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Assessment of Technology and Yield Gap of Chickpea in Transitional Plains of Inland Drainage Zone of Rajasthan

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Abstract

*Different intervention practices were demonstrated by Krishi Vigyan Kendra Abusar Jhunjhunu (SKRAU Bikaner) under NICRA Project since 2011 on the farmer's field of Bharu, Madansar, and Chakwas villages of Mandawa Tehsil. The project "National Innovations in Climate Resilient Agriculture" works diversely for the Natural Resource Management, Crop Production, Livestock and Institutional Interventions, in which Chickpea (*Cicer arietinum *L.) Var.GNG-1581 and GNG-2144 was Demonstrated on farmers field during these consecutive Rabi seasons (2015-16 to 2021-2022). During these Seven years, chilling stress, frost, unseasonal rains, hail, inclement weather prolonged rains (during the harvesting stage) were the common problems of this seasons. So under such conditions late sown, as well as rainfed conditions, high yielding, resistant to wilt and pod borer tolerant varieties performing better than traditional varieties. Seven season results revealed that there was full technological gap in 4 different practices (variety, Seed treatment through F.I.R system, weed management practices and plant protection) a partial gap in 3 different practices (seed rate, fertilizer management and irrigation) and was no gap in 2 practices (land preparation and line sowing methods). Further, Average grain yield of Chickpea showed a remarkable increase (18.07%) in demonstration fields as compare to local check; however it is still behind to potential yield. The average technological gap, extension gap and technology index were 7.52 q ha^{-1}, 2.22 q ha^{-1} and 34.20 % respectively. The total cost of cultivation (Rs ha^{-1}), gross return (Rs/ha), net return (Rs ha^{-1}) and B: C ratio under the demonstration fields were reported with an average of 31567 Rs ha^{-1}, 68835 Rs ha^{-1}, 37268 Rs ha^{-1}, 2.20 as compared to local check with an average of 29634 Rs ha^{-1}, 58277 Rs ha^{-1}, 28772 Rs ha^{-1}and 1.99 respectively during the period of research study. Further, the future study on variable climate conditions and edaphic factors requires determining the gap between potential and demonstration yield. The study recommends that the improvement of productivity in chick pea may be achieved through fulfilling the gap between demonstration and local check practices.*

Keywords: Drought, Extension Gap, Technology Index

Introduction

Chickpeas (*Cicer arietinum*) are legumes (a subclass of pulses) of the *Fabaceae* family. In northern India, it is sometimes referred to as grame and occasionally as Egyptian or Kabuli chana. With a 75% share of global output, India is the greatest producer of chickpeas (FAO, 2016; Maurya and Kumar, 2018; Gaur *et al*., 2019). Australia, Canada, Ethiopia, India, Iran, Mexico, Myanmar, Pakistan, Turkey, and the United States are the top producers of chickpeas out of the 50 nations that produce it (Archak *et al*., 2016; Dixit *et al*., 2019). Although it is said that the eastern Mediterranean is where the chickpea originated, its most likely location of origin is South Western Asia. Chickpeas are produced over an area of 137 lakh hectares around the world, with a yield of 1038 kg ha^{-1} and a production of 142.4 lakh tonnes. India contributes 70% of the 116.2 lakh tonnes of chickpeas grown on 112 lakh hectares with a productivity of 1036 kg ha-1 in 2020–21. It is a significant Rabi season food legume with a wide geographic distribution that accounts for 39% of the nation's total production of pulses (Singh *et al.*, 2014). India leads the globe in gramme output, which is then followed by Australia, Myanmar, and Ethiopia. In terms of total pulse production in India, chickpea comes in first, followed by black gramme. Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharastra, Andhra Pradesh, Gujarat, Karnataka, Haryana, Bihar, and West Bengal are the main states that produce chickpeas. Rajasthan has a land area of 18.39 lakh ha, a tonnage of 11.52 lakh, and a productivity of 1041 kg per hectare. According to WHO recommendations, India should consume 80 g of pulses per person per day. Its availability per person, however, is only 42 g per day (Tiwari and Shivhare, 2016). As a result, the country's population must grow together with the production of pulses. The productivity of chickpeas, however, is insufficient to meet the growing human population's need for protein (Henchion *et al.*, 2017; Chaturvedi *et al.*, 2018). High levels of protein are found in its seeds. By increasing soil fertility through symbiotic biological nitrogen fixation (BNF) with Rhizobium leguminosarum, all leguminous crops contribute significantly to sustainable agriculture. According to Singh *et al*. (2014), it is a good source of protein (18–22%), carbohydrate (52–70%), fat (4–10%), minerals (calcium, phosphorus, iron), and vitamins. It makes a great animal feed. Its straw was also a rich source of fodder. Most significantly, unexpected climate change is the main barrier to the production of chickpeas because it increases the frequency of drought and temperature extremes, such as high (> 30°C) and low (15°C) temperatures, which significantly lower grain yields (Gaur *et al.*, 2013; Kadiyala *et al.*, 2016).As a result, it is necessary to create chickpea cultivars that provide a high and stable yield under such stressful conditions (Devasirvatham *et al.*, 2015; Devasirvatham and Tan, 2018). In light of climate change and the growing global population, drought stress is a severe issue for agriculture (Tardieu *et al.*, 2018). Extreme droughts have a deleterious effect on plant growth, physiology, and reproduction, which lower crop yields (Barnabas et al., 2008). The main causes for restricting the potential yield of pulses include conventional farmers' sowing practises, inappropriate crop geometry, avoidance of balanced major (N, P, K), Secondary nutrients and biofertilizers, bio-pesticide, and climate variability's. The productivity of chickpeas is far lower than the theoretical yield. Although there has been significant advancement in agricultural research and education, the farming community has not been able to fully benefit from these advances due to the low rate of technology adoption at the farmer level. Trials conducted on farms have adequately shown that the production technique currently in use is capable of raising productivity by at least 30%. To turn the idea into reality, this is combined with technology advancements and operational synergy among planners, administrators, researchers, extension workers, and developmental agencies. The primary goal of NICRA demonstrations is to show off recently released crop production and protection technologies as well as their management techniques on a farmer's field in various agro-climatic regions and farming contexts. Scientists are required to research the elements that contribute to higher crop output, the production restrictions in the field, and produce data on production and feedback information while conducting demonstrations in the farmer's field. While the actual yield can be defined as the economic crop produced by the farmers with their available resources, the maximum attainable yield can be defined as the economic crop produced under the best management practises. To minimize the difference between different types of yield, it is necessary to determine the yield gap and technological gap responsible for the poor yield. Keeping these constraints under consideration, a study was conducted to improve the productivity of the chickpea by determining the technological gap, extension gap and technology index. The present study was conducted at farmer's field with objective to know the impact of Trainings and Improved transfer technology on chick pea with respect to farmer's community. The main objective of the Demonstration was to: Demonstration of Plant nutrient and Plant protection centric improved technologies and management practices in a compact block covering large areas, Enhance productivity of Pulses, Area expansion of Pulses crops, Stimulate other farmers of the adjoining area to adopt these technologies and Bring fallow / barren land under Pulses cultivation with low inputs.

Methodology

The district Jhunjhunu with an area of 5928 km^2 is situated in north eastern fringe of thar Desert of India lying between 27° 38' 15" to 28° 31' 14" N latitude and 75° 01' 32" to 75° 05' 51" E longitude, on an altitude of 300 to 450 meter above mean sea level.

The mean annual rainfall of the district is 444.5 mm. On an average most of rainfall is received during onset of summer monsoon in 26 to 32 rainy days. The potential annual evapo-transpiration is 1578 mm exceeds always to the precipitation characterizing short growing period. The mean maximum and minimum temperatures are 45° C and 23° C, respectively. Occasionally during winters the minimum temperature dips below 0° C at some places. A study was conducted at Jhunjhunu district, three villages of districts selected purposely in which chickpea is a dominated crop. The NICRA project was carried out in three villages namely Bharu, Madansar, and Chakwas villages of Mandawa Tehsil to assess the technology and yield gap between Demonstration and farmers practices (check). The soil is sandy to sandy loam with slightly alkaline pH of 7.9 and EC of 0.21 dSm^{-1}. The nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) were 265, 36 and 185 kg ha^{-1}, respectively.

The tan best management practices (BMP) were selected comprised improved high yielding and location specific varieties (GNG-1581, GNG-2144), optimum seed rate (80 kg ha^{-1}), line sowing, seed treatment, applied balance dose of fertilizers on the soil test basis, timely weed management, irrigation scheduling and plant protection measures. The BMP was based upon a number of the year proven research and recommendation of crop management practices at the time of variety release. The Demonstration were conducted on farmers' field and monitored by experts. The same number of nearby farmers was selected for the collection of actual information of chickpea crop grown under the management of farmers. The crop yield was determined from each plot of Demonstration and farmers practice by crop harvest. Yield expressed in q ha^{-1}. The economic analysis of both Demonstration and farmer practice comprised both fixed (land revenue and depreciation cost of farm implements) and variable cost includes human labour, irrigation and all the inputs used during crop cultivation (Table 1). The expenditure incurred in different activities during cultivation had collected from the Demonstration and Farmer practices for determination of cost of cultivation, net return and benefit-cost ratio. The technology gap, extension gap and technology index were calculated by adopting the following equations given by (Samui *et al*., 2000).

Technology gap = Potential yield – Demonstration Yield

Extension gap = Demonstration yield – Farmers yield

Technology index = ((Potential yield - Demonstration yield) / Potential yield} X 100

Results and Discussion

The adoption gap was workout by the following the standard procedure of 3 gaps, i.e. full gap (Not adopted best management practices), partial gap (Not fully adopted best management practices) and Nil (fully adopted best management practices) (Table 1). Among the selected 10 best management practices, five practices had not adopted by the farmers viz. varieties, seed treatment, seed inoculation, weed management and plant protection. Not adoption of these practices could be the cause for low productivities of chickpea in the region. Selection of improved high yield variety is striving for obtaining a better yield (Nikulsinh., 2012).The partial gap was found in 3 best management

Table 1: Details of practices

S. No.	Technology	Improved technology	Farmers practice	GAP (%)
1.	Variety	GNG-2144	Local	Full gap
2.	Land Type	Mediumland	No proper choice	Nil
3.	Land preparation	Ploughing & harrowing	Ploughing & harrowing	Nil
4.	Sowing method	Line sowing	Improper	Full gap
5.	Seed rate	50 kg ha^{-1}	60 kg ha^{-1}	Higher seed rate
6.	Seed treatment	With Carboxin 37.5%+ Thiram 37.5% @ 2 g kg^{-1} of seed	No application	Full gap
7.	Seed inoculation	Rhizobium & PSB	No seed treatment	Full gap
8.	Fertilizer dose (NPKS kg ha^{-1})	25:50:25:20	20:50:10:0	Partial Gap
9.	Pre-emergence herbicide	Pendimethalein @3.3 lha^{-1}	No application	Full gap
10.	Plant protection	Integrated pest management	Indiscriminate application	Full gap

practices viz. seed rate, fertilizer management and irrigation. Whereas, nil gap was observed in two practices land preparation and sowing methods (Samui *et al.*, 2000). Overall, it indicates that more extension efforts are needed to disseminate best management practices to the farmers for ensuring the adoption of all the practices. Seed Yield of Chickpea Data depicted on Table 2, an average of 7 years and 140 demonstrations sites revealed that seed yield of Demonstration (14.48 q ha^{-1}) was higher than farmer's practices (12.25 qha^{-1}), Demonstration Practices increased 18.07 percent seed yield as compared to farmer's practices. Therefore, the region has a huge opportunity for improvement in crop productivity of chickpea. Dissemination of BMP could be a better option. However, the yield obtained in Demonstration Practices was still lower than the potential yield. It may be due to the harsh climatic condition of the region, almost negligible rain during the dry season and higher temperature at the time of maturity of the crop led to lower yield of Demonstration Practices (Singh *et al.*, 2018; Bairwa *et al.*, 2013)

Technology Gap

In case of the technology gap, the differences between potential yield and yield of demonstration plots were 8.80, 4.82, 9.22, 7.54, 6.49, 7.30 and 8.50 q ha^{-1} during Rabi 2015-16 to 2021-22 respectively. On an average technology gap under four years Demonstration Practices 7.52 q ha^{-1}. It exhibits scope of further improvement in Demonstration Practices by refinement of best management practices inconsideration with agro-climatic conditions and soil factors. The technology gap observed may be due to dissimilarity in fertility status, climatic conditions etc. It may be taken as the location-specific refinement in BMPs is required to fulfil the technological gap (Table 2).

Extension Gap

Extension gap of 1.80, 3.14, 2.09, 2.44, 2.25, 2.15 and 1.70 q ha^{-1} was observed Rabi 2015-16 to 2021-22 with on an average 2.22 q ha^{-1}. It is needed to educate the farmers through various extension activities for the adoption of improved technology. Poor linkage between farmers and extension agencies may be one of the important factors responsible for the low adoption of best management practices (Table 2). It is therefore need to educate the farmers on improved crop management practices to decrease the extension gap, which is possible through more extension efforts (Kumar, 2014).

Technology Index

A perusal of information given in Table 2 revealed that the technology index ranged from 21.90 to 41.90 percent in 2016-17 and 2018-19, respective. It indicates, the climatic factors govern the technology index, favourable climatic condition during 2016-17 reduces index and harsh climatic condition adversely affected the performance of the demonstration. Overall four year average of technology index was 34.20 percent. It may be taken as requirement of location specific research on BMPs, which have ability to perform variable climatic conditions (Thakral *et al.*, 2002).

Economics of Demonstration

The economic viability of improved technologies over traditional farmer's practices was calculated depending on prevailing prices of inputs and output costs. It was found that the cost of production varied from Rs.26500 to 33250 ha^{-1} with an average 31567 Rs ha^{-1}, of improved technology against the variation in the cost of production Rs 24300 to 31600 ha^{-1} with an average of Rs. 29634 ha^{-1} in local check. Cultivation of improved technologies gave higher net

Table 2: Grain yield and gap analysis of front line demonstrations on chickpea at farmers' field

Year	No. of Farmers	Area (ha)	Yield (q ha^{-1}) Demonstrated practices	Farmer's practices	% Increase over control	Technology Gap (q/ha)	Extension gap (Kgha^{-1})	Technology Index (%)
215-16	10	4.0	13.20	11.40	15.79	8.80	1.80	40.00
2016-17	20	8.0	17.18	14.04	22.36	4.82	3.14	21.90
2017-18	20	8.0	12.78	10.69	19.55	9.22	2.09	41.90
2018-19	20	8.0	14.46	12.02	20.30	7.54	2.44	34.27
2019-20	20	8.0	15.51	13.26	16.96	6.49	2.25	29.50
2020-21	20	8.0	14.70	12.55	17.13	7.30	2.15	33.18
2021-22	30	12.0	13.50	11.80	14.40	8.50	1.70	38.63
Average	20	8.0	14.48	12.25	18.07	7.52	2.22	34.20

Table 3: Economic analysis of front line demonstrations on chickpea

Year	Cost of cultivation (Rs. ha^{-1})		Gross return(q ha^{-1})		Net Return (q ha^{-1})		B:C Ratio	
	DP	FP	DP	FP	DP	FP	DP	FP
2015-16	26500	24300	66000	57000	39500	32700	2.49	2.35
2016-17	31200	28500	91054	74412	59854	45912	2.92	2.61
2017-18	32500	29400	56232	47036	23732	18536	1.74	1.66
2018-19	33250	31100	57840	48080	24590	16980	1.75	1.55
2019-20	32320	31225	65142	55692	32822	24467	2.02	1.78
2020-21	32450	31310	74970	64005	42520	32695	2.31	2.04
2021-22	32750	31600	70605	61714	37855	30114	2.15	1.95

DP = Demonstrated practices; FP = Farmer's practices

return ranges from Rs. 39500 to 59854 ha^{-1} with a mean of Rs. 37268 ha^{-1}. The improved technology also gave higher benefit-cost ratio 2.49, 2.92, 1.74, 1.75, 2.02, 2.31 and 2.15 compared to 2.35, 2.61, 1.66, 1.55, 1.78, 2.04 and 1.95 under local check in the corresponding season. The higher net return and benefit cost ratio might be due to the better production of chickpea crops grown under Demonstration compared to farmers practice (Table 3).

Conclusion

The technological gap may not be completely fulfilled in the region due to low rainfall during crop growing season, scarcity of irrigation water and resource-poor farmers. However, there is a huge opportunity to improve the chickpea productivity by fulfilling the yield gap. Demonstrations on BMP have the potential to bridge the gap by sensitization and creation of awareness among the farmers of the region. Further, study strongly recommends future research and extension work for the determination of the socio-economic reason for practicing age-old practice by the farmers and rapid diffusion of BMP. The Demonstrations produced a significant positive result and provided an opportunity to demonstrate the productivity potential and profitability of the latest technology (intervention) under real farming situation.

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