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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(4): 383-387

www.thepharmajournal.com
Received: 10-02-2022
Accepted: 13-03-2022

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Enhancing the kabuli gram productivity through suitable technological interventions with furrow irrigated raised bed system

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Abstract
The present investigation was conducted to study the performance of kabuli gram (Phule G-517) sown on Furrow irrigated Raised Bed System (FIRBS) in Dewas district of Malwa Region of Madhya Pradesh. The field experiments were conducted by Krishi Vigyan Kendra, RVSKVV, Dewas at different villages of district *viz.* Narana, Nanadharakhedi, Dakachya, Gorba, Amlawati, Nipaniya, Rajoda, Binjayana, Khatmba and Chhoticurlai during the rabi season of the year 2015-16, 2016-17 and 2017-18 to evaluate the productive performance of Kabuli gram under FIRBS. On the basis of three years average data, 19.89 per cent yield advantages was recorded under demonstrations with improved technological practices with FIRBS as compared to farmer's traditional way of kabuli gram cultivation. The results of economic analysis of demonstrations revealed that average higher gross return Rs.128850 per ha and net return Rs.96410/ ha as compared to farmer's practices which were Rs. 107475/ ha and Rs 77797 per ha respectively. The average higher additional net returns Rs. 18713/ha and effective gain Rs. 15876 /ha obtained under demonstrations could be due to improved technology, raised bed technique, non-monetary factors, timely operations of crop cultivation and scientific monitoring. It is concluded that the technology needs to be popularized to decrease the extension gaps, technology gap, technology index, adoptions gaps and there by yield gap so as to increase the income of farmers. The economic details of the demonstrations give us a green signal to further popularize them among the farming community for large scale adoption.

Keywords: FIRBS, Phule G-517, Kabuli gram, FLD

1. Introduction

Chickpea (*Cicer arietinum* L) is the most important pulse crop of India contributing about 30% of total pulse acreage and about 40% of total pulse production of the nation. India ranked first in area and production in the world, followed by Pakistan, Australia and Iran. The highest productivity of 6120 kg/ha is observed in Isreal followed by Yemen, Canada and Egypt. India productivity was 920 kg/ha yields (Tiwari and Shivhare, 2016) [17]. MP is the largest producer of chickpea in India which contributes about 39 per cent followed by state Maharashtra (14%) and Rajasthan state (14%) (Kumar, *et al.* 2011.) [5]. In several chickpea producing state Andhra Pradesh registered highest productivity 1559 kg/ha followed by Bihar 894 kg/ha, Gujarat 850 kg/ha and Madhya Pradesh 711.8 kg/ha (Anonymous 2011) [1].

The district level highest contribution in production of Kurnool, AP (2.56%) followed by Vidisha (2.07%), Sagar (1.99%) of M.P.state. Dewas district has 6th rank (1.33%) at the national level. District-wise area, production and yield of top ten district of India in respect of production are presented below which contributed 15.24 per cent and 18.86 per cent of total area and production of chickpea in the country. The yield was revealed that the potential districts yield is higher than the National average yield. While district Dewas (Madhya Pradesh) have more productivity of Chickpea 1511 kg/ha as compared to M.P. State and national level. Although the yield potential of chickpea varieties is about 2500 kg ha^{-1}. The gap between present productivity and potential of variety may be due Adoption of traditional farming system, non-adoption of recommended production technologies due to lack of knowledge and conviction about latest technologies, major abiotic and biotic stresses. Thus, it can be inferred that front-line demonstration is an effective extension intervention to demonstrate the production potential of improved technologies in Chickpea crop on farmers' field. Therefore, it is recommended that the extension agencies engaged in transfer and application of agricultural technologies on farmer's field should give priority to organize frontline demonstrations for harnessing the productivity potential of chickpea crop, reduce the technology gap, technology adoption and minimizing the disease and insect infestation.

In recent years, FIRBS has proved to be one of the important components of low cost sustainable production system. This planting system facilitates mechanical weed control, increased water use efficiency, reduced crop lodging and has lower seed requirement (Sayre, 2000) [8] and (Yadav *et al.*, 2002) [21]. In this system, water moves horizontally from the furrows into the beds (subbing) and is pulled upwards in the bed towards the soil surface by capillarity, evaporation and transpiration, and downwards largely by gravity. Raised bed planting of cereals, pulses and vegetables, on an average, increased yield by 24.2 per cent and saving of irrigation water by 31.2 per cent (Connor *et al.*, 2003) [3]. The major concern of this system is to enhance the productivity and save the irrigation water. 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) [10]. Hence, the present investigation was, therefore conducted to study the performance of kabuli gram sown on Furrow irrigated Raised Bed System (FIRBS) in Malwa Region of Madhya Pradesh. Scientists of Krishi Vigyan Kendra, RVSKVV, Dewas were laid out the demonstrations on farmers field to initiated and disseminated the new variety of Kabuli gram Phule G-517 with new technology of Sowing Furrow Irrigated Raised Bed System (FIRBS).

2. Material and Methods

The field experiments were conducted by Krishi Vigyan Kendra, RVSKVV, Dewas at different villages of district *viz.* Narana, Nanadharakhedi, Dakachya, Gorba, Amlawati, Nipaniya, Rajoda, Binjayana, Khatmba and Chhoticurlai during the rabi season of the year 2015-16, 2016-17 and 2017-18 to evaluate the productive performance of Kabuli Gram under FIRBS. The village Narana, Dakachya, Rajoda and Nanadharakhedi situated in the block Sonkutch, Khatmba, Amlawati, Nipaniya, Binjayana and Chhoti churlai, comes in the block Dewas, while Gorba in Tonkkhurd block of the Dewas district. Total 33 demonstrations were conducted in 10 villages of 3 blocks. The climate of the region is tropical sub-humid receiving an annual rainfall of 1067 mm with maximum and minimum temperature of 45 °C and 5 °C, respectively. The soils of experiment sites were medium black soil with pH 7.5 to 7.8, organic carbon (0.28 to 0.40%) at the time of initiation of field experiment. On soil fertility account, it was low in available N (178 kg/ha), medium in P (17.2 kg/ha) and K (340 kg/ha) and S (13.8 kg/ha).

Before conducting the demonstrations a list of farmer prepared by group meeting and specific skill training was imparted to the selected farmers regarding different aspects of kabuli gram cultivation. In the demonstration one control plot was also kept where farmer practice was carried out.

The technological interventions were comprised of suitable improved varieties of kabuli gram that was Phule G-517 with full package of practices *viz.* proper tillage, proper seed rate, time of sowing and sowing on FIRBS, balanced dose of fertilizer (20 kg Nitrogen 60 kg P2O5, 20 kg K_2O/ha), Trichoderma and Rhizobium culture @ 5 gm/kg of seed as seed treatment, proper irrigation, weed management and improved plant protection measure were applied (Table 1) at farmers' fields. The field was prepared and trapezoidal shape raised beds were made mechanically by tractor driven furrow irrigated raised bed planter. The experiments were conducted at 33 farmers' field and area of each field was kept 4000 sq m. The width of bed was kept 50 to 55 cm with two rows (at 40 to 45 cm distance) of kabuli gram on each raised bed. Recommended seed rate 80 kg/ha was used for sowing. First irrigation was applied at the time of branching (35-40 d after sowing) and second irrigation was at the stage of pod formation (90-95 d after sowing) through the furrow. But in the control plot where farmers practices were carried out (use of non-descriptive variety like dollar, sowing by simple seed drill, imbalance use of fertilizer, no weeding and indiscriminate use of plant protection measures).

The demonstrations on farmers' fields were monitored by respective scientists of krishi Vigyan Kendra from sowing to harvesting and made to guide them for timely application of important inputs and crop management. The relevant extension activities like field days at the demonstration site were organized These visits were also utilized to collect data, feedback information for further improvement in research and extension programme. Data of plant height, no of branches per plant, no of pods per plant, no of plants per sq mt, grain yield, biological yield were recorded from demonstrations field and control plot by random crop cutting method and analyzed with suitable statistical tool.

The data on production cost and monetary returns were collected from both the demonstrations and control plots to work out the economic feasibility of the technology. Cost of cultivation was calculated on the basis of prevailing rate of inputs. Gross income was calculated by yield multiplied with sale rate of produce. Net income and benefit cost ratio was computed by the following formula.

Net income = Gross income – Cost of cultivation

$$\text{Benefit cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

The technology gaps, extension gaps and technology index were calculated as per following formula given by Samui *et al.* (2000) [9].

Technology Gap = Potential yield – Demonstration yield

Extension gap = Demonstration yield – Farmers yield (Control Plot)

$$\text{Technology Index} = \frac{(Yi^* - Yi)}{Yi^*} \times 100$$

Where, Yi^* = Potential of the Crop

Yi = Demonstration yield of Crop

Additional Cost, Additional Return and Effective Gain were calculated as per following formula given by Singh *et al.* (2019) [14].

Additional cost in improved technology (Rs/ha) = Cit-Cfp

Where, Cit = Cost of improved technology (Rs/ha)

Cfp = Cost of farmers practice (Rs/ha)

Additional returns (Rs/ha) = Nrit - Nrfp

Where, Nrit = Net returns of improved technology (Rs/ha)

Nrfp =Net returns of farmers practice (Rs/ha)

Effective gain (Rs/ha) = Additional returns – Additional cost of improved technology

3. Results and Discussion

The gap between the existing and recommended technologies of kabuli gram in was presented in table-1. Full gap was observed in case of use of variety, seed rate, method of sowing and partial gap was observed in Sowing time, fertilizer application, Irrigation, weed management and plant protection measures. This definitely was the reason of not achieving potential yield. Farmers were not aware about recommended technologies. Farmers in general used unidentified varieties instead of the recommended high yielding resistant varieties. Unavailability of seed in time and lack of awareness were the main reasons. Farmers applied higher seed rate than the recommended and they were not using seed treatment technique for the management of seed born diseases and also not aware the application of micronutrient i.e. ammonium molybdate for enhancement of yield, because of lack of knowledge and interest.

Table 1: Differences between technological intervention and farmers practices

Particular	Technological Interventions	Existing Farmers Practices	Gap
Variety	Phule G- 517 (Kripa)	Doller (Unidentified Variety)	Full
Seed Rate	80 kg/ha	125 kg/ha	Full
Seed Treatment	*Trichoderma* powder and *Rhizobium* culture @ 5 g/kg seed and Ammoniuam Molybdate @ 1 g/kg seed	Seed Treatment by chemical	Full
Time of Sowing	15 October to 15 November	First Fortnight of October	Partial
Sowing Method	Furrow Irrigated Raised Bed System	Seed Drill	Full
Fertilizer Application	N:P:K 20:60:20 Kg/ha	Imbalance use of fertilizer	Partial
Irrigation	Ist at the Time of Braching (40 to 45 DAS) IInd at the Pod Filling stage (75-80 DAS)	No consideration of Critical stages	Partial
Weed Control	Pendimethalin 30% EC @ 3.3 lit./ha + One hand weeding at 60 days after sowing	Improper chemical weed Control	Partial
Plant protection Measures	Need based Plant protection measures profenophos @ 750 to 800 ml/ha)	Injudicious Use of Insecticide	Partial

The perusal of data given in table 2 reveals that the yield of kabuli gram fluctuated successively over the years in demonstration plots. During 2015-16 to 2017-18 the average demonstration yield was recorded to be 17.18 q/ha, it was noted highest yield 17.66 q/ha during 2017-18. The increase in percentage of yield was ranging between 14.58 to 26.14 during three years of study. On the basis of three years, 19.89 per cent yield advantages was recorded under demonstrations with improved technological practices with FIRBS as compared to farmer's traditional way of kabuli gram cultivation. The results clearly speak the positive effects of improved technologies over the exiting practices towards enhancing the yield of kabuli gram. The significantly average number of pods /plant (51.4), number of plant/sq m (37.3), straw yield (17.18 q/ha) and, biological yield (35.54 q/ha) were observed under recommended practices with furrow irrigated raised bed system with as compared to farmers conventional practices number of pod /plant (41.8), number of plant/sq m (32.4), straw yield (15.21) and biological yield (29.54 q/ha). Positively response of FIRBS technique was observed which improves the aeration and biological activities within the soil and improvement of nutrient holding capacity with the incorporation of biofertilzer was corroborated with the earlier findings of (Aulakh and Malhi 2005) [2]. The year-to-year fluctuations in yield and cost of cultivation can be explained on the basis of variations in prevailing social, economical and revailing microclimatic condition of that particular village. Yield enhancement in different crops in Front Line Demonstration has been also documented by Haque (2000) [4], Tiwari and Saxena (2001) [16], Tiwari *et al.*, (2003) [18], Tomer *et al.*, (2003) [19] and Singh *et al.* (2019) [11].

Table 2: Effect of package of practices on yield parameters of Kabuli Gram.

Year	No of Demonstration	Variety		Yield (q/ha)		Increasing in yield (%)	No of Plant / sq m		No of Pods / plant		Straw Yield (q/ha)		Biological Yield (q/ha)	
		FP	RP	FP	RP		FP	RP	FP	RP	FP	RP	FP	RP
2015 -16	10	Unidentified Variety (Doller)	Phule G-517	14.75	16.90	14.58	32.8	36.5	42.6	50.9	16.85	19.24	31.6	36.14
2016 -17	15	Unidentified Variety (Doller)	Phule G-517	14.25	16.98	19.16	32.6	37.3	42.2	50.3	15.25	20.01	29.5	36.99
2017 -18	8	Unidentified Variety (Doller)	Phule G-517	14.00	17.66	26.14	31.9	38.2	40.6	52.9	13.52	15.83	27.52	33.49
Mean				14.33	17.18	19.89	32.4	37.3	41.8	51.4	15.21	18.36	29.54	35.54

Table 3: Statistical analysis of Yield and Yield attributes of demonstration over farmer's practices

Treatment	Yield (q/ha)	No of Plant / sq m	No of Pods / plant	Straw Yield (q/ha)	Biological Yield (q/ha)
RP	17.18	37.4	51.4	18.36	35.54
FP	14.33	32.4	41.8	15.21	29.54
SEm+	0.44	0.78	1.14	0.93	0.79
CD (P=0.05)	1.27	2.23	3.28	2.68	2.29

The technology gap shows the gap in the demonstration yield over potential yield and The results revealed that the average technology gap was recorded 0.82 which was maximum in 2015-16 (1.1 q/ha) and minimum in the year 2017-18 (0.34 q/ha) showed in Table 4 The trend reflects the farmers' cooperation in carrying out such demonstrations with encouraging results in subsequent years. The demonstrations were laid down under the supervision of KVK Scientist at the farmer's field. The technology gap observed may be attributed to the dissimilarity in soil fertility status and weather condition. Similarly result also observed by Mokidue *et al.* (2011) [6] and Tomar *et al.* (2011) [20].

Table 4: Gap in grain yield production of kabuli gram under demonstration

Year	Variety		Yield (q/ha)		Potential Yield (q/ha)	Technology Gap (q/ha)	Extension Gap (q/ha)	Technology Index (%)
	FP	RP	FP	RP				
2015-16	Unidentified Variety (Doller)	Phule G-517	14.75	16.9	18	1.1	2.15	6.11
2016-17	Unidentified Variety (Doller)	Phule G-517	14.25	16.98	18	1.02	2.73	5.67
2017-18	Unidentified Variety (Doller)	Phule G-517	14.00	17.66	18	0.34	3.66	1.89
Average			14.33	17.18	18.00	0.82	2.85	4.56

Extension gap is a parameter to know the yield differences between the demonstrated technology and farmer's practice. The extension gap showed an increasing trend and observed data depicted in table 4. The extension gap are ranging between 2.15 to 3.66 q/ha during the period of study emphasizes the need to educate the farmers through various means for the adoption of improved Agriculture production to reverse the trend of wide extension gap. More and more use of new HYV's by the farmers will subsequently change this alarming trend of galloping extension gap. The new technologies will eventually lead to the farmers to disenchantment discontinuance of unidentified variety with the new technology. The results are in agreement with research worker Patel *et al*., (2013), who stated that, location-based problem identification and thereby specific interventions may have great implications in the enhancement of crop productivity.

The ratio between technology gap and potential yield expressed as percentage is technology index. The technology index showed the feasibility of the evolved technology at the farmer's fields. Higher technology index reflected the insufficient extension services for transfer of technology. The lower value of technology index shows the efficacy of good performance of technological interventions. The average technology index was observed 4.65 per cent under demonstration (Table 4). This variation indicates that result differ according soil fertility status, weather condition, non availability of irrigation water and insect-pests attack in the crop. The results of the present study are in consonance with the findings of Singh *et al.,* (2007) [13], Patel *et al.,* (2013) [7] Singh (2015) [12] and Singh, *et al.,* (2019) [11].

Table 5: Economic performance of the recommended practices over farmer's practices

Year	Variety		Cost of Cultivation (Rs)		Gross Return (Rs)		Net Return (Rs)		Additional Cost (Rs)	Additional Return (Rs)	Effective Gain (Rs)	B:C Ratio	
	FP	RP	FP	RP	FP	RP	FP	RP				FP	RP
2015-16	Unidentified Variety (Doller)	Phule G-517	29558	32170	110625	126750	81067	94580	2612	13513	10901	3.74	3.94
2016-17	Unidentified Variety (Doller)	Phule G-517	29801	32550	106875	127350	77074	94800	2749	17726	14977	3.59	3.91
2017-18	Unidentified Variety (Doller)	Phule G-517	29750	32600	105000	132450	75250	99850	2850	24600	21750	3.53	4.06
Average			29703	32440	107475	128850	77797	96410	2737	18613	15876	3.62	3.97

The input and output prices of commodities prevailed during each year of demonstration were taken for calculating cost of cultivation, net return and benefit cost ratio (Table 5). The data revealed that, monetary returns were directly influenced by the market price of kabuli gram and cost of production during the successive years of demonstrations. Different variables like seed, fuel, fertilizers, bio-fungicide, bio-insecticide, weedicide and chemical pesticides were considered as a technological intervention and on an average an additional average investment of Rs. 2737 was made under demonstration.

The results of economic analysis of demonstrations revealed that average higher gross return Rs.128850 per ha and net return Rs.96410/ ha as compared to farmer's practices which were Rs. 107475/ ha and Rs 77797 per ha respectively. The average higher additional net returns Rs. 18713/ha and effective gain Rs. 15876 /ha obtained under demonstrations could be due to improved technology, raised bed technique, non-monetary factors, timely operations of crop cultivation and scientific monitoring. Analysis of the yield performance also revealed that cost benefit ratio of demonstration plots were observed significantly higher (3.94, 3.91 and 4.06) than farmers practices 3.74, 3.59 and 3.53 respectively during 2015-16 to 2017-18. Hence, favorable cost benefit ratios proved the economic viability of the intervention made under demonstration and convinced the farmers on the utility of intervention. Similar findings were reported by Singh *et al.,* (2007) [13], Patel *et al.,* (2013) [7], Singh (2015) [12].

4. Conclusion

Organization of frontline demonstration is good practice to influence not only the participating farmers but also the neighboring farmers. As the demonstrations are conducted under the supervision of the scientist in farmers' fields, they are more authentic and results could to generalized to that vicinity. The demonstrated improved practices are superior when compared to farmers practice. The farmers expressed positive attitude towards the demonstrations through their perception on the technology. There was a extension gap between technological intervention and existing practices in kabuli gram production technology due to lack of knowledge and conviction of improved technologies. Technology and extension gap showed that the farmers were not aware about improved package and practices of kabuli gram production technologies; therefore it is recommended that the farmers should be aware for adoption of improved technologies and varieties through various extension aids (training, demonstration *etc.*). The technology index shows the feasibility of the technology demonstrated at farmer's field. The lower technology index showed that the good performance of technological intervention. So, it is concluded that the technology needs to be popularized to decrease the extension gaps, technology gap, technology index, adoptions gaps and there by yield gap so as to increase the income of farmers. The economic details of the demonstrations give us a green signal to further popularize them among the farming community for large scale adoption. Therefore, under this situation, extension agencies can also play a significant role to transfer improved technologies among farming communities for sustainable production and productivity. Thus, it can be said, that the adoption of improved package of practices of kabuli gram production technology may result in higher productivity per unit area.

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