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Prospects of Mungbean as an Additional Crop in Rice Wheat System of Punjab Pakistan

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Abstract Mungbean is a beneficial as well as crucial pulse crop which has high economical and commercial values widely grown in Asia. It is cheap source of dietary protein, iron and minerals. It belongs to family Leguminosae and is valuable grain legume which comprises major portion of proteins, minerals, vitamins and essential amino acid. In Pakistan it ranks second in Pulses production after Chickpea. Mungbean suffers from several diseases due lack of good cultural practices and insight about the genome of this crop. These diseases caused by fungus, bacterium and viruses. Major diseases including Yellow Mosaic disease (YMD), Urdbean leaf crinkle disease (ULCD), Cercospora leaf spot disease (CLSD) and were caused by yellow mosaic virus, *Cercospora canesens* and Urdbean leaf crinkle virus respectively. Annually, 40-80% grain yield losses were caused due to these diseases. To overcome these threats scientists/researchers are using approaches to develop resistant and high yielding Mungbean genotypes/cultivars. The area under Mungbean cultivation is decreasing day by day because most of varieties were matured at 100 to 120 days which were not suitable in our cropping pattern. There is a dire need to develop those varieties having high yield, resistant to diseases and insect pest, early and synchronize maturity (60-80 days).

Keywords Scenarios, Mungbean, Supplementary Crop, Rice-Wheat, Punjab Cropping Patterns

1. Introduction

Pulses area is continuously decreasing as pulses are unable to contest with major crops like wheat, cotton, sugarcane and rice. In pulses, Mungbean area has been decreased from 237,000 ha in 2002-03 to 118,000 ha in 2017-18. This decline is mainly due to replacement of Mungbean with Bt- cotton in chief Mungbean cultivating areas like; Bhakkar, Layyah and Mianwali districts. Now there is dire need to find out new niches for Mungbean cultivation. Rice wheat cropping system is a major cropping system of the Punjab, mainly in rice growing areas comprising of Sialkot, Gujranwala, Sheikhupura, Hafizabad, Okara, Nankana Sahib, Narowal, Mandi Bahauddin, Kasur, Jhang etc districts covering about 1.4 million ha which is about 30% of Punjab Thal area. Wheat is harvested during the last fortnight of April and the land remains vacant to the start of July till the transplanting of rice crop. In addition to that, both the crops are exhaustive in nature and results in soil nutrient depletion hence lowering the yield of both crops. There is a scope of sowing Mungbean as a catch crop from mid-April till the 1st week of July. This will not only provide additional income to the farmers but owing to its nitrogen fixing ability will recover the soil fertility status of soil resulting in higher yield of both rice and wheat. Only if 25% of the rice wheat area of Punjab is brought under Mungbean catch crop, it can result in 427850 ha increase in area and 213925 tons increase in production which is 272% more than the current production level. This can not only help in attaining self-sufficiency in pulses but also improving quality of food by cereal pulses combination. The major issues which can curtail the popularization of Mungbean cultivation in rice wheat system as a catch crop are:

- Long maturity duration of current Mungbean varieties.
- Mungbean yellow mosaic virus (MYMV)
- Urdbean leaf crinkle virus (ULCV)
- Cercospora leaf spot disease (CLS)

As a good feature of its short duration and its ability to adopt in multiple sowing seasons Mungbean can fit very well in spacious display of niches space in the prevailing crop rotation. An additional crop of Mungbean can be assimilated in the un-cultivated period (May-June) after wheat harvest and before rice or maize plantation. In order to popularize Mungbean as an additional crop in between wheat and rice, early maturing (60 days) are required. The

local Mungbean lines do not appropriate in the above niche due to their late maturity and are sternly affected by heat stressed in May-June and monsoon rains at harvesting if sown after wheat harvest. They also suffer from excessive growth and asynchronous maturity. If we succeeded in the development of short duration heat tolerant varieties of Mungbean it will be a major breakthrough to intensification in the outcome of the farmers and to enhance the soil fertility which ultimately enhance the production of both rice and wheat in these areas.

With the development of very early maturing (60 days), MYMD, CLS and LCD tolerant and synchronous maturing variety, it may become possible to grow Mungbean as a catch crop in Rice-Wheat cropping system of Punjab. Sowing of catch crop of Mungbean besides providing enough net cash returns over variable cost also add sufficient nitrogen (37 kg ha^{-1}) by which 25 percent nitrogen (N) is saved for the subsequent crop (Sekhon *et al., (2007)*.

In Pakistan, research work on Mungbean is mainly focused on the development of high yielding, disease resistant, large seeded and short duration varieties Patel (2011). There is an increase in yield per hectare from 477 kg ha^{-1} (2001-02) to 793 kg ha^{-1} but still a large gap exists between varietal potential and farmer's yield which needs to be fulfilled. Mungbean crop is exaggerated by numerous biotic and abiotic stresses. Habib *et al*., (2007) described that the vulnerability of Mungbean varieties to diseases and insect pests is the major cause of their low yield in Pakistan. Heavy losses under epiphytotic conditions have also been observed. A significant reduction in plant height (18.5 to 40.5%), number of pods per plant (11.7 to 64.0%), seeds per pod (5.8 to 82.2%), pod length (7.4 to 35.0%), 1000-seed weight (10.6 to 53.3%) and grain yield per plant (32.2 to 78.6%) due to MYMV disease has been observed (Khatak *et al*., 2000a).

2. Mungbean Growing Areas

Mungbean is a traditional pulse crop of Pakistan having 25% protein. Among the four provinces of Pakistan, Punjab is the major Mungbean-growing province that un-aided donates 86 and 87 % of area and production, respectively (Anonymous, 2012-13). Seed yield of Mungbean per acre is very low which is due to low varietal potential along with poor management practices. Contrary to the other major crops, Mungbean can be efficaciously cultivated on marginal lands with low inputs. It is the second major pulse crop in these areas. Major production area comprises the southern part of the Punjab province especially Bhakkar, Layyah and Mianwali Districts.

In Punjab; Gujranwala, Sialkot, Sheikhupura, Hafizabad, Okara, Nankana Sahib, Jhang, Narowal, Mundi Bahauddin and Kasur are the major rice growing districts. In Punjab rice has been grown on an area of 1711.4 thousand hectares, which account 74% of Pakistan rice area (Anonymous 2012-13). Rice-Wheat cropping system delivers constant productivity and better income to the farmers. In addition, this system facilitated greatly in industrial expansion, employment facilities and economic growth of the country. Though, it is prompting solemn problems like absolute fall in water table, more swarm by diseases and insect pests and exhaustion of soil fertility etc. According to an estimate, Rice-Wheat system can eliminate more than 650 kg ha^{-1} nitrogen and phosphorus because this system observed to be highly exhaustive (Shah *et al*., 2011). Depletion of soil nutrients observed to be occurs in Rice-Wheat system and in long term productivity was also observed to be affected. In addition to that such a system results in negative nitrogen balance in the soil although all the crops grown under this system have been provided with recommended doses of fertilizer (Shah *et al*., 2003). To combat soil nutrient problems farmers used chemical fertilizers which are highly expensive. The application of expensive fertilizers is not possible in developing countries. Wheat is harvested during the month of April and the land remains vacant from end of April to mid of July till the transplanting of rice crop. In addition to that both cereal crops have been continuously grown in these districts year after year and no other rotation has been practiced, which is very dangerous for soil fertility and may be the major reason of soil nutrients depletion. Incorporation of a leguminous crop in Rice-Wheat system helps in maintaining the N level of soil. It also improves mineralized N contents of soil and organic carbon (Shah *et al*., 2003; Shafi *et al*., 2007; Abbasi *et al*., 2009 and Bukht *et al*., 2009). To fill the gap between wheat harvesting and rice transplanting and to enhance the nutrients status of the soil there is a dire need to grow some leguminous crop on that area during the month of April-June which may increase soil fertility through biological nitrogen fixation and help to increase organic matter of the soil in addition to the extra income. Positive impact of inclusion of summer legumes (Mungbean) in Rice-Wheat System was observed in Pakistan (Mann, 2000). Legumes contribute substantially to paddy yield straw and nitrogen status of soil.

3. Major Yield Limiting Factors

Any disturbance in the metabolic processes caused by various biotic and abiotic stresses confronted by the plant may lessen the actual yield. The harshness of various anxieties is basically due to wobble weather conditions that triumph year after year, thus decreasing pulses yield at farmer's field and potential yield. Low yielding cultivars and susceptibility to diseases i.e. Mungbean Yellow Mosaic Disease (MYMD), Cercospora Leaf Spot (CLS) and Urdbean Leaf Crinkle Disease (ULCD) which are the major diseases of Mungbean particularly.

MYMD transmitted by white fly (*Bemisia tabaci Genn*.) is the foremost limitation causing low seed yield. White fly persistently transmits Mungbean yellow mosaic virus (MYMV) and infects all growth stages of Mungbean (Honda and Ikegami, 1986). Among the viral diseases, Mungbean yellow mosaic virus is very devastating in Pakistan particularly in summer season. The disease is characterized by the manifestation of yellow flecks or dots on young leaves and the auspicious trifoliate leaves evident uneven yellow and green patches causing reduction in leaf size. In severe cases there is complete yellowing of leaves followed by stunted growth, few flowers and pods with shriveled seeds. Disease incidence ranges between 30-100% causing yield losses that range between 60-80%, depending upon the disease severity and the crop stage at which plants get infected. The incidence of MYMV has been detected and identified in commercial plots of Mungbean in Pakistan and range from 4 to 40% depending upon crop variety and location in Pakistan have been reported (Bashir *et al*., 2006). However, in naturally infected susceptible cultivars it varies with the time of infection and yield losses may reach up to 100% (complete crop failure). Apart from Pakistan MYMD is the crucial hazard to Mungbean production in India, Sri Lanka, Bangladesh, Papua New Guinea, Philippines and Thailand (Honda *et al*., 1983; Chenulu & Verma, 1988; Malik & Bashir, 1992; Jones *et al.,* 2003) and inflicts heavy yields losses annually. MYMD is caused by Mungbean yellow mosaic begomoviruses belonging to family Geminiviridae. Like other begomoviruses its viral particles are isometric and germinate having 18 to 30nm in size with two single stranded DNA molecules (DNA A & DNA B) of 2726 and 2775 nucleotides, respectively (Bos, 1999 and Hull, 2004). This virus is spread by whitefly (*Bemisia tabaci* Genn) and through grafting but not through seed, sap and soil (Nair and Nene, 1973 and Bashir 2003). Mungbean Yellow Mosaic Virus (MYMV) may render a resistant variety to become susceptible to some extent after a certain period when new viral strains are produced. Thus, varieties generally appear to be resistant or tolerant at one location may show susceptible behavior at another location. It has been noted that a single recessive gene is responsible for MYMV resistance in Mungbean Sehrawat *et al.,* (2015). The expression of major gene responsible for MYMV resistance/susceptibility was affected by modifying genes which were also found to be equally responsible for the inheritance of MYMV (Khattak *et al*. 2000b and Akhtar *et al.,* 2016).

The pathogen resources of MYMV resistance have not been identified. However, Vigna species isolates MYMV were used to evaluate and distinguish the susceptibility reaction against the disease (Sudha *et al.,* 2014). The disease occurs over a wide range of climatic conditions in summer and the resistance against this disease was found to be scarce in Mungbean germplasm (Shad *et al*. 2006). Incorporation of resistant genes in the present cultivars is the only practical way to control viral diseases (Bashir *et al*., 2006) and diminishes heavy yields losses annually. Initially the disease appears as small yellow spots along the veins on young leaves and then spread over the leaves. Under severe infection, the characteristic symptoms include yellowing or chlorosis of entire leaf on whole plant followed by necrosis, shortening of internodes, severe stunting of plants with no yield or few flowers & deformed pods producing small, juvenile and shriveled seeds (Akhtar & Haq, 2003; Bashir *et al*., 2006 and Akhtar *et al*, 2009).

Cercospora Leaf Spot (CLS), a fungal disease caused by *Cercospora canesens* is distributed by spores of infected leaves. Characteristic symptoms include leaf spots with brown to greyish center and reddish-brown border. This is an imperative disease of Mungbean and is usually occurs in severe form, causing heavy yield losses. Cercospora Leaf Spot causes severe yield losses to Mungbean; upto 23% and 47% and is a serious disease in Mungbean growing areas of Pakistan especially where high humidity prevails. During rainy season hot and humid conditions are favorable to encounter this disease. It starts appearing after 35 days of planting, spreads rapidly depending on the humidity during growing season and causes premature defoliation of pods and grains. Severe leaf spotting and defoliation arises at the time of flowering and pod formation under conditions favorable for this disease (Bashir & Zubair, 1985).

Leaf crinkle disease (LCD) originated by Urdbean Leaf Crinkle Virus (ULCV) is a very serious disease, widely distributed in Pakistan (Bashir & Zubair, 1985). In Pakistan, 35% to 81% grain yield losses due to ULCV has been reported, depending on genotype and time of infection (Bashir *et al*., 1991).The virus has been reported to be transmitted by Aphid species (*Aphis craccivora* and *A. gossypii*), whitefly (*Bemisia tabaci*) and leaf hoppers (Narayansamy & Jaganthan 1973).The disease starts appearing within 5 weeks after sowing and is characterized by crumpling, curling and wrinkling of leaves often tied with stunting and irregularity of floral organs. Improvements in size trail by crinkle surface of lamina are the distinctive symptoms on affected trifoliate leaves. Pollen production, fertility and consequent pod formation is sternly reduced thus affecting seed weight and size of seeds in infected plants primary to decrease in yield.

Mungbean crop may be sown in the 1st week of May after harvest of wheat and harvested 60 days after sowing to ensure timely plantation of rice crop. Limited availability of short duration, photoperiod insensitive and heat tolerant cultivars limits the adoption of this practice, so during the development of new Mungbean genotypes for rice wheat system, these factors must be given due consideration. Although current Mungbean varieties have the ability to produce good yield (Table 1) when Mungbean is sown as catch crop in between wheat and rice crops. The main problem of popularizing this crop is maturity duration of current varieties like MN-2011 and

AZRI M-2006, which take about 70-75 days to mature.

Table 1. Yield data of Mungbean catch crop trials conducted at farmers field in Rice Wheat cropping system conducted under AIP-AVRDC Project.

Year	Location	Area planted (ha)	Variety	Yield (kg/ha)
2015	Chandikot	4.25	NM-2011	1170
	Farooqabad	1.62		1297
2014	Chandikot	31.2	AZRI M-06	1500
	Farooqabad	3.80		510

4. Synchronous Maturity

For finding good yield of catch crop of Mungbean synchronous maturity is compulsory along with early maturity. Earlier quite a few researchers detailed positive effect of synchronous pod maturity in seed yield (Pierre *et al*., 2003; Hamid *et al*., 2004 and Chen *at al*., 2008). Stimulation of flowering and synchronous renovation from vegetative phase to the floral opening is an imperative stage of synchronous maturity (Corbesier *et al*., 2003).

The time of pod maturation is a vital feature in the synchronous pod maturation and in classification on the degree of indetermination of growth period may simplify to approve suitable and well-organized plant breeding approaches to develop high yielding Mungbean genotypes with synchronous growth pattern (Shgarma-Natu & Ghildiyal, 2005). The term degree of indetermination has been used to exemplify modification from days to first flowering (D_1) to 90% pod maturity (D_3) in Mungbean (*Vigna radiata* L. Wilczek) (Khattak *et al*., 2001). In spite of the position of synchronous maturity, Mungbean pod ripening is not synchronous (Yeates *et al*., 2000), irregular pod maturity primes to low yield and low harvest index (HI) in Mungbean (Bushby & Lawn, 1992 and Egli & Bruening, 2006). A high harvest index means high percentage of seed yield in total biomass production. Thus, in order to increase the seed yield, selection of higher harvest index genotypes could be accomplished through synchronous maturity. The contrary possessions on seed yield due to high leafiness and synchronous flowering have been observed (Bisht *et al*., 1998 & 2005). Cultivation of Mungbean in fallow period between wheat and rice crop pledges a good backup of worth Rs. 30,000 to 40,000 per acre by investing a little amount on seed and irrigation. Growing of Mungbean also improves fertility status of soil and increases yield of the succeeding crops.

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