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ARTICLES

Farmers' Willingness to Pay for Stress-Resilient Maize Hybrids in Rain-fed Agro-Environment in Karnataka

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ABSTRACT

Although maize plays a vital role in the food, fodder, and livelihood security of millions of farmers in India, it is highly vulnerable to drought and heat stress. Maize cultivation is prevalent in stress-prone agro-ecology, where the risk of losing the yield and income of smallholder farmers is high. Development and deployment of stress-resilient maize hybrids to farmers in marginal areas are crucial for coping with drought risk. The adoption of stress-resilient varieties depends on farmers' perception of the hybrid and willingness to pay (WTP) for it. In this paper, the study has estimated WTP for stress-resilient maize hybrids using primary data collected from 180 maize-growing farm households from rain-fed agro-environments in the Indian state of Karnataka. WTP was estimated using a double-bounded dichotomous choice model, and the mean WTP worked out to ₹ 312.76/kg. Farmers are WTP 37 per cent premium prices to stress-resilient maize hybrid as compared to the average price paid to conventional hybrids.

Keywords: Stress-resilient maize hybrid, Willingness to pay, Double-bound, Preference heterogeneity, Karnataka, India.

JEL classification : Q12, Q16, Q18, R22

I

INTRODUCTION

Atmospheric temperature is one of the major weather parameters contributing to crop development and final yield. But temperature beyond the critical limit adversely affects crop physiological development stages like the flowering, grain setting, and milking stage, particularly in maize crops. Climate change is already taking place. During the 20th century, Earth's mean global temperature rose by almost 0.74°C and is expected to increase by a further 1.1°C to 6.4°C by the end of the 21st century (IPCC, 2007). The South Asian countries have experienced more frequent incidences of extreme temperatures in the twenty-first century (Lal, 2005; 2011; Hijioka *et al*., 2014; Tesfaye et al. 2017). A review of the literature by Hijioka et al. (2014) indicates an increase in heat frequency over the middle of the twentieth century in most of Asia. Literature review on climatic studies suggests that the occurrence of high daytime and

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night time temperature will rise in the near future, and it will be a major impediment to global food production and food security (Lobell *et al*., 2011a; Cairns *et al.*, 2012; Hijioka *et al*., 2014). Climate change is expected to adversely affect the yield of staple crops in stress-prone environments- maize by 9-19 per cent, wheat by 44-49 per cent, and rice by 14 per cent (Nelson *et al.,* 2009). The IPCC estimated that by the 2050s in parts of Asia, climate change could result in declines in agricultural output by 5–30 per cent compared to 1990 levels (IPCC, 2007). Maize is primarily susceptible to heat stress during the multiplicative stage (Edreira *et al.*, 2011; Cairns *et al.,* 2012; Mayer *et al*., 2014; Rezaei *et al.,* 2015) and it is reported that each degree increases in day temperature beyond 30 °C reduces the final yield of maize by 1 per cent under favourable growing conditions and by 1.7 per cent under drought-stressed conditions (Lobell *et al*., 2011b). Lobell and Burke (2010) suggested that an increase in temperature of 2° C would result in a greater reduction in maize yields than a decrease in precipitation by 20 per cent within sub-Saharan Africa. Most of South Africa's sub-tropical maize growing areas are highly susceptible to heat stress during the reproductive (anthesis) and early grain-filling stage, particularly during the pre-monsoon season (Prasanna 2011). High temperature is responsible for reduced pollen water potential, the quantity of pollen shed, and the cause of reduced pollen viability (Schoper *et al.,* 1987), which ultimately reduces grain setting and yield. In South Asia's stress-prone environments, productivity is very low, with less than half that of farms using irrigation systems (Zaidi *et al*., 2014).

India is largely a developing economy with an amazing variety of geographical regions, biodiversity, and natural resources. However, the country is one of the most vulnerable to climate change risks worldwide. The study conducted by Rao *et al.* (2013) predicted that change in the frequency of days from March to May when maximum temperatures exceed the normal by 4^{o} C at least and changes in the incidents of dry spells (>= 14 days) from June to October during the mid-century (2021-2050) or end-century (2071-98) relative to the baseline (1961-90) in India. Karnataka ranks first in area (1.42 million hectares) and production (4.26 million tonnes) of maize in India in 2019-20 (Government of India, 2021). Out of the total maize area sown (1.20 million hectares) in the rainy season, 19.58 per cent was irrigated (0.24 million hectares), and 80.42 per cent was rainfed (0.97 million hectares) in 2018-19 as per the Department of Agriculture, Karnataka. Karnataka has the second largest area under rain-fed agriculture after Rajasthan. Droughts occurred in 13 years in Karnataka in the last 16 years. Nearly 80 per cent of talukas in the state are drought-prone (Government of Karnataka, 2018). Rainfed agriculture is more vulnerable to climate change. Many global research institutions are engaged in developing maize germplasm with drought tolerance (Lybbert and Bell, 2010) and heat tolerance (Tesfaye *et al.,* 2017). International Maize and Wheat Improvement Center (CIMMYT) is developing and deploying abiotic stress-tolerant hybrids in collaboration with national partners. The impact of any innovation of technology depends on the extent to which farmers adopt them. Farmers' acceptance of stress-tolerant maize varieties is ruled by their

willingness to pay (WTP) for different traits. While many stakeholders, including research institutions, and seed companies, play crucial functions in the dissemination of improved varieties, which must encompass the attributes desired by the farmers. The best way to assess demand for desired traits is to quantify their implicit prices. Hence, this study was designed to estimate the WTP for preferred traits with a deliberate focus on stress resilience in India's drought-prone communal farming areas. Several studies have examined trait preference and associated WTP in a range of crops over the last ten years (Carlsson *et al*., 2004; Poudel and Johnsen, 2009; Smith and Fennessy, 2011; Wale and Yalew, 2007; Ward *et al*., 2013). One could not find studies on farmers' WTP for stress resilience maize in India. Therefore, this study aims to fill this knowledge gap by assessing farmers' demand for stress-resilient (SR) maize hybrids in the stress-prone ecology of India. This study seeks to understand and estimate the price farmers are willing to pay for the new technology. We used a double-bound dichotomous choice model to gain insights into farmers' demand for stress-resilient hybrid technology. This paper contributes to the literature with the objectives of (a) estimating farmers' WTP for a stress-resilient maize hybrid in the stress-prone Karnataka state of India and (b) examining factors affecting WTP. Data collection methods and analytical frameworks are provided in Section II. The empirical results are presented and discussed in Section III. The last section provides conclusions.

II

DATA AND METHODOLOGY

Data

This study is based on primary household survey data collected from optimal and stress-prone environments in Karnataka from March to April 2019. Two districts (Dharwad and Gadag) were selected purposively based on the potential for the adoption of SR maize hybrid. Dharwad district has an optimal environment with assured rainfall conditions, whereas the Gadag district has a drought-prone environment. As per the Department of Agriculture, in Karnataka, the maize area sown in the rainy season was 36,649 ha in Dharwad, 100 per cent of which was under a rainfed cropping system. In Gadag, the total maize area sown was 38,870 ha; out of that, 74 per cent was under a rainfed cropping system (Department of Agriculture, Government of Karnataka). Dharwad and Hubli blocks were selected from the Dharwad district, and Shirahatti and Laxmeshwar blocks were selected purposively from the Gadag district. Data was collected through face-to-face interviews with a structured questionnaire. The questionnaire elicited information on household socio-economic status, cropping systems, income sources, and WTP for SR maize hybrids. Finally, 180 farm households (91 from Dharwad and 89 from Gadag) were selected randomly for the survey. Enumerators were hired locally and trained in data collection and the contingent valuation method to assess WTP.

Analytical Framework

Contingent valuation is the preferred method to estimate the valuation of goods and services that are not available in the market. In this method, the researcher creates a hypothetical market for a non-market good or novel product, invites a group of subjects to operate in that market, and records the results. The value generated with the hypothetical market is treated as an estimate of the value of the non-market goods or services, contingent upon the particular hypothetical market (Mitchell and Carson, 2013). WTP is the maximum amount of money an individual is willing to pay for a new product (Kimenju and De Groote, 2008). WTP can be estimated through open-ended or close-ended questions. Open-ended questions provide direct estimates and are easy to analyse, but people often find it difficult to state their WTP for a new product (Hanemann and Kanninen, 1996). Close-ended questions are closer to real-life situations and have become the tactic of choice (Arrow *et al.*, 1993). In this method, WTP is not directly observed, but assumptions about its distribution can be made, and its parameters, including the mean WTP of a population in monetary terms, can be estimated from survey data (Lusk and Hudson, 2004; Kimenju and De Groote, 2008). In the double-bounded dichotomous choice model, the buyer is presented with two consecutive bids; therefore, the second bid depends on the response to the primary. If the consumer answers "yes" to the first bid (B_i), the second bid (B^u) is set higher, but if the individual responds "no" to the first bid, the second bid (B^d) is set lower. There are four possible outcomes: "yes" to the first bid followed by a "yes" to the second bid (with probability denoted by P^{yy}); "yes" followed by "no" (P^{yn}); "no" followed by "yes" (P^{ny}); and two consecutive "no" answers (P^{nn}). Hence four probabilities for bid responses can be presented as:

$$\text{P (Yes, Yes)} = \text{Prob (WTP} \geq B^u) \quad \ldots. (1)$$

$$\text{P (Yes, No)} = \text{Prob (WTP} \geq B^u) - \text{Prob } (WTP \geq B_i) \quad \ldots. (2)$$

$$\text{P (No, Yes)} = \text{Prob (WTP} \leq B_i) - \text{Prob (WTP} \leq B^d) \quad \ldots. (3)$$

$$\text{P (No, No)} = \text{Prob (WTP} \leq B^d) \quad \ldots. (4)$$

The first bid was decided based on discussions with seed dealers, existing prices of different maize seed brands, and seed subsidies provided by the department of agriculture in Karnataka. To receive information on a wider range of values, different amounts for the bids are assigned randomly between respondents *i*. Combining the probabilities of the four outcomes, the log-likelihood function for this model for a sample of N consumers takes the form

$$\ln L = \sum_{i-1}^{N} d^{YY} \ln\left[1 - \Phi\left(\frac{B^u - \beta' x}{\sigma}\right)\right] + d^{YN} \ln\left[1 - \Phi\left(\frac{B^u - \beta' x}{\sigma}\right) - \Phi\left(\frac{B_i - \beta' x}{\sigma}\right)\right] + d^{NY} \ln\left[1 - \Phi\left(\frac{B_i - \beta' x}{\sigma}\right) - \Phi\left(\frac{B^d - \beta' x}{\sigma}\right)\right] + d^{NN} \ln\left[\Phi\left(\frac{B^d - \beta' x}{\sigma}\right)\right] \quad \ldots.. (5)$$

Whereas B_i is the initial bid, B^u is the upper bid, B^d is the lower bid, d_i^{YY}, d_i^{YN}, d_i^{NY} and d_i^{NN} are binary variables, with 1 denoting the occurrence of that particular outcome and 0 otherwise. The parameter σ is the standard error of the regression model that picks up the randomness in the offer function. The coefficient of the estimate β can be inferred as the marginal effect of the variable x on WTP. The mean WTP is acquired by appraising the projected coefficient at the variables mean values.

Interval Regression Model

The study has used interval regression to estimate the mean WTP and factors affecting on it. The interval regression requires two outcome variables, the lower limit of the interval (B^d) and the upper limit of the interval (B^u). Stata 16.1 is software used to estimate the results.

III

RESULTS AND DISCUSSION

Farm Characteristics

The socio-economic characteristics of survey households indicated the Table 1. Out of surveyed households, 55 per cent of households from Gadag district, which represent a drought-prone rainfed agro-environment, and 45 per cent of farmers from Dharwad district, which is assured rainfall agro-environment. The mean age of the household head was 48.81 years old, with a minimum age was 21 years. Male-headed households were 98 per cent, indicating a male dominance hierarchy. The average household consisted of 6.96 persons. Regarding caste, 33 per cent of the household belongs to the general caste, while 57 per cent represents other backward castes, remaining from the scheduled tribe and scheduled caste. The average education of the household head was 6.74 years representing the secondary level of education. Farming was the primary occupation for almost 97 per cent of households, indicating complete dependence on agriculture for livelihood. The average farm size was 5.74 ha which comes under the medium farm size category. The average land allocated to maize (2.79 ha) 48.60 per cent of the total land suggested the importance of the maize crop in the surveyed region. An average of 1 ha of the land was taken by 22 per cent of households as leased-in land.

Seed is one of the important inputs that must be easy to access at the right time and in required quantity. Dealer is a major source of seed, 69 per cent of households purchased seed from dealers, 27 per cent of households purchased from Raithu Samparka Kendra (RSK), followed by 1.11 per cent from agricultural universities and the rest purchased from co-operative society, NGOs, friends/relatives. RSK was introduced by the Government of Karnataka under the Ministry of Agriculture and Co-operation during 2000-01 to provide effective agricultural extension services to the farmers to adopt the latest agricultural technologies. The social group differentiated the subsidy – a general caste farmer was provided with a subsidy of ₹ 20/kg while

TABLE 1: DESCRIPTIVE STATISTICS OF FARMERS IN STUDY LOCATIONS

Variables	Overall sample N (180)			
	Mean	Std. Dev.	Min	Max
(1)	(2)	(3)	(4)	(5)
District (Gadag=1, otherwise=0)	0.55	0.50	0	1
Age of household head (years)	48.81	13.01	21.00	80.00
Sex of the household head (Male=1, otherwise=0)	0.98	0.13	0.00	1.00
Household size (No)	6.96	4.20	2.00	33.00
Caste (General=1, otherwise=0)	0.33	0.47	0.00	1.00
Caste (OBC=1, otherwise 0)	0.57	0.49	0.00	1.00
Education (years)	6.74	4.85	0.00	17.00
Occupation of the household head (Farming=1, otherwise=0)	0.97	0.16	0	1
Farm size (ha)	5.74	6.03	0.40	29.15
Maize cultivated area (ha)	2.79	3.54	0.20	23.48
Leased-in land (yes=1, otherwise=0)	0.22	0.42	0.00	1.00
Household associated with any group (yes=1)	0.40	0.49	0.00	1.00
Source of seed (If purchase from dealer=1, otherwise=0)	0.69	0.46	0.00	1.00
Source of seed (If purchase from RSK=1, otherwise=0)	0.27	0.44	0.00	1.00
Method of sowing (dibbling=1, otherwise=0)	0.54	0.50	0.00	1.00
Number of extensions visits per year	1.40	1.77	0.00	7.00
Seed shop distance from home (km)	8.85	5.47	0.00	25.00
Access to credit (yes=1, otherwise=0)	0.74	0.44	0.00	1.00
Field day participation (yes=1, otherwise=0)	0.17	0.37	0.00	1.00
Years of experience in maize cultivation (years)	10.78	6.68	1.00	40.00
Total livestock (numbers)	2.92	2.47	0.00	16.00
Frequency of occurrence of drought years (over 10 years)	2.33	1.24	0.00	4.00
Yield (quintal/ha)	30.61	19.73	0#	61.75
Price received (₹/quintal)	1399.19	344.97	0#	2040

Source: CIMMYT survey, March-April 2019.

Note: RSK- Raitha Samparka Kendra; # Indicates the complete crop loss due to moisture stress at the vegetative stage and pollination time; so not received any yield and income.

scheduled caste farmers were provided with a subsidy of ₹ 30/kg. The price range was observed from ₹ 80/kg to ₹ 360/kg in the study area, influenced by the type of hybrid and its brand. Most farmers were unaware of the type of hybrids like single-cross, double-cross, and three-way cross. Single-cross hybrids are costlier than other types of hybrids. The marginal and small farmers were attracted to cheaper hybrids, but experienced and rich maize farmers preferred single cross hybrids for their higher productivity attributes. Other factors also come into play with the RSK, like distance from villages to RSK. Sometimes farmers have to make double trips to get the improved seeds from RSK, if the seed is not available in time. The high transportation cost per unit affects the decision on the sources of seeds and other inputs from RSK or nearby dealers. Dibbling sowing method was followed by 54 per cent of farmers, 39 per cent of farmers used a tractor-drawn-seed drill, and only 6 per cent of farmers practiced bullock-drawn seed drill methods. Seed shop distance from farmers' homes was an average of 8.85 km to a maximum of 25 km reported by farmers. Depending upon the rapport between farmers and dealers, the mode of payment takes place. Nearby dealers also provide 2-3 months' credit period to farmers and act as key sources of information for farmers. The average number of extension visits of farmers to

sources of information was only 1.40/year. Only 40 per cent of the households were connected with farmer's groups or co-operatives, and 74 per cent of farm households had access to credit services. Seed companies conducted field demonstrations to show the performance of hybrid in the location, but only 17 per cent of households participated.

The mean years of experience of maize is 10.78 years which ranges from 1 to 40 years. Some farmers started adopting maize because of less water availability. The total number of livestock consisted of 2.92 per household, with a maximum extended up to 40. The mean frequency of drought years was 2.27 years over ten years, but drought has occurred 3-4 times over ten years in stress-prone districts like Gadag. The average yield was 30.61quintals/ha. The central government declared a minimum support price for maize at ₹ 1700/quintal in 2018-19. But the average price received by farmers was ₹ 1399/quintal, partly because almost 100 per cent of farmers sold maize produce from their farm gate or home. Although prices are higher in a regulated market, they prefer to sell at their farm gate to mitigate the additional costs of transportation, loading/unloading charges, and the commission or market fees for selling in the regulated market.

Farmer's Willingness to Pay and Determinants

Of the surveyed farmers, 66 per cent were willing to buy stress-resilient maize hybrids at a premium price. However, 34 per cent of farmers rejected the first bid of seed packet price. Out of that 34 per cent of farmers, 74 per cent were willing to buy this hybrid after the discount on the first bid price, whereas 23 per cent were not willing to buy it as they were comfortable with their present hybrid, or they might be late adopters. As this is a new hybrid, the farmers who rejected the first bid wished to know the seed's performance in the field, indicating that they might adopt the new hybrid at the first bid price if they liked the performance. Subsequently, primary bid rejecters were provided with a discount, extending from 5 to 35 per cent of the price of the first bid. These farmers were ready to pay a premium price after seeing the performance of the new hybrid in the field.

The interval regression model is used to estimate the willingness to pay for the stress-resilient maize hybrid presented in Table 2. The mean willingness to pay for SR hybrid is ₹ 1250.90/4 kg seed bag (₹ 312.76/kg). Farmers had paid ₹ 912.83/4 kg seed packet (₹ 228.20/kg) for the conventional hybrids in the market, including triple, double, and single-crossed maize varieties. Farmers are willing to pay a 37.03 per cent premium price (₹ 84.52/kg) for the stress-resilient maize hybrid compared to the farmers who paid for conventional hybrids in the market. A similar type of study on WTP indicated that, farmers in Zimbabwe, WTP a premium of 2.56 times for an additional tonne of yield per acre for drought tolerant maize hybrid (Kassie *et al*. 2017). Consumer WTP was 13.8 per cent higher than the average price of non-genetically modified (GM) maize meal for genetically modified food in Kenya (Kimenju and De Groote, 2008).

TABLE 2. WILLINGNESS TO PAY AND SOCIO-ECONOMIC DETERMINANTS: INTERVAL REGRESSION ESTIMATES

Variables (1)	Coeff. (2)	Robust Std. Err. (3)
Age of household head (years)	2.75	3.12
Caste of household (General=1)	80.60	88.96
Education of household head (years)	11.12	8.69
Household associated with any group (yes=1)	-3.02	82.71
Proportionate of maize area (per cent)	5.18***	1.43
Leased-in land (yes=1)	-33.62	85.91
Source of seed purchased (dealers=1, otherwise=0)	124.30	79.90
Source of seed purchased (RSK=1, otherwise=0)	-158.38*	88.73
Method of seed sowing (dibbling=1, otherwise=0)	152.26**	78.74
Access to credit (yes=1, otherwise=0)	245.17***	79.35
Number of extensions visits per year	-39.31**	22.50
Field day participation (yes=1, otherwise=0)	197.89*	114.06
Distance to seed shop from home (km)	-5.00	6.83
Frequency of occurrence of drought years (over 10 years)		
1 year (time)	94.93	132.64
2 years (times)	256.53**	130.63
3 years (times)	301.62**	155.40
4 years (times)	135.30	140.60
Total livestock owned by household (numbers)	45.29**	17.81
Experience in maize cultivation (years)	8.72	6.31
District (Gadag=1)	-52.11	99.05
Constant	88.86	289.23
/lnsigma	5.85***	0.09
Sigma	347.31	31.75
Log-likelihood	-140.42	-
Wald chi2(20)	85.87	-
Prob > chi2	0.000***	-
Estimated mean WTP (₹/4kg bag)	1250.90	-

Note: ***, **, * indicates statistically significant at the 1 per cent, 5 per cent and 10 per cent respectively.

The determinants affecting willingness to pay are summarised in Table 2. The model estimated that, out of a total of twenty variables, nine significantly influenced he WTP for a new stress-resilient maize hybrid. The proportion of maize area positively and significantly affected the WTP price. A higher proportion of total cultivated land being dedicated to maize growing was a strong positive factor for WTP for abiotic stress-resilient maize hybrids. The farmers who allocated more land to maize growing were willing to pay more than the farmers who allocated low acreage to maize for stress-resilient maize hybrids. Previous studies also showed a positive relationship between land and farmers' WTP for agricultural technologies (Krishna and Qaim, 2007; Gulati and Rai, 2015) and found that wealthier farmers are willing to pay a relatively higher premium for innovative technologies. The source of seed purchased from RSK was negative but significantly influenced the WTP. The farmer, who bought the seed from RSK, is expecting to subsidise the seed and is willing to pay less price as compared to the farmers who purchased the seed from other sources like dealers, NGOs, friends/relatives, etc. Farmers who purchased seeds from dealers were ready to

pay ₹158.38 premium price to SR maize hybrids than farmers who purchased seed from RSK. The SR maize hybrid was not yet listed in the RSK for distributing the maize hybrids. As per the company representative, the company is following the procedure to enrol stress-resilient maize hybrid in the RSK-listed maize hybrids. In Kenya, seed companies have started marketing their seed using novel packaging features to emphasise on product quality and authenticity. With concerns raised about poor seed quality and outright fraud in seed quality, farmers in Kenya WTP 15 per cent premium per bag for quality seeds directly purchased from seed company compared to local retailers (Gharib *et al.,* 2021). The method of sowing was also a major factor which influenced the WTP. Farmers who followed the dibbling method of sowing are willing to pay ₹ 152.26 more than those who followed sowing by bullock and tractor-drawn seed drill. In the dibbling method, proper distance and seed sowing depth was followed by the farmers. As a result, less seed is required, and proper germination leads to the healthy vigour of the crop. Farmers' WTP for stress-resilient hybrids increases with an increase in access to finances, as it improves the liquidity of the farm households in rural areas. Farmers with access to credit are willing to pay ₹ 245.17 premium price than farmers who do not have access to credit. The previous review of literature reported that access to credit is directly associated with the adoption of any new technology (Malek *et al*., 2017; Bernard and Spielman, 2009; Hansen *et al*., 2015; Makate and Makate 2019), a result confirmed by our study which shows that access to credit increases the WTP a premium price for a stress-tolerant hybrid. The number of extensions visit by farmers was significant but negatively associated with the likelihood of WTP for the new stress-resilient maize hybrid. Karnataka is one of India's states, where almost 100 per cent of farmers adopted hybrid maize varieties (FICCI, 2018). In such cases, extension officers/agencies promoted high-yield hybrid varieties. As this is a new hybrid, awareness about the new stress-resilient maize hybrid among farmers and extension officers should be popularised by different communication channels.

Field day participation was another most important variable, influencing significantly and positively on WTP. Seeing is believing is the concept of onsite demonstration. The involvement of farmers in the field-day participation leads to an increase in the awareness, and are willing to pay ₹ 197.89 premium price as compared to farmers who did not attend field-day demonstration in the study area. The frequency of drought years was another important climatic factor driving' farmer's WTP, and our results show a positive and statistically significant relationship between the number of drought years and WTP. Farmers who experienced drought two and three times over the last ten years, WTP was ₹ 256.53 and 301.62 premium price for SR hybrids as compared to the farmers who have not experienced drought, respectively. Livestock raising is one of the complementary businesses farmers prefer with agriculture. Farmers with more numbers of livestock, WTP ₹ 45.29 premium price over the farmers with a low number of livestock. SR hybrids deliver better yield and fodder than conventional hybrids, which is helpful to cope with fodder shortages in bad weather

year. Years of experience in maize cultivation positively influence the WTP because with more experience farmers become more comfortable paying a premium price for SR hybrids.

Heterogeneous Demand for SR Hybrids

The heterogeneous demand for SR hybrids with respect to caste, sources of seed and experience of maize cultivation is presented in Table 3. Significant difference has been observed between the general and OBC caste of the household. General caste household farmers are willing to pay ₹ 72.94 more than the WTP of OBC farmers which is significant at 10 per cent level. SC-ST farmers WTP 76.86 less than the general caste farmers but the difference is not significant. Adoption of any variety and the price paid to the variety are determined by sources of seed from where farmers purchased seed. As the subsidized seed is provided in RSK, farmers' WTP for SR hybrids was ₹ 983.36/4 kg of seed bag as compared to other sources of seed. Farmers believe in the extension services and the product delivered by agricultural universities to them. Significant differences were observed in WTP if seeds were purchased from RSK and agricultural university. Farmers are willing to pay premium prices of ₹ 1316.00/4kg of seed bag for SR hybrids if produced and purchased from agricultural universities as compared to RSK. Dealers were the most preferred sources of information and for purchasing inputs by farmers. Significant differences were observed in WTP for SR hybrids in sources of seed purchased from RSK and from dealers. Farmers are ready to pay premium prices of ₹ 1332.78/4 kg of seed bag to purchase SR hybrid seed from dealers.

TABLE 3. HETEROGENEOUS DEMAND FOR STRESS-RESILIENT MAIZE HYBRID

(1)	WTP (2)	SD (3)	Diff# between groups (4)
Caste oh household			
General	1300.25	234.05	-
OBC	1228.20	277.26	72.04*
SC-ST	1219.04	367.21	81.21
Sources of seed			
Seed purchased from RSK	983.36	235.14	-
Seed purchased from agricultural university	1316.00	295.2	332.65***
Seed purchased from dealers	1332.78	241.19	349.24***
Experience of maize cultivation			
Experience <=5 years	1151.45	320.58	-
Experience 6 to 10 years	1222.21	262.61	70.80
Experience 11 to 15 years	1303.30	228.12	151.90**
Experience >=16 years	1355.01	239.98	202.60***

***, **, indicates statistically significant at 1 and 5 per cent level, respectively.

Willingness to pay further break-up with respect to years of experience in maize cultivation. Farmers with experience of 5 years and 6-10 years, WTP ₹ 1151.45 and ₹1222.21/seed bag, but the difference is not significant. Significant differences were

observed among the farmers with maize cultivation experiences of 11 to 15 years and more than or equal to 16 years, WTP ₹ 151.90 (significant at 5 per cent) and ₹ 202.60 (significant at 1 per cent) more prices as compared to farmers up to 5 years of experience, respectively. Also, 11-15 years of experience in maize farming, WTP ₹ 81.09 more premium prices as compared to 6-10 years of experience in maize farmers. It revealed that farmers with more than 15 years of maize cultivation experience have faced more drought years and its effects on yield loss, and it could be reasons for more experienced maize farmers WTP high premium prices to SR maize hybrid as compared to low experience maize farmers.

The demand curve for SR maize hybrid across sources of seed is presented in Figure 1, and years of maize cultivation is presented in Figure 2. Overall, all demand curves are elastic, but the source of seed of RSK and demand curve for 5 years of maize experience were more elastic than other groups. Private sector is dominating in the maize seed market in India. Moreover, a willingness to pay and differential demand curves could be useful for the private sector to decide seed price and to quantify the potential market for stress-resilient maize hybrid in the maize dominating agroecology.

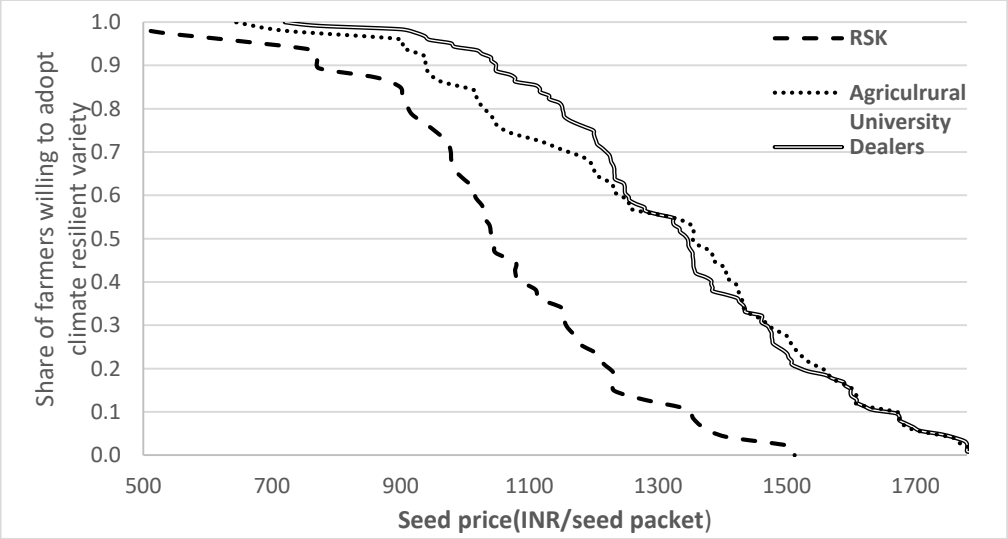

Figure 1. Estimated Demand Curve at Various Sources of Seed

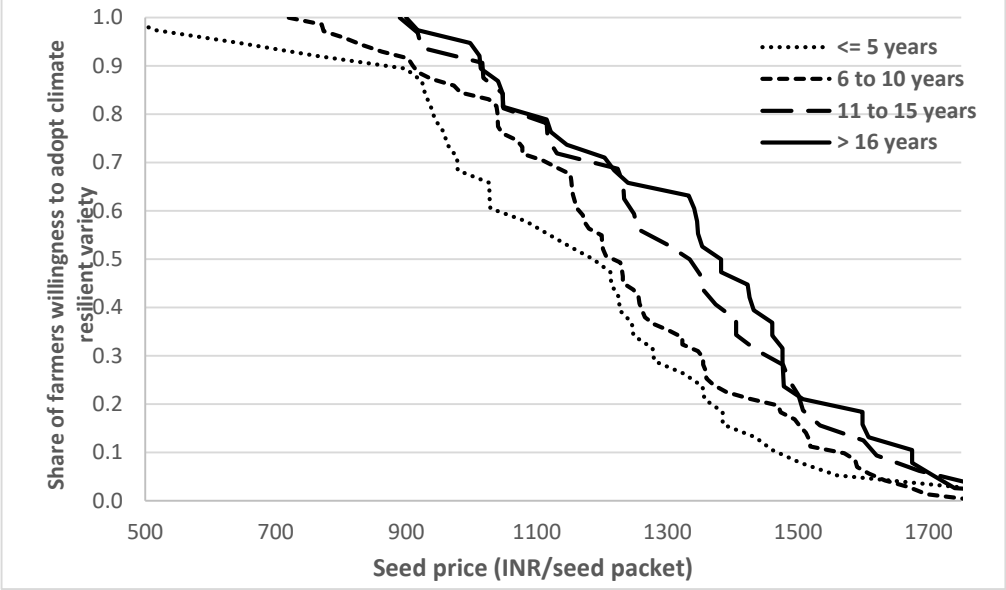

Figure 2. Estimated Demand Curve with respect to Years of Maize Cultivation

IV

CONCLUSION

Drought and heat-associated stress will continue in the future, impacting rain-fed maize-based livelihood systems and affecting the production and income of maize farmers. Therefore, the development and deployment of stress-resilient maize hybrids that reduce the vulnerability of marginal farmers are crucial. Most of the maize hybrids targeted optimal environmental conditions and rain-fed maize are neglected by private seed companies, whereas public research institutions focus on negated areas. The rainy season is the only season for the rain-fed maize and fodder production system. If a farmer loses income because of climate shock, they have to wait for the next season and depend on support from the government or borrow money from money lenders for survival. Stress-resilient maize hybrids are able to give a cushion to farmers by providing minimum yields and income in adverse conditions.

Price is an important criterion in the selection of a maize variety by farmers and also affects the rate of adoption of particular hybrids on the ground level. So, it is important to analyse what price farmers are willing to pay for a stress-resilient maize hybrid if deployed in the maize market. The study employed a double-bounded dichotomous choice model to estimate WTP. It was found that 66 per cent of farmers were willing to pay a premium price for stress-resilient maize hybrids in Karnataka. The mean WTP with explanatory variables was ₹ 1250.90/4kg of packaging size (₹ 312.76/kg), which was ₹84.52/kg more than the existing price of non-stress resilient

maize hybrids in the market. Awareness of farmers about different traits of the hybrids was the crucial positive influencing factor for any maize varietal adoption. The proportion of maize area (per cent), sources of seed purchased, method of sowing, access to credit, number of extension visits, field-day participation, the occurrence of drought frequency and total livestock numbers were significantly affecting WTP of SR hybrids. Access to credit was an important determining factor for WTP for new hybrids. Without access to credit, no technology would be adopted on the ground. It is best suitable for crop diversification in the mono-cropping region. Extension activities must be designed innovatively to speed up the awareness and adoption of stress-resilient hybrids in identified stress-prone environments. Like RSK, the subsidy should be provided by the state agriculture department on stress-resilient seeds to farmers in highly vulnerable districts to the stress-prone environment. Obviously, yield is an important trait in optimal conditions, but in a resource-poor environment, sustainable yield or income is more important than fluctuating yield to support livelihood, which will be deliverable through the deployment of abiotic stress-tolerant hybrids.

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