

TECHNOLOGY FOR INCREASING WHEAT PRODUCTION IN INDIA

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Introduction

Wheat is the second most important food crop of India and it contributes nearly 30 per cent of total food grain production in the country. During 1988-89, as per preliminary estimates a total of 54 million tonnes of wheat grain was produced with an approximate average of 2,250 kg per hectare.

Since 72 per cent of the wheat is grown under irrigated condition, there is vast scope for further increase in productivity. The results of large scale national demonstrations organised under farmers' field conditions show that the realizable potential of the available varieties is 40 q/ha at the national level while it is around 45 q/ha in Punjab, Haryana, Uttar Pradesh, Bihar and Rajasthan. Even in the southern states where wheat is grown under tropical climates, 30 q/ha of yield can be obtained. However, our national average is only around 22.5 q/ha.

The state-wise figures for average productivity level reveal that there are large variations in yield per hectare achieved in different wheat growing states. Even within the states there are vast differences under different ecological and agroclimatic regions. A part of the variation in yields in different regions is due to inherent environmental factors but a major part of it is due to the level of input used, popularization of the latest varieties, extent of adoption of improved management practices such as the latest recommended production and protection technologies. It is interesting to note that some of the low yielding but potentially productive regions such as Bihar and eastern Uttar Pradesh not only suffer from low input levels and lack of adoption of improved management practices but are also stuck-up with the variety-Sonalika which was released more than 20 years back while several improved alternative varieties are available now. This indicates slackness in the approach which needs to be rectified.

This compilation aims to project major technologies available which are expected to help in narrowing the gap between the realized and realizable yields under different situations including the constrained environments.

The information contained in this bulletin may be supplemented with more location specific technologies recommended by state agricultural universities.

General Technical Guidelines

- * Choose the latest recommended varieties for your area specific to each cultural condition, i.e., irrigated-timely sown ; irrigated-late sown and rainfed.
- * Use certified/quality seed of good physical purity and germination.
- * Treat seeds with appropriate fungicides to control loose smut in northern states.
- * Do not delay sowing beyond the recommended period. Delay of each day results in more and more reduction in yield.
- * Get the soil tested for fertility status and apply recommended quantity of fertilizers using correct method of application.
- * Check for micronutrient deficiencies in intensive crop rotation areas.
- * Adopt recommended soil amendment practices in problematic soils.
- * Keep the weeds under control. Use weedicides if necessary.
- * Irrigate at the correct time and avoid over irrigation.
- * Adopt proper crop protection measures.
- * Use right type of equipments for various operations particularly seed-cum-fertilizer drill, and adopt all safety measures.
- * Harvest the crop soon after its maturity.
- * Adopt recommended bins/practices for storing the grains.

Recommended Technology

I. Improved Varieties¹

Latest improved wheat varieties, released by the central as well as state varietal release committees, should be adopted for commercial cultivation. Wheat varieties released/under cultivation in each zone and different cultural conditions, which should be popularized/continued to be grown are as follows :

1. Northern Hills Zone (NHZ)

Hilly parts of J&K, Himachal Pradesh, Uttar Pradesh, Sikkim, West Bengal, Assam, Meghalaya and other far eastern states.

- (i) **Irrigated-timely sown** : CPAN 1796, HB 208, HD 2380*, HS 240*, UP 1109*
- (ii) **Rainfed-timely sown** : VL 421, CPAN 1796, HB 208, HD 2380*, HS 240*, UP 1109*
- (iii) **Rainfed-very early sown** : VL 616
- (iv) **Rainfed-late sown** : HS 207*

Notes : * In Uttar Pradesh VL 401 and 404 are grown on a limited scale can still be continued.

* Sonalika should be withdrawn/discontinued.

2. North Western Plains Zone (NWPZ)

Punjab; Haryana; western Uttar Pradesh; Rajasthan (except Kota and Udaipur divisions); Delhi and foot hills of J&K and Himachal Pradesh.

- (i) **Irrigated-timely sown** : (a) HD 2204, HD 2329, HD 2009, HD 2428*, PBW 154*, PBW 34 (d).

¹ In the text (d) denotes durum variety

* Denotes recently released variety which needs to be popularized

- (a) Varieties for earlier NPZ comprising of Punjab, eastern Haryana and western UP.
- (b) Varieties for earlier NWPZ comprising of arid parts of Haryana, Rajasthan and northern Gujarat.

- (b) HD 2009, Raj 1972, WH 283, Raj 1555 (d), Kalyansona, Raj 3077*, WH 416*.
- (ii) Irrigated-late sown : (a) HD 2285, HD 2270*, PBW 226*.
: (b) WH 291, Raj. 2184, VW 120, Sonalika, Raj 3077*.
- (iii) Rainfed-timely sown : (a) C 306, WL 410, IWP 72, DL 153-2 (Kundan), PBW 65, PBW 175*, WL 2265.
: (b) C 306.
- (iv) Salt affected soils : WH 157, KRL 1-4.
(PBW 65, Raj 1972 and Raj 3077 also suitable for moderately affected soils)
- (v) State releases
- Punjab : WL 1562 for irrigated-timely sown, and PBW 138 for irrigated-late sown conditions.
- Haryana : WH 147 for irrigated, timely sown condition.
- UP : UP 368 and UP 2003 for irrigated-timely sown condition.

Notes : * WL 711 should be discontinued while HD 2009 should be discouraged in sub-mountainous areas of Punjab, UP, Jammu and Himachal Pradesh and other regions where Karnal bunt is a problem.

* Kalyansona and Sonalika are still grown in some parts and should be discouraged.

* HD 2285 is also suitable for very late sown conditions (end December/beginning January).

3. North Eastern Plains Zone (NEPZ)

Eastern Uttar Pradesh (comprising of areas lying east of the line connecting Etah and Nainital except Jhansi division); Bihar; Orissa; West Bengal (except hilly regions), plains of Assam, Meghalaya, Arunachal Pradesh and other far eastern states.

- (i) Irrigated-timely sown : HP 1102, UP 262, HUW 206, K7410 (Shekhar).
(HD 2402 is suitable for Bihar, W. Bengal and Assam).
- (ii) Irrigated-late sown : HP 1209, HD 2307, HUW 234.
(BW 11 is suitable for W. Bengal and Assam),
- (iii) Rainfed-timely sown : C 306, K 8027*

- (iv) Rainfed-late sown : HDR 77* is recommended for southern Bihar, W. Bengal and Assam.
- (v) Salt affected soils : WH 157, KRL 1-4.
- (vi) State releases
UP : UP 368, UP 2003 for irrigated-timely sown condition.

Notes : * Cultivation of Sonalika is very extensive in this zone and should be discouraged.

* HD 2307 is suitable for very late sown condition also.

4. Central Zone (CZ)

Madhya Pradesh, Jhansi division of UP, Kota and Udaipur divisions of Rajasthan and Gujarat.

- (i) Irrigated-timely sown : Lok 1, WH 147, HD 2236, Raj. 1555 (d), HI 1077*.
- (ii) Irrigated-late sown : Lok 1, J 405, Swati, HD 2327, Sonalika.
- (iii) Rainfed-timely sown : C 306, Sujata, Mukta, JU 12 (d), Meghdoot (d), A-9-30-1 (d), Narbada-4, Hyb 65.
- (iv) Salt affected soils : WH 157, KRL 1-4.
(Lok 1 is suitable for moderately affected soils).
- (v) State releases
MP : Narbada 112 for rainfed condition.
Gujarat : J 24 (GAUW 10) for irrigated timely sown and GW 2 (d) and A 206 (d) for rainfed conditions.

Note : Cultivation of Kalyansona and Sonalika should be discouraged.

5. Peninsular Zone (PZ)

Maharashtra, Karnataka, Andhra Pradesh, Goa and plains of Tamil Nadu.

- (i) Irrigated-timely sown : HD 2189, DWR 39, HD 4502 (d), HD 2380*.
- (ii) Irrigated-late sown : Sonalika, HI 977*, HD 2501*.
- (iii) Rainfed-timely sown : NI 5439, N 59 (d), Bijaga Yellow (d), MACS 1967 (d).

(iv) State releases

Karnataka : KDW 16 (Keerthi) for irrigated-timely sown condition.

Maharashtra : AKW 381 for irrigated-late sown condition.

Note : NI 5439 should be withdrawn from irrigated areas, and cultivation of Kalyansona should be discouraged.

6. Southern Hills Zone (SHZ)

Hilly areas of Tamil Nadu and Kerala.

(i) Restricted irrigation : HW 741, HW 971*, HUW 318,*
NP 200 (dicocum).

(ii) Rainfed : NP 200 (dicocum).

II. Cultural Practices

Package of cultural practices for various crop production conditions of different regions are as follows :

1. IRRIGATED TIMELY SOWN CROP

(i) Field preparation :

The soil should be well pulverised by ploughing, planking and cultivating so that it is free from clods and also stubbles of the previous crop and weeds. Adequate moisture in the seeding zone should be ensured by pre-sowing irrigation (*palewa*). In heavy soils some additional cultivation may be needed.

(ii) Date of sowing :

For all high yielding semi-dwarf varieties recommended for irrigated condition, adjustments should be made in such a way that the date of sowing is reached after the mean daily temperature has dropped down to 22-23°C. The optimum time of sowing for various zones is as follows :

(A) *NWPZ, NEPZ, CZ and PZ* : 1st fortnight of November.

(B) *Northern Hills Zone* :

(a) **Mid Hills (upto 1500m sea level)** : 1st fortnight of November.

(b) **High Hills (above 1500m sea level)** : 2nd fortnight of October.

(c) **Very High Hills (mono-cropped)** : Beginning of May.

(C) *Southern Hills Zone* :

Two crops of wheat in a year : (a) October for the cool season crop

(b) May/June for summer season crop

(iii) Depth of sowing :

All varieties : 5-6 cm deep.

(iv) Seed rate :

- (a) NHZ, NWPZ, NEPZ and CZ : 100 kg/ha.
 (b) Peninsular Zone : 125 kg/ha.

Notes : * 100 kg and 125 kg seed rates per hectare are sufficient for varieties with seed weight of around 38 g/1000 grains. In case of bold seeded varieties, increase the seed rate by 25 per cent. Germination should not be less than 85 per cent.

* In the North Eastern Plains Zone for broadcast sown wheat in rice stubbles, use 125 kg/ha.

(v) Row spacing :

All varieties : 20-22.5 cm apart.

Note : A closer row spacing of 15 cm or alternatively criss-cross sowing with row spacing of 22.5 cm help to enhance yield levels and can be easily adopted when using seed drill.

(vi) Irrigation schedule (for all zones) :**(A) Under optimum water availability :**

Four to six irrigations depending on soil and climatic conditions according to following schedule.

- (a) **Four irrigations** : Crown Root Initiation (CRI), i.e., about 3 weeks after sowing, tiller completion, boot and milk stages.
 (b) **Five irrigations** : CRI, tiller completion, late jointing, flowering and milk stages.
 (c) **Six irrigations** : CRI, tiller completion, late jointing, flowering, milk and dough stages.

(B) Under limited water availability :

- (a) **One irrigation** : Inbetween CRI and tillering stages.
 (b) **Two irrigations** : CRI and boot stages.
 (c) **Three irrigations** : CRI, boot and milk stages.

Notes : * Irrigation at CRI stage should be light.

* For each centimetre of rain, delay the subsequent irrigation by couple of days.

* More irrigations may be needed in the North Western Plains Zone and Peninsular Zone under very dry climatic conditions and very light soils.

* In the humid parts of North Eastern Plains Zone only 3-4 irrigations may be necessary.

(vii) Fertilizer requirement (for all zones) :**(A) Under assured irrigation :**

Nitrogen (N) : @ 80-120 kg/ha depending on previous crop. Wheat following maize, *bajra*, *jowar* and rice should be given 120 kg N/ha. Wheat following legume may be given only 80 kg N/ha.

Phosphorus (P) : @ 40-60 kg of P_2O_5 /ha.

Potash (K) : Based on soil test analysis.

(B) Under limited irrigation :

Nitrogen (N) : @ 60 kg/ha

Phosphorus (P) : @ 30 kg P_2O_5 /ha

Potash (K) : Based on soil test analysis.

Notes : * Half the quantity of nitrogen and full quantities of P and K should be applied at or before sowing. Phosphorus should be placed 5 cm below the seed. Remaining half quantity of nitrogen should be top dressed at first irrigation.

* Blanket application of fertilizers should be resorted to only when soil analysis facilities are not available. Adjustments must be made on the basis of soil analysis results.

* Quantities of chemical fertilizers should be adjusted in case of availability of farm yard manure. Nearly 5 kg of nitrogen is supplied by one cart-load of well rotten FYM. Combination of these two improves the soil texture and gives the best results.

(viii) Weed control :**(A) Mechanical method :**

Interculture after about one month of sowing. Use improved hand hoe or wheel hoe.

(B) Chemical methods :

Should be adopted where infestation of weeds is very heavy.

(a) If the dominant weed is *Phalaris minor*, following herbicides may be used :

* Methabenzthiazuron (tribunil/ambinil/yield/parch) @ 1.5 kg a.i./ha, 30-35 days after sowing.

* Isoproturon (tolkan/graminon/arelon etc.) @ 0.75 kg a.i./ha, 30-35 days after sowing.

* Metaxuron (dosanex/hexamar/hilnex) @ 1.5 kg a.i./ha, 30-35 days after sowing.

- * Pendimethalin (stomp) @ 1.0 kg a.i./ha, 2-3 days after sowing (pre-emergence).
- (b) If the dominant weed is wild oats or there is a mixed population of *Phalaris minor* and wild oats, the following herbicides may be used :
Isoproturon or Metaxuron may be used as recommended above.
- (c) For broad-leaved weeds like *Chenopodium*, *Convolvulus* etc. use :
2,4-D @ 0.4 kg a.i./ha., 30-35 days after sowing.
- (d) In case of mixed populations of grassy and broad leaved weeds, use :
Mixture of Isoproturon and 2,4-D at the recommended doses of each.

Notes : * Spray the post emergence herbicides a few days after first irrigation while there is still sufficient moisture in the soil.

- * Required quantity of herbicides are to be mixed in 500 to 700 litres of water for spray in one hectare.
- * Spray the weedicides on clear and sunny day only.
- * Do not disturb the soil after spray.
- * Do not use foot sprayer as it can disturb soils.
- * Do not use herbicides in mixed cropping areas but Isoproturon can be used on inter-cropped mustard which is tolerant to it.
- * Do not use 2,4-D on HD 2009 as it is highly sensitive.
- * In case of *durum* wheat reduce the dose of Isoproturon to 0.50 kg a.i./ha, delay spray by additional 3-4 days and do not use on light soils.
- * Do not use weedicides on sandy soils.

(C) *Cultural and preventive weed control measures* :

- (a) Use the clean wheat seed free from weeds.
- (b) Sowing of wheat crop at the optimum recommended time.
- (c) Closer row spacing or criss-cross sowing helps to reduce damage.
- (d) Basal dose of fertilizers are to be placed 4 to 5 cm below the seeds.
- (e) Weeds should be removed before they set seed.
- (f) Bunds and irrigation channels should be kept free from the weeds.
- (g) Vigilance should be kept so that weeds do not spread through irrigation water.

- (h) Some suitable alternative *rabi* crop like berseem and *rabi* maize should be grown in rotation with wheat in areas heavily infested with *P. minor* and wild oats.
- (i) Since weeds spread very fast, weed control should be organised as a community effort at village or block level.

2. IRRIGATED LATE SOWN CROP

(i) Date of sowing :

The seeding of late sown wheat crop should not be delayed beyond :

- * North Western Plains Zone : 25th of December
- * North Eastern Plains Zone : 15th of ,,
- * Central Zone : 15th of ,,
- * Peninsular Zone : 10th of ,,

(ii) Seed rate :

125 kg/ha in all the zones except Peninsular Zone where the seed rate should be 150 kg/ha. In case of bold seeded varieties, increase the seed rate by 25 per cent.

(iii) Row spacing : 15-18 cm in all zones.

(iv) Fertilizer requirement (in all zones) :

- Nitrogen (N) : @ 60-80 kg N/ha
- Phosphorus (P) : @ 30-40 kg P₂O₅/ha
- Potash (K) : Based on soil test analysis.

(Recently an enhanced dose of 60 kg P₂O₅/ha has been recommended)

Notes : * Blanket application of fertilizers should be resorted to only if soil analysis results are not available.

- * Total quantities of phosphorus and potash and half the quantity of nitrogen should be applied at or before sowing. Phosphorus should be placed 5 cm below the seed at the time of sowing. The remaining quantity of N should be applied at the time of first irrigation, i.e., CRI stage.

3. RAINFED CROP

Success of rainfed wheat depends on the amount of soil moisture conserved from the monsoon, so every effort should be made to ensure that maximum amount of moisture is conserved in the soil from monsoon rains. In this regard bunding and levelling to check run-off and ponding of water and occasional deep ploughings are important. During rainy season weeds should be removed by ploughing whenever necessary as they consume large amount of water. After the cessation of monsoon, cultivations should be followed by planking to prevent excessive exposure of the soil and to break the clods.

Sowings should never be done before 15th of October owing to very high temperatures. Soil and seed treatment with chemicals to control white ants, cutworms, foot rots, etc., are important under rainfed condition. Use of fertilizers and seed drills should be encouraged.

- (i) **Time of sowing** : End of October to beginning of November. In case moisture is conserved in upper layers of soil, semi-dwarf varieties perform better when sown in first fortnight of November.
- (ii) **Seed rate** : 100 kg/ha
- (iii) **Row spacing** : 20-25 cm (in more rigorous moisture stress areas like PZ increase it to 30 cm).
- (iv) **Depth of sowing** : Seed must be placed in wet zone and should not go below 5-6 cm of soil surface. In case moisture is deep, drill seed properly and do not plank after sowing.
- (v) **Fertilizer requirements** :
 - Nitrogen (N)** : @ 40 kg N/ha
 - Phosphorus (P)** : @ 20 kg P₂O₅/ha
 - Potash (K)** : Nil

Note : Total quantities of N and P should be drilled 10 cm deep (5-6 cm below the seed) at or before sowing. Use of seed-cum-fertilizer drill is very helpful for placing the seed and fertilizer at the correct depths for getting good crop stand under moisture stress conditions. Appropriate drill suitable for the region/requirement should be used.

4. INTER-CROPPING PATTERNS

(i) Irrigated condition :

Intercropping in irrigated wheat is normally not very profitable. However, mustard is commonly intercropped with wheat in north western plains of India. A ratio of eight rows of wheat and one row of mustard at relatively higher level of fertilizer has been found to increase over-all returns and can be adopted profitably.

(ii) Rainfed condition :

Intercropping of pulses and oilseed in wheat is a common practice in rainfed areas. Intercrops of 8 wheat : 1 mustard and 4 wheat : 2 gram/linseed/safflower/lentil/peas are quite common in various parts of the country. Recommended dose of fertilizers should be used.

Notes : * In intercropping systems, if needed, the weedicide Pendimethylin (stomp) @ 1 kg a.i./ha (pre-emergence) may be used.

* Under irrigated condition sowing time of intercrops should not be delayed. This will decrease the yield of the crop and increase the occurrence of diseases and pests. Normal time of sowing is first week of November.

III. Disease Control

1. Rusts :

Use resistant varieties. All latest released varieties are resistant to rusts important in the region of recommendation.

2. Loose smut :

It is an internally seed borne disease and infection takes place at the time of grain formation. If the grain to be used as seed next year is protected from infection, the crop raised from it will be free from the disease. This can be achieved by regular rigorous roguing of infected plants to some extent. Alternatively seed should be treated with fungicides particularly for plots to be used for seed production or to protect the general crop if necessary. The recommended control measures are :

- (a) Grow resistant varieties like PBW 65, PBW 34 in NWPZ and VL 421 in NHZ.
- (b) Dress seed with Carboxin (vitavax) or Carbendazim (bavistin) @ 2.5 g/kg seed.
- (c) Adopt solar heat treatment, i.e., soaking of seed in water for four hours and then sun drying. Operation should be carried out in dry, hot and non-windy days during the month of May and June.

3. Karnal bunt :

- (a) Use resistant/tolerant varieties like HD 2285, WL 1562, PBW 154, PBW 226, PBW 34.
- (b) Use thiram or MEMC @ 2.5 g/kg seed as prophylactic measure for seed-borne inoculum.
- (c) Sow the crop in time and avoid irrigation at flower emergence.

4. Hill bunt and Flag smut :

Treat the seed with organomercurial compounds like cerasan or agosan @ 2 g/kg seed or non-mercurial compounds such as Carboxin or Carbendazim 2.5 g/kg seed.

5. Powdery mildew :

- (a) Use tolerant varieties such as HS 207 and HS 240 in hilly regions.
- (b) Use sulphur dust or kerathane in problematic pockets/years.

6. Leaf-blight :

Dithiocarbamates such as dithane Z-78 or dithane M-45 @ 0.25% may be sprayed as per recommendations.

7. Foot-rot or damping-off :

Treat the seeds with fungicide MEMC @ 2 g/kg or brassicol @ 3 g/kg seed.

IV. Nematode Control

1. Ear-cockle and Tundu :

Remove nematode galls by sieving or floatation in 2% common salt solution and wash thoroughly in plain water. Dry the seed before sowing.

2. Molya disease :

- (i) Plough the fields two to three times during May-June.
- (ii) Rotate with non-host crop such as gram, carrot, radish, marigold and resistant varieties of barley for one or two years.
- (iii) Apply carbofuran @ 1.5 kg a.i./ha in the soil.

V. Insect Pest Control

1. Termites :

- (i) Treat seeds with aldrin 400 ml of 30 EC per quintal of seed for termite control. Before application, the insecticide should be diluted with five litres of water. The emulsion should be sprayed over the seed uniformly spread on the floor. The seed should be turned over to ensure proper mixing. The treated seed should be left overnight for drying before sowing.

Soil application of aldrin 5% or BHC 10% @ 25 kg/ha after final ploughing but before planting is also effective.

- (ii) For the control of termites in standing crop, aldrin 30 EC @ 1.25 l/ha may be used with irrigation water. This treatment is also effective against root aphids.

The same dose of aldrin may be diluted in 5 litres of water and mixed with 50 kg of sand and broadcasted in the field before irrigation. This is also effective if the crop is unirrigated.

2. Shoot fly :

Shoot fly attacks early and late sown crops. Hence to avoid damage by this pest, the sowing should be done between mid-November to mid-December only. If however, late sowing is done and shoot fly incidence (dead hearts) is noticed, spray cypermethrin @ 50 g a.i./ha. Repeat treatment at 15 days interval, if necessary.

3. Brown wheat mite :

Spray any one of the following pesticides against brown wheat mite on the first appearance of pest :

- (i) Formothion (anthio 25 EC @ 650 ml/ha)
- (ii) Oxydemeton methyl (metasystox 25 EC @ 650 ml/ha)
- (iii) Phosphamidon (dimecron 100 @ 250 ml/ha). This treatment will also control aphids and jassids. Repeat if necessary, after 15 days.

4. Other insect pests :

For the control of caterpillar pests, like armyworm, cutworm, gram pod borer and other lepidopterous pests and Pyrrilla, spray one of the insecticides namely :

- (i) Carbaryl (sevin 50 WP @ 2.5 kg/ha)
- (ii) Fenitrothion (folithion 1000 @ 500 ml/ha or sumithion 50 EC @ 1 l/ha)
- (iii) Dichlorvos (nuvan 100 EC @ 500 ml/ha).

5 Aphids and Jassids :

Spray any one of the following pesticides along with 500 litres of water/ha :

- (i) Diamethoate 30% 330 ml
- (ii) Phosphamidon 85% 100 ml
- (iii) Carbaryl 50% W.P. 1000 g

6. Rat control :

The poison baits should be prepared by mixing Zinc Phosphide (1 part) and crushed grains (50 parts) along with some sweet oil. One tea spoon of this mixture should be kept in each rat hole. Mass control is more beneficial.

VI. Physiological Disorders

1. Micronutrient deficiencies

The adoption of intensive cropping systems in various parts of the country has resulted in occasional micronutrient deficiencies. Some of the common ones are listed below.

(i) Zinc deficiency :

This deficiency generally appears in light soils under intensive cropping. The symptoms are failure of stem elongation and necrosis and chlorosis in plant leaves in the middle. The leaves break later on.

The deficiency can be rectified by applying zinc sulphate @ 25 kg/ha along with fertilizers once in 2-3 years or by foliar spray of 0.5% zinc sulphate (21% zinc).

For foliar spray prepare the solution by dissolving 1 kg zinc sulphate and $\frac{1}{2}$ kg unslaked lime in 200 litres of water. This solution is sufficient for spraying in one acre of wheat once only, while 2-3 sprays at 15 days intervals are needed.

(ii) Manganese deficiency :

Generally appears in light soils in intensive cropping regions specially under rice-wheat. The symptoms appear on middle leaves as interveinal chlorosis with light greyish yellow to pinkish brown or buff coloured specks of variable sizes confined largely to 2/3 lower portion of the leaves. Later the specks coalesce forming a streak or band in between the veins which remain green. At earing stage, the symptoms become predominant on flag leaf.

Spray 0.5% MnSO_4 solution (1 kg MnSO_4 in 200 litres of water) two to four days before first irrigation and 2-3 sprays afterwards at weekly intervals.

(iii) Sulphur deficiency :

Sandy soils are most prone to this deficiency. It is more severe when winter rains continue for long time in the early growth period. The symptoms first appear on the younger leaves with fading of the normal green colour. This is followed by chlorosis resulting in chlorotic stripping between the veins, stunted growth of the plants, delayed maturity and fewer tillers.

The situation can be avoided by using sulphur containing fertilizers like ammonium sulphate and single superphosphate.

(iv) *Boron deficiency* :

Boron deficiency occurs in alkaline calcareous soils and acid leached sandy soils. In India it is generally found in certain pockets of north eastern plains. The deficiency symptoms are chlorotic patches on the middle leaves of 3 week old plants which later on become pronounced and develop bright orange colouration. The inflorescence is improperly developed (zig-zag axis, short awns, apical part discoloured) and thus grain formation is poor. Occurrence of completely sterile spikes is also reported.

To ameliorate the situation Borax @ 10-15 kg/ha should be applied in the soil by broadcast. Foliar application of 'B' (Solubor @ 0.2-0.5%) is preferred if deficiency occurs during the growth season for which multiple sprays are needed for complete recovery.

2. Adverse soil conditions

Alkalinity and salinity are the important adverse soil conditions widely prevalent in several wheat-growing states.

(i) *Alkaline soils* :

Such soils are frequent in Haryana, Punjab, Uttar Pradesh, parts of Bihar and Madhya Pradesh. Alkalinity is caused by an excessive concentration of carbonates and bicarbonates of sodium. The crop stand is reduced owing to poor seedling emergence, low tillering and weak plant growth. If the pH is above 9.2, wheat crop should not be grown without the adoption of recommended soil amendment practices. These may involve the use of gypsum @ 10 to 15 tonnes/ha, depending upon soil test and adoption rice-wheat rotation. Other specific recommendations for increasing the wheat production from alkaline soils are :

- * Use 10-15% higher seed rate than normal.
- * Apply 20% higher dose of nitrogen.
- * Restrict phosphorus and potassium applications only when soil tests justify their use.
- * Use compost wherever possible.
- * Follow a strict schedule for field preparation to avoid bad seed-bed conditions.

(ii) *Saline soils* :

Saline soils are prevalent in Haryana, Punjab, Rajasthan, Uttar Pradesh, Gujarat, Maharashtra, Karnataka and Andhra Pradesh. The situation arises because of an excessive concentration of chlorides and sulphates. The crop germination and growth is restricted and yield starts declining beyond 3-4 ECe. Significant yield reduction occurs beyond 6-8 ECe in most high yielding varieties.

Recommendations to ameliorate the situation are :

- * Use slightly higher seed rate.
- * Follow a rigid water management schedule, which involves a heavier than normal first irrigation, followed by frequent light irrigations with occasional heavy irrigations.
- * Use normal recommended levels of nitrogen but split into 3 equal doses to be applied at seedling, tillering and grain-filling stages.

(iii) *Acidic soils* :

Such soils are found in several high rainfall areas with excessive leaching which results in low bases content. These are commonly encountered in far eastern states, viz., Bihar, West Bengal and certain high altitude area of north western hills. Typical symptoms include restricted plant growth and reduced P uptake. These symptoms start becoming acute below 5.5 pH. Rectification can be achieved by applying lime. Recommended dose of lime varies from 1-2 tonnes per hectare but the exact requirement must be got determined by actual soil test.

VII. Harvesting and Threshing

To minimize losses from shattering and other environmental hazards, the crop must be harvested soon after maturity. The best time for harvesting is at a grain moisture of about 15% and when the seed has become hard. If the straw is wet, it should be dried till the stem can be broken by hand. To vacate the fields quickly, Combine Harvester which can harvest and thresh the crop simultaneously, should be hired and used. Tractor drawn and self propelled combine harvesters may also be used. For manual harvesting always use improved sickles. If the conditions permit tractor drawn reaper can be used for harvesting purpose.

Several types of wheat threshers are available and are very helpful. The optimum speed recommended by the manufacturers of the threshers should be followed keeping in view the capacity of the machine, grain breakage and size of the *bhusa* particles. To avoid accidents during threshing, use threshers with automatic feeding mechanism. In case of manual feeding threshers, the minimum length of feeding chute should be 90 cm and the length of covered portion should not be less than 45 cm.

Adopt the following safety measures while taking up the threshing work :

- * Never use any intoxicant while working on threshers.
- * All the working components of the thresher should be properly shielded.
- * Never put loose clothes, bangles, wrist watches etc. while working on the thresher.
- * The operator should not insert his hand deep in the feeding trough while feeding the harvest.
- * Some water and sand should be kept within the easy reach of the operator so that in case of fire hazard, the same can be used to control it.
- * If the thresher is to be operated by tractor, use spark arrester on the exhaust pipe of tractor.
- * A first-aid-box must always be kept at the site.

VIII. Post-Harvest Care

To avoid losses in storage, the grains should be dried in sun to the moisture content of less than 10%. Improved storage structures like Pusa Bin or other recommended bins which are airtight, can be used for storage. The store should be regularly inspected for pest infestation. Fumigation of the seed in the stores by aluminium phosphide tablets @ 1 tablet per tonne is recommended.

Empty godowns before storage, should be fumigated likewise or the surface of godowns and outer surface of storage structures can also be treated before storage of grains with melathion 50 EC @ 15 ml diluted in 4.5 litres of water and sprayed per 93 m² of the surface.

The surface treated with an insecticide must not come in direct contact with grains.

