permanent Tillage Techniques After 2 Years

Treatment	Bulk density(Mg m^{-3})	Cone Index	Infiltration rate(mm hr^{-1})	AMWD(mm)
DSNBed	1.56	2.57	84.7	0.41
TPNBed	1.54	2.60	81.4	0.39
DSWBed	1.54	2.41	82.3	0.46
TPWBed	1.52	2.45	79.5	0.42
DSFBed	1.62	2.81	55.7	0.27
TPFBed	1.64	2.83	52.2	0.24
Initial	1.52	2.28	-	0.35
C D at 5%	0.08	0.17	10.42	0.06

improved significantly with from initial value of 0.35 to 0.41 in narrow permanent beds and 0.46 in wide permanent beds where as it declined to 0.24 in conventional practice (TPFBed). Similarly, maximum infiltration rate was recorded with narrow permanent beds followed by wide permanent beds and the lowest being with conventional practice (TPFBed). At initial time bulk density of surface layers remains lower under bed planting than under conventional tillage. This is because top of beds remains loose. The lower bulk density means more porosity especially in upper surface. The cone index was increased significantly under all the tillage and crop establishment techniques but the extent of increase was more under conventional tillage systems.

CONCLUSION

Diversification of crops and cropping systems that have high water productivity, profitability and long-term sustainability with the availability of

modern management techniques may prove a better alternative in this respect. Horticultural crops also tend to have a positive poverty reduction bias, being labor intensive and small scale. Water is becoming a scarce resource for crop production and promoting the diversification with intensification using water, wise technologies has become mandatory for sustainability.The intercropping of vegetables and other high value crops with the availability of new crop establishment techniques i.e., FIRBS is the way towards nutritional security and economic growth of the farmers large number of technological optional for crop diversification are available which need kind attention of the extension agencies for their dissemination and acceleration of adoption at farm level.

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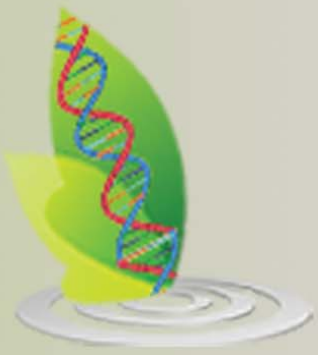

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