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Research Article

Population density of wheat aphid and its natural predators on different wheat varieties planting at different times under ecological zone Sheikhupura, Punjab, Pakistan

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Abstract

Three year field experiments were conducted to study the population density of wheat aphid and their beneficial fauna on different wheat varieties planted at different times at Adaptive Research Farm Sheikhupura, Pakistan in rice wheat cropping system. The experiment was laid out in split plot design in which varieties were replicated thrice in each planting date. Data for aphid population their predators, meteorological data, yield parameters and grain yield under different planting dates were recorded. Three years results revealed that in this ecological zone for wheat crop the planting dates 10th to 30th November performed better with respect to less attack of aphids, proper days required for maturity, number of grains per spike, number of tillers per m^{-2}, thousand grains weight and grains yield. Late sown planting date causes reduction in yield due to reduce values of yield attributes and attack of aphid at growth stages while early sown date causes

reduction in yield due to loss of grains weight by aphid feeding as the climatic conditions favors the development of aphids.

Key words: Aphids; Planting dates; Varieties; Wheat; Yield

Introduction

Wheat (*Triticum aestivum L.*) being a most important crop, grown on the principal area in Pakistan and has an important role in financial strength of the country [1]. It is the most leading grain crop and staple food for the individuals of Pakistan [2]. More than 35 % of the global population consumed wheat as an essential food [3]. Several biotic and abiotic factors are responsible for low yield of wheat per hectare in Pakistan as matched to other countries of the world [4, 5]. Among insect pests of wheat, aphids are the major contributing factor in yield reduction in Pakistan. It is reported that about 35-40 % yield loss due to wheat aphid by sucking cell sap [6] and its population density depends on abiotic factors [7]. In Pakistan during February- March aphid population rises and at the same time its predator's population also increases depends upon the local climatic conditions [8].

[9] reported that among aphid species *Sitobion avenae* (English grains aphid), Green bug (*Rhopalosiphum padi*) and bird cherry oat aphid (*Schizaphis graminum*) are common in Pakistan

Aphids invade the crop at diverse growth steps and both the nymphs and adults suck cell sap thus reducing the vigor of the plants. Honey dew excretion is often productive and smutty moulds generally convoy aphid's invasion which ultimately affects the rate of photosynthesis in plants. Aphids reproduce very quickly under encouraging situations on stems, leaves and inflorescence. [10] described that aphids draw sap from shoots and leaves that result in distortion and chlorosis of leaves. Due to negative effect and over reliance of pesticides is prohibited in Pakistan, several cultural control measures like intercropping of canola/sarsoon lines balance use of NPK fertilizers are the common practices for control of aphids.

Choice of suitable planting date is dynamic to get high production due to dissimilarity among the weather situations [11]. In rice wheat cropping pattern sowing of wheat is becoming late due to which sustaining high yield is much challenging.

The production damages affected by any of the aphid species was in the range of 35- 40 percent at fifteen aphids per plant [12]. To stop heavy damages by aphids, numerous mechanisms have been developed containing physical chemical, biological, mechanical, cultural and host plant resistance. Pesticide treatment alone causes environment and health dangers in addition to pest resistance to chemicals due to their disproportionate and unselective uses. Studies on selection of different wheat genotypes for resistance against cereal aphids were conducted by various scientists; mainly the three principal aphid species, i.e. *Sitobion avenae*, *Rhopalosiphum. padi* and *Schizaphis graminum* [13]. Aphid predators including syrphid fly maggots, lacewings and lady beetles parasitize on all aphid species and are usually less discerning than parasitoids. Those flourish under high aphid densities and are therefore, not usually appropriate for use when aphid number is truncated [14]. Lady beetles are effective predators as those essential to consume many aphids per day for oviposition. Alternatively, Syrphid flies and its larvae are predaceous on aphids [15]. Additionally, Chrysopa spp (Neuroptera: Chrysopidae) are also insatiable predators of uncovered eggs and small larvae of all the aphids, mealy bugs and lepidopterous pests. It has a benefit above egg parasitoids that it nourishes on both larvae and eggs of pests and also its host range is considerable wider [13]. Intensity of aphids attack depends upon

the local climatic conditions and stage of the crop. Several control measures like chemical, cultural, biological have been reported for control of aphids in wheat.

To assess the population density of wheat aphids on different wheat varieties planting at different times may be helpful in managing wheat aphids by optimizing suitable planting time under ecological zone of Sheikhupura. No local data is accessible on handling aphid population in wheat crop through integration of planting date, so, the present study was directed to assess the outcome of planting dates on aphid invasions to circumvent recounted losses to grain yield in wheat. Traditional practices like alteration in sowing time may be helpful in supervision wheat aphids keeping in assessment the indigenous agro climatic situations.

This study designed at inspecting the population subtleties of wheat aphids under the naturally occurring natural control mediators and also dedicated on finest planting period under local agro-climatic conditions of Adaptive Research Farm, Sheikhupura, and Punjab, Pakistan.

Material and methods

Experiment was arranged in split plot design and comprised of five different varieties and five different sowing dates conducted for three consecutive years (2016-17, 2017-18 & 2018-19) during rabi season . There were five main plots of planting dates and 15 sub plots of different varieties in each main plot during each year of crop season. Varieties were replicated in each sowing date and distance between replication was 2.0 ft. during each year. Individual subplot 28.5 m^2 was maintained during each crop season. Total 15 subplots were maintained in one main plot (one planting date). At each sowing date, wheat seeds were disseminated by hand drill technique, using suggested seed rates (1^{st} to 20^{th} November, 1^{st} December and 11^{th} December planting dates, respectively). Standard agronomic practices were applied to raise uniformly the wheat crop grown on each sowing date. DAP (Diammonium phosphate; 46 percent phosphorus (P) and 18 percent nitrogen (N)) was applied as a basis of phosphorus. Urea (46 percent) was applied as a basis of N and MOP (60 %) was used as a basis of potash. All the application of potash and phosphorus were applied as basal at the time of sowing while N was applied in two equal breaches.

For statistics analysis, data was collected on aphid population and aphid infestation at 07 days interim at the appearance of aphid starting from 1^{st} week of February to end of March for the period of each crop season. There were eight counts regarding recordings of aphid populations of crop seasons 2016-17/2017-18/2018-19. During each specimen selection, ten wheat plants from each plot were arbitrarily selected. The number of aphids per tiller of each plant was documented as aphid density **[4, 16]**. Number of aphids at bottom, middle and top leaf of the infected tiller and natural enemies per 05 plants were counted. The regular antagonists connected with the cereal aphids were calculated on each sampling date and adults, pupae, larvae and eggs per five plants were taken into description for predators. All the dissimilar phases of the Chrysopa spp. (*Chrysoperla carnea*), Syrphid flies (*Ischiodon scutellaris*) and lady beetles (*Cocinela suptemntata*) were together measured and calculated as Chrysopa, Syrphid flies and ladybird beetles correspondingly.

At the time of maturity $1m^2$ areas from each plot was harvested and threshed for recording of grains yield. Data regarding relative humidity percent and temperature was recorded from the observatory on daily basis during the crop season. The parameters studied were exposed to analysis of variance and the means were related by the least substantial modification (LSD) at 0.05 probability level of significance **[17]**.

Results and discussion

Data regarding density of mean aphid population per tiller of three consecutive crop seasons (2016-17, 2017-18 & 2018-19) on five wheat varieties planted at five different times were presented in (Tables 1-5) which depict population dynamics of aphids in eight sampling counts in each planting date. It reveals that the aphids arrived in the 1st week of February (04/2) with mean population of three years 1.33, 1.13, 0.59, 0.19 & 0.28 aphids per tiller on the varieties Galaxy-2013, Faisalabad-2008, Ujala-2016, AARI-2011 and Punjab-2011 sown on planting dates 01 November ,11th November, 21st November, 1st December and 11th December respectively (Table 6). The population increased gradually till end February on the dates 1st November, 11th November and 11th December. Significant increase in aphid population was noted from 1st week of March to mid-March during each crop season. Peak aphids' population was recorded on all wheat varieties at all sowing dates during 1st and second week of March with 44.21, 41.99, 37.86, 35.26 and 40.13 aphids per tiller on five planting dates respectively (average of three consecutive years). A significantly high population of aphids per tiller was recorded on all varieties sown during 1st November and 11th December dates during each crop season. Decline in aphid population was noted during 4th week of March with a mean of 3.46, 1.86, 2.26, 2.86 & 6.51 aphids per tiller on all wheat varieties planted at different times and came to end during 1st week of April.

During the period 1st week to mid-February maximum aphids were counted on varieties planted during 1st November & 11th December during each crop season. The period where minimum population was counted on wheat varieties planted on 11th November, 20th November and 1st December. During the mid-February to last week of February maximum 16.0 and 14.23 aphids were counted on planting dates 1st November & 11th December and minimum 3.19 and 3.33 aphids per tiller was counted on Wheat varieties planted at 21st and 1st December sowing times. Similarly 1st week of March to mid-March and mid to last week of March high population of aphid was counted during each crop season on all planting dates. The population gradually increased and reached to its peak during the 2nd week of March, which slowly declined and came to an end during the 1st week of April. Two peaks of aphid was noted in whole crop season during each year of study period, highest population was noted from end February to March at temperature range from 18.11 to 22.54 ^{o}C and humidity from 68.6 to 52.1 %. The metrological data is given in (Table 7).

On average of three consecutive year of crop seasons data regarding varietal expression with respect to aphid infestation was presented in (Table 8) it depicts that maximum aphids per tillers were counted on varieties that planted on 1st November and 11th December while minimum aphids per tiller was counted on all varieties that planted during 11th November and 21st November (Table 8).

Keeping in view the sampling dates and different planting times that presented in (Table 9), it shows that data on average of three crop seasons among sampling dates peak aphid population was counted on sampling dates 25th Feb. and 18th March under all sowing dates , at this time the wheat crop under all sowing dates were at dissimilar periods. The huge number of aphid infestation happening during the 1st week of February which progressively increased with the somatic stage of the plants in all crops established at dissimilar sowing time.

Table 1. Comparison of mean aphid population per tiller on different wheat varieties planted on 1st November an average of consecutive three year 2016-19

Varieties	Number of aphid counts from February to end March at week interval							
	4/2	**11/2**	**18/2**	**25/2**	**4/3**	**11/3**	**18/3**	**25/3**
Galaxy 2013	0.66a	3.00b	4.66a	11.00a	10.33b	40.00a	48.33 ab	11.33a
Faisalabad 2008	1.33a	3.33ab	3.00b	11.00a	19.66a	47.66a	38.33b	1.33a
Ujala 2016	1.66a	5.00a	4.33ab	7.33a	14.00a b	43.33a	40.00ab	1.33a
AARI- 2011	1.00a	2.33b	3.66ab	8.33a	20.66a	49.00a	45.00ab	1.33a
Punjab 2011	2.00a	4.00ab	3.66ab	10.66a	19.66a	38.33a	50.00a	2.00a
LSD (p≤5%)	1.49	1.68	1.53	6.75	6.92	11.33	10.74	0.97

Table 2. Comparison of mean aphid population per tiller on different wheat varieties planted on 11th November an average of consecutive three year 2016-19

Varieties	Number of aphid counts from February to end March at week interval							
	4/2	**11/2**	**18/2**	**25/2**	**4/3**	**11/3**	**18/3**	**25/3**
Galaxy 2013	1.33a	2.00a	3.33a	5.66ab	13.33ab	34.00b	45.00a	2.33ab
Faisalabad 2008	1.00a	1.66a	4.00a	12.00a	11.00b	45.33a	36.66a	1.00c
Ujala 2016	0.66a	1.33a	4.66a	10.66ab	17.00 ab	39.66 ab	39.33a	3.00a
AARI- 2011	1.66a	1.66a	4.33a	4.66b	20.66a	33.33b	43.33a	1.66bc
Punjab 2011	1.00a	2.33a	5.66a	8.00ab	12.00b	41.00ab	45.66a	1.33bc
LSD (p≤5%)	1.55	1.43	3.48	6.42	7.41	10.59	1 6.64	1.16

Table 3. Comparison of mean aphid population per tiller on different wheat varieties planted on 21st November an average of consecutive three year 2016-19

Varieties	Number of aphid counts from February to end March at week interval							
	4/2	**11/2**	**18/2**	**25/2**	**4/3**	**11/3**	**18/3**	**25/3**
Galaxy 2013	0.66a	1.00b	1.66ab	3.00a	9.33b	45.00a	55.00a	2.66ab
Faisalabad 2008	0.33a	1.00b	2.00ab	3.00a	11.00b	30.33b	24.66b	1.33b
Ujala 2016	0.66a	1.00b	2.33ab	4.00a	16.33a	32.66b	32.66b	3.66a
AARI- 2011	1.00a	1.66ab	1.33b	3.33a	11.33b	21.33c	50.66a	2.33ab
Punjab 2011	0.33a	2.00a	3.00a	2.66a	6.00c	46.66a	26.33b	1.33b
LSD (p≤5%)	1.00	0.97	1.55	1.75	2.94	8.20	16.59	2.06

Table 4. Comparison of mean aphid population per tiller on different wheat varieties planted on 1st December an average of consecutive three year 2016-19

Varieties	Number of aphid counts from February to end March at week interval							
	4/2	**11/2**	**18/2**	**25/2**	**4/3**	**11/3**	**18/3**	**25/3**
Galaxy 2013	0.00a	1.66a	1.66a	4.33a	3.33d	64.66a	47.33a	5.00a
Faisalabad- 2008	0.33a	0.66b	0.66b	4.66a	8.66b	30.33b	25.66b	1.33b
Ujala 2016	0.33a	0.00c	1.00ab	3.00ab	7.00ab	17.33b	27.00b	5.33a
AARI- 2011	0.33a	1.00b	1.00ab	2.33b	6.00bc	25.00b	34.00ab	1.33b
Punjab 2011	0.00a	1.00b	0.66b	2.33b	4.33cd	85.00a	42.33ab	1.33b
LSD (p≤5%)	0.94	0.59	0.84	1.98	2.25	23.15	18.35	1.41

Table 5. Comparison of mean aphid population per tiller on different wheat varieties planted on 11th December an average of consecutive three year 2016-19

Varieties	Number of aphid counts from February to end March at week interval							
	4/2	11/2	18/2	25/2	4/3	11/3	18/3	25/3
Galaxy-2013	0.00 a	10.00 a	9.00 a	22.66a	20.00a	52.33a	39.33a	6.66a
Faisalabad-2008	0.20 a	6.66 ab	4.33bc	13.33b	12.00a	45.66a	38.33a	8.33a
Ujala-2016	0.55 a	6.00 ab	6.33b	11.66b	11.00a	40.00a	40.00a	6.66a
Aari-2011	0.00 a	4.33 b	4.33bc	14.00b	14.33a	55.00a	40.00a	4.33a
Punjab-2011	0.66 a	4.00 b	2.00c	9.00b	13.33a	44.00a	43.00a	6.60a
LSD (p≤5%)	0.83	5.19	2.94	5.69	10.55	15.53	10.32	5.08

Table 6. Trend of aphid Population per tiller at different sampling dates under five different planting times an average of consecutive three year 2016-19

Sowing Dates	Sampling Dates							
	4/2	11/2	18/2	25/2	4/3	11/3	18/3	25/3
1st November	1.33	3.50	6.43	16.0	17.0	43.53	44.21	3.46
11th November	1.13	1.79	4.39	8.19	14.79	38.66	41.99	1.86
21st November	0.59	1.33	2.06	3.19	10.80	35.19	37.86	2.26
1st December	0.19	0.86	0.99	3.33	5.86	44.46	35.26	2.86
11th December	0.28	6.19	5.19	14.13	14.23	47.39	40.13	6.51

Table 7. Metrological data during wheat grown period at AR Farm Sheikhupura

	2016-17			2017-18			2018-19		
	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.	Jan.	Feb.	Mar.
Max. Temp (^{0}C)	18.7	25.4	27.0	17.4	20.0	26.5	18.4	18.1	22.5
Min. Temp (^{0}C)	5.9	9.4	13.2	6.0	8.7	13.0	5.9	6.4	11.2
Humidity (%)	70.0	65.4	50.2	71.0	63.0	55.0	70.7	68.6	52.1
Rainfall (mm)	1.50	0.08	0.33	1.5	3.5	1.0	1.12	3.01	0.29

Table 8. Comparison of mean aphid Population per tiller on different wheat varieties planting at five different times (average of three consecutive years 2016-19)

Varieties	No. of aphids per tillers (Ave. of eight counts) at different date of sowing				
	1st Nov.	11th Nov.	21st Nov.	1st Dec.	11th Dec.
Galaxy-2013	22.3	15.2	13.8	15.8	17.8
Faisalabad-08	19.8	9.4	10.8	14.6	17.3
Ujala-2016	18.8	8.2	10.3	13.1	16.0
Aari-2011	17.0	10.0	9.7	13.0	14.3
Punjab-2011	17.9	13.0	9.7	12.3	14.6

Table 9. Yield of Different Wheat Varieties Planted at different times (average of three years 2016-19)

Varieties	Yield kg ha^{-1}				
	01.11.2018	11.11.2018	21.11.2018	01.12.2018	11.12.2018
Galaxy-2013	3327.7 a	3700.0 a	3645.5 a	3510.9 a	2776.7
Faisalabad-08	3287.6 a	3541.1 ab	3646.6 a	3395.5 b	2850.0
Ujala-2016	3255.5 a	3605.5 b	3560.0 b	3453.2 a	2800.0
Aari-2011	2913.3 ab	3354.3 c	3282.7 bc	3150.0 c	2750.0
Punjab-2011	3033.3 b	3461.0 c	3400.0 c	3325.3 ab	2820.3
LSD (p≤5%)	111.15	84.20	98.73	103.13	43.82

Sowing time exaggerated the plant development arrangement. In our findings, modification in sowing time transformed the development phases of wheat crop. This modification also exaggerated the aphid incidence on wheat crop. First time incidence of aphid was recorded at end of stem elongation (1st November), 1st node phase (11th November), stem elongation phase (21st November), at start of stem elongation (1st December) and at end of tillering phase (11th December). **[18]** noted aphids on wheat plants at the stage of stems, leaves, heads and tillers. They also detected that aphids retained developing on the flag leaf and catching the developing awns and heads. This occurrence abridged photosynthetic doings, decrease in fertilization which consequences in low grain produce. At the peak of aphid population the crop growth stage was 1st November at ears fully appear, 11th November at ear initiation, 21st November at booting, 1st December at flag leaf and 11th December at 2nd node stage. Our results presented that greater population of aphids was due to tender crop growth stage that was perfect for aphid nurturing. Periodic population of aphid presented important modification among eight surveillance dates for three repeated years. These results are in conformism with that of **[19]**, who stated that the aphid invasion on wheat crop trendy in the month of January touched it's highest during the 2nd week of March. Early sown crop plants had earing stage at this time crop was effected with aphids that infection leads to reduction in yield while optimum sowing was at progressive development phases than late propagated crops and thus crop presented an escape from aphid invasion. Time of invasion and crop development stage is a significant and important as the level of invasion on wheat crop for aphid vulnerability and its effect on grain produce.

Data presented in (Table 6), depicted that at early counts more aphid population was documented on the sowing dates 1st and 5th while rare infestation of aphid was counted on wheat planted on 2nd, 3rd and 4th dates. At mid of sampling dates 25/2 and 4/3 same level of aphid infestation was observed and recorded on all sowing dates except 2nd, 3rd & 4th and all varieties planted during each crop season while maximum population of aphids were counted on all varieties and planting dates during the sampling dates 11th and 18th March counting dates (Table 6). Aphid decline was documented on all sowing dates and varieties at the end of March during each crop season.

In this study maximum population was detected on late planted crop (11th December) and early sown crop (1st November) during 3rd week of March during each crop season. Overall seasonal aphid population was higher on late (11th December) & early (1st November) than that on timely sown crop (11th to 30th November) in rice–wheat cropping system. **[20, 21]** reported that aphids population reaches the peak in March and drops sharply at the beginning of April. It was also testified that highest aphid population was existent at milky stage while its peak dropped during dough period **[22]**. Results also supported with the observations of **[23]** who reported that aphid peak rests high in late planted crop and it is very less in well-timed planted crop, even lower than that of primary planted crop.

Results revealed that aphid population declined from end march this was due to rise in day and night temperature and appearance of beneficial fauna during each year in rice wheat cropping system. It was noted that grubs & adults of lady bird beetle found actively feeding aphids during mid to end March during each cropping season. Our findings are in agreement with **[24]** who recounted that natural opponents of aphids might play a significant part in dropping pest population. Our results are similar to that of **[4, 25]**, who described peak of aphid population during mid-February to mid-

March. It may be due to quicker aphid breeding during the cold meteorological conditions. Our results are also agreed with that of [16, 21, 26], who recorded aphid peak during March. [27] reported that at the end of March, rise in temperature, presence of beneficial fauna and humidity cause vegetation decline or removal of aphid invasion. These findings also supported the findings of our study. Our results are also similar to [4, 16] who reported failure in aphid population afterward mid-March due to the maturing of crop, rise in temperature and the outbreak of coccinellid beetles. The predators population per five plants at different sowing dates was also calculated in three consecutive years and found that with the increase of predators population, the aphid population decreases (Table 10). Our findings were also supported by [14].

Table 10. Predators population per five plants at different sowing dates an average of eight counts

Planting Dates	No. of Predators per five plants during three consecutive years 2016-19		
	2016-17	2017-18	2018-19
1st November	7.4	7.0	5.1
11th November	7.2	8.0	4.0
21st November	6.2	5.6	7.3
1st December	6.0	4.9	5.2
11th December	8.4	5.8	6.5

Our conclusions are buoyed by the conclusions of [28] who described that crop propagated in December suits more vulnerable for aphid species. [23] also testified that aphid invasion can be reduced by sowing of wheat primary in the period. These conclusions are in promise with our findings that less attack of aphid was noted on crop sown during mid to end November. [29] also recounted that delayed sowing of wheat crop develop witnessed with increased aphid population. Appropriately sown wheat crop is not only significant for improved crop growth but also have less strength of aphid invasion. Together early and late sowing of wheat crop causes decrease in production due to many biotic and abiotic reasons [30]. [31] reported maximum grain yield at timely sowing and lower grain produce in delayed sowing.

Data regarding impact of the aphid population on grain yield mean of three consecutive crop season of different varieties planted at five different times presented in (Table 8). It shows that maximum grain yield 3700.0, 3541.0, 3605.5, 3354.3 and 3461.0 kg $ha^{-1}$was recorded from the varieties Galaxy-2013, Faisalabad-2008, Ujala-2016, AARI-2011 and Punjab-2011 respectively planted during 11th November followed by 21st November sown crop during each crop season while minimum 2776.7, 2850, 2800,2750 & 2820.3 kg ha^{-1} grain yield was obtained from Galaxy-2013, Faisalabad-2008, Ujala-2016, AARI-2011 & Punjab-2011 respectively planted during 11th December and the yield recorded from the varieties sown during 1st November remained at 2nd rank of minimum level. Among planting dates early sown 1st November crop effected with wheat aphids and decreased yield by decreasing plant vigour, thousand grains weight and grains per spike. The planting date 11th and 21st November gave better yield than that of others while late sown planting date 11th December did not perform well due to suffered with aphids , less number of productive tillers and grains per spike. [32] reported that high aphid population is the reason of yield loss in wheat. Postponement planting of crop cause decrease in development in addition to

produce of crop, due to several reasons like aphid feeding, less number of tillers and reduced grains weight **[33]**. Feeding by aphids significant reduced plant growth, grains per spike, thousand grains weight and yield.

Conclusion

Change in planting dates influences the plant development in wheat crops. This alteration in plant development influences the strength of aphid invasion on wheat plants. Crops propagated during November have fewer aphid concentrations and have the aptitude to stand aphid feeding damage for their progressive plant growth causing greater grain produce as matched to crop propagated during December. From the study it is concluded that yield and aphid infestation were considerably exaggerated by planting dates. Postponement in propagating dates can influence severe decrease in development and produce. For optimum time of wheat sowing in rice–wheat cropping system is 10-30th November keeping in view local climatic conditions. So it is suggested that wheat would be propagated at optimal propagating time for better production. It is recommended that avoid too early and too late sowing of wheat in Sheikhupura zone.

Authors' contributions

Conceived and designed the experiments: M Shahbaz, Performed the experiments: M Shahbaz & S Riaz, Analyzed the data: G Nabi, S Muhammad & AA Khan, Contributed materials/ analysis/ tools: A Palwasha, M Riaz, F Ahmad, Z Ali, U Shakir, A Hussain & MA Ali, Wrote the paper: M Shahbaz & I Manzoor.

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